REMARKABLE LUMINOUS PHENOMENA IN NATURE

Compiled by:

William R. Corliss

A CATALOG OF GEOPHYSICAL ANOMALIES

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WEB SITE: www.science-frontiers.com

COMPILATION: Science Frontiers: Some Anomalies and Curiosities of Nature (first 86 newsletters organized and indexed)

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PREFACE

This volume is a major expansion of the first catalog in this series, which is entitled Lightning, Auroras, Nocturnal Lights. This was published in 1982. Since that time, I have amassed so much additional information on luminous phenomena that this new volume is desirable. Because this new edition is almost twice the size of the 1982 book, a new title seems indicated.

Seventeen new sections have been added and some of the old ones have been greatly expanded. In particular, there are many additional observations of low-level auroras, ball lightning, nocturnal lights, and marine light wheels. There are now 128 illustrations of luminous phenomena. The indexes have been necessarily enlarged to accommodate the hundreds of new references.

The updated and revised Preface to the 1982 volume now follows.

After more than thirty-five years of scouring the science and popular-science literature for anomalies, my major observation is that the search has been most fruitful. In fact, I have wondered why the scientific community itself has not been systematically compiling such information. It is surprising that a Catalog of Anomalies does not already exist to guide scientific thinking and research. It is at least as important to recognize what is anomalous as it is to realize what is well-explained in terms of prevailing paradigms. With this outlook and philosophy, here is an expanded edition of the first volume of such a Catalog. It is largely the product of one person's library research. The work has been carried forward entirely through the sale of these Catalog volumes and associated publications.

Under the aegis of the Sourcebook Project, I have already published 35 volumes, totalling roughly 15,000 pages of source material on scientific anomalies. (See page iv for a list of titles.) As of this date, these 35 volumes represent only about 45% of my data base. New material is being added at the rate of about 1,200 new items per year, about 700 of which come from the current scientific literature. This acquisition rate could easily be multiplied several-fold just by spending more time in libraries. Even after ~~thirty~~ years, only a handful of English-language journals have received my serious attention. The journals in other languages, government reports, conference papers, publications of research facilities, proceedings of state academies of science, and an immense reservoir of pertinent books remain almost untapped. Every library foray uncovers new anomalies; the world's libraries are bulging with them.

Given this rough assessment of the extent of the anomaly literature, one can understand why the Catalog of Anomalies will require at least 35 volumes, many of them larger than the one you now hold. I visualize a shelf of these 35 volumes, or an equivalent CD, accompanied by master indexes, to be the logical initial step in providing scientists with access to what, in my opinion, is not well-explained. The underlining of "my" is significant because anomalousness is often in the eye of the beholder. It depends upon how well one is satisfied with those explanations based on currently accepted paradigms. In the Catalog of Anomalies, the data rule; all theories and hypotheses are considered tentative. The history of science, from the luminiferous ether to the static continents, demonstrates that this is a wise policy.

Will the Catalog of Anomalies impact science significantly? Probably not---at least not right away. Quite often the initial reaction to the volumes already published has been disbelief and even disdain. The data must be in error; the data are too often anecdotal; the data are too old; the purported anomaly was really explained long ago. Germs of truth reside in such complaints. Some science and some observations reported in the Catalog are certainly bad; but this is mini-

mized by a heavy reliance upon respected journals. In addition, the baseline of well-established theories---against which anomalousness in measured---is always shifting. And for every anomaly that can be explained away, a trip to a library will quickly replace it with ten more from impeccable sources. Nature is very anomalous or, equivalently, Nature is not yet well-understood. Much remains to be done in both anomaly research and in the resulting scientific research that will ultimately dispose of these anomalies.

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October 1, 2001

"ROUND ABOUT THE ACCREDITED AND ORDERLY FACTS OF EVERY SCIENCE THERE EVER FLOATS A SORT OF DUST-CLOUD OF EXCEPTIONAL OBSERVATIONS, OF OCCURRENCES MINUTE AND IRREGULAR AND SELDOM MET WITH, WHICH IT ALWAYS PROVES MORE EASY TO IGNORE THAN TO ATTEND TO .... ANYONE WILL RENOVATE HIS SCIENCE WHO WILL STEADILY LOOK AFTER THE IRREGULAR PHENOMENA. AND WHEN THE SCIENCE IS RENEWED, ITS NEW FORMULAS OFTEN HAVE MORE OF THE VOICE OF THE EXCEPTIONS IN THEM THAN OF WHAT WERE SUPPOSED TO BE THE RULES."

William James

Illustrations initialed JCH are the work of John C. Holden

HOW THE CATALOG IS ORGANIZED

PURPOSE OF THE CATALOG

The Catalog of Anomalies is designed to collect and categorize all phenomena that cannot be explained readily by appealing to prevailing scientific paradigms. Such phenomena are termed "anomalies." Following its definition, each anomaly is rated in terms of: (1) its substantiating data; and (2) the seriousness of the challenge it poses to mainstream paradigms. Next, important examples of the anomaly are recorded, some of the more interesting ones in greater detail. Finally, all the examined references are listed. Thus, the Catalog is a descriptive guide as well as a reservoir of examples of the phenomena along with their supporting references. Science researchers thus have a substantial foundation for beginning further investigations of these intriguing phenomena. In short, the basic purposes of the Catalog are: the collection and organization of the unknown and the poorly explained in order to facilitate future research and explanation.

GENERAL PLAN OF THE CATALOG

It was tempting to organize this Catalog alphabetically, making it an "encyclopedia of anomalies." But many of the phenomena have obscure names or, even worse, no names at all. Under these circumstances, alphabetical access to the data base would be difficult. Therefore, a system of classification was designed based upon readily recognized aspects of nature, such as lightning or mammal morphology. The universe of anomalies is first divided into nine general classes of scientific endeavor, as illustrated in the diagram on the following page. Few people would have difficulty classifying a phenomenon as biological, astronomical, geological, etc. The second, third, and fourth levels of classification are also based upon generally recognized aspects of nature. The similarity of this sort of classification to that employed in natural-history field guides is quite intentional. Like bird identification, phenomenon classification soon becomes second nature. In fact many of the phenomena described in this Catalog are accessible to anyone with normal senses and a little optical help.

Most catalogs employ numbering systems, and this one is no exception. Rather than use a purely numerical system, the first three levels of classification are designated by letters. The triplets of letters selected have some mnemonic value. Thus, a GLA anomaly is easily recognized as belonging to the geophysics class (G), involving luminous phenomena (L), and, more specifically, auroras (A). The number added to the triplet of letters marks the fourth classification level, so that GLA4 signifies the category of low-level auroras, as indicated in the diagram on the next page. Every class of anomaly has such a unique alphanumeric code. All cross references and indexes are based on this system. Catalog additions and revisions are made easier with this approach, as it did with this book.

These codes may seem cumbersome at first, but their mnemonic value to the compiler has been considerable. The codes are simple, yet they are flexible enough to encompass the several thousand types of anomalies in the several diverse scientific disciplines that have so far been investigated.

A glance through this volume will reveal that each entry for an anomaly type bears an X-number, and each reference an R-number. GLA4-X12 therefore specifies the twelfth entry for low-level auroras; and GLA4-R1 is the first reference in this section's bibliography.

First-order classification		Second-order classification		Third-order classification		Fourth-order classification	
A	Astronomy	E	Atmospheric optics	A	**Auroras**	1	**Auroral pillars**
B	Biology	F	Falls	B	**Ball lightning**	2	**Auroral arches**
C	Chemistry & Physics	H	Hydrospheric phenomena	D	**Discharge phenomena**	3	**Auroral meteors**
E	Earth Sciences	L	**Luminous phenomena**	L	**Lightning**	4	**Low-level auroras**
G	**Geophysics**	M	Magnetic phenomena	M	**Meteor-like phenomena**		⋮
L	Logic & Math	Q	Earthquakes	N	**Nocturnal lights**		⋮
M	Archeology	S	Sound	W	**Marine phosphorescence**		⋮
P	Psychology	W	Weather			31	**Bright cloud-like patches**
X	Unclassified						

Bold-face subjects are covered in this volume.

CATALOG CODING SCHEME

HOW DATA AND ANOMALIES ARE EVALUATED

Each anomaly type is rated twice on four-level scales for data "validity" and "anomalousness," as defined below. These evaluations represent only the opinion of the compiler and must be considered only rough guides.

DATA EVALUATION SCALE

1 Many high-quality observations. Almost certainly a real phenomenon.

2 Several good observations or one or two high-quality observations. Probably real.

3 Only a few observations, some of doubtful quality, The phenomenon is questionable

4 Unacceptable, poor-quality data. Such entries are included only for purposes of comparison and amplification.

ANOMALY EVALUATION SCALE

1 Anomaly cannot be explained by modification of present laws. Major paradigms are challenged.

2 Can probably be explained through relatively minor modifications of present scientific laws.

3 Can probably be explained using currently accepted theories. Primarily of curiosity value.

4 Well-explained. Included only for purposes of comparison and amplification.

Referring to the evaluation scales above, it should be remarked that anomalies that rate "1" on both scales are very rare. Such anomalies, however, are the most important because they have the potential to force scientific revolutions.

ANOMALY EXAMPLES

Examples of anomaly types and entries discussing them are designated by the letter X in the body of the Catalog. Except in the cases of extremely common phenomena, such as ball lightning, all of the examples discovered so far are entered. If the example is of the "event" type, time and place are recorded if they are available. Such data are the basis of the Time-of-Event and Place-of-Event indexes provided in some volumes. These indexes may lead to obscure cause-and-effect relationships. When library research has unearthed a great many examples of a specific anomaly, only the more interesting and instructive are treated in detail. In the examples and entries, direct quotations from eye-witnesses and scientific experts are often employed to convey accurately the characteristics and significance of the phenomena.

THE REFERENCES AND SOURCES

Each anomaly type and the examples of it are buttressed by all the references that have been collected and examined. Since some of the references deal with several examples, each reference includes the X-numbers of the examples mentioned. When a reference covers more than one type of anomaly, it is repeated in each anomaly bibliography. Actually, there is little such repetition.

Perusal of the Source Index will demonstrate that the great majority of the references employed come from the scientific literature. Heavily represented in this volume of the Catalog are such journals as: Nature, Science, and Marine Observer. Some less-technical publications are also used occasionally, such as: Science News and New Scientist. All of the serials just mentioned are generally very reliable, although one must always be wary when dealing with anomalous phenomena. In addition to these often-referenced publications, a wide spectrum of other journals dealing with geophysics has been found useful.

The sources consulted date from the beginning of organized science some 200 years ago. The great bulk of the references, however, comes from the past 80 years. In geophysics, especially, the explosive growth of the data base is remarkable. Indeed, advances are being made so rapidly in geophysics that some of the information printed in this volume will be outdated before the books leave the bindery.

THE INDEXES

Most Catalog volumes conclude with several separate indexes. At first glance this may seem to be too much of a good thing, but in the context of a science-wide endeavor each index helps tie the whole together.

The Source Index shows immediately the dependence of this Catalog upon the scientific literature rather than newspapers and other popular publications. Its real purpose, though, is the rapid checking of newly acquired references to determine whether they have already been caught in the fishing net of the library-research aspect of the Catalog effort. The Source Index is doubly valuable because many footnotes and bibliographies in the scientific literature omit article titles and, sometimes, even authors! The researcher also comes across vague references to such-and-such an article by so-and-so back in 1950 in Nature. In such cases, the rather ponderous Source and First-Author Indexes can help pin down references lacking in specifics. The Time-of-Event Index will help investigators link causes and effects together.

The four Indexes use the Catalog codes described above rather than page numbers. The codes are permanent whereas page numbers would change as volumes are revised. The mnemonic value of the Catalog codes is evident here, too, because the approximate nature of each Index entry is readily apparent, while page numbers provide only location.

SUPPORTING PUBLICATIONS OF THE SOURCEBOOK PROJECT

The Catalog volumes curently being published are actually distillations of huge masses of source material. The Sourcebook Project has already published 35 volumes of such material, as detailed on p. iv. Phase I of the Sourcebook Project resulted in ten loose-leaf notebooks called "Sourcebooks." To meet the demands of libraries, Phase II supplanted the Sourcebooks with a series of six "Handbooks," which are casebound, much larger, and more comprehensive than the Sourcebooks. Phase III, now in progress, is the cataloging phase. This consists of systematizing the data base, which now comprises some 40,000+ articles, and the publication of the "Catalogs."

CATALOG ADDENDA AND REVISIONS

Over 1200 new reports of anomalies are collected each year from current and older scientific journals. New anomaly types and additional examples of types already cataloged are accumulating rapidly. When sufficient new material has been assembled, Catalog volumes will be revised and expanded.

The Sourcebook Project welcomes reports of scientific anomalies not already registered in extant Catalog volumes. Reports from scientific journals are preferred, but everything is grist for the anomaly mill! Credit will be given to submitters in new and revised Catalog volumes. If the reports are from current literature, they may be mentioned in Science Frontiers, the Project's newsletter. Send data to: Sourcebook Project, P.O. Box 107, Glen Arm, MD 21057, USA.

The Project's web-site address is: www.science-frontiers.com.

INTRODUCTION TO LUMINOUS PHENOMENA

The primary sensory channel for detecting unusual natural phenomena will always be the human eye. Nothing catches the attention faster than a mysterious light. Who hasn't jumped at a nearby flash of lightning or pondered a far-off light moving through the night sky? Was it just an airplane or some phenomenon unknown to science? Most strange lights of course turn out to have prosaic scientific explanations; but this catalog volume will demonstrate that some luminous phenomena still tax the ability of today's science to account for them.

The lights described here are self-luminous; like a light bulb they shine through the release of internal energy rather than the reflection of light from the sun, moon, or other external source. This category includes lightning, the auroras, meteors, marine bioluminescence, and other luminous displays that manufacture their own light. Halos, rainbows, mirages, and phenomena depending upon reflected light are covered in another volume of this catalog.

The earth's atmosphere absorbs sunlight and streams of subatomic particles spewed out by the sun. This influx of solar energy fuels many of our terrestrial luminous phenomena. Various chemical and electrical processes convert solar energy into the auroras, lightning, St. Elmo's Fire, the Andes Glow, and that host of curious and beautiful luminous phenomena that make up this volume. A meteor transforms its energy of motion into light as it plunges into the atmosphere. Closer to the earth's surface, the incredible geometrical displays of marine phosphorescence draw their energy from minute organisms in the seawater. Finally, the earth itself is a reservoir of energy. The ponderous motion of an earthquake somehow ignites the sky with electric flashes, glows, and moving balls of light. Gases escaping from the earth's crust may be converted into those soft lambent flames called will-o'-the-wisps. Nature is profligate with energy and has discovered many ways to turn it into visible light.

Genuine mysteries surround many of the luminous phenomena described in this volume. For example:

> The precise energy sources of some of the phenomena are unknown.
>
> Ball lightning, normal lightning, and the so-called ghost lights sometimes display prankish, uncanny behavior that seems to transcend objective science.
>
> Some auroras seem to descend close to the earth's surface where conditions supposedly preclude their formation.
>
> Some auroras, most marine phosphorescent displays, and a few electric discharge phenomena manifest themselves as curious geometrical patterns (rings, wheels, parallel bands, and other unlikely patterns) that are most difficult to explain.
>
> Ghost lights, ball lightning, marine light displays, and several other classes of phenomena involve the murky problems of human perception and the role of the mind. Indeed, we already know that some lights, such as those experienced by the astronauts when bombarded by cosmic rays, do not truly exist.

This rich lode of luminous phenomena provides a fertile ground for scientific exploration. Unfortunately, the controversial aspects of many of the phenomena and the highly subjective nature of many of the reports make this a risky field for scientists to tackle.

GLA AURORA-LIKE PHENOMENA

Key to Phenomena

GLA0 Introduction

Auroras are luminous displays of the northern skies in the Northern Hemisphere and the southern skies in the opposite hemisphere. The repertoire of "normal" auroral displays is remarkable, ranging from an unimpressive, dull-greenish glow just tinting the northern horizon to kaleidoscopes of flickering red, yellow, and bluish flames and arches that fill half the heavens. The convoluted, eerie draperies, the silently flashing displays, and the cavorting flames we call the Merry Dancers grip the modern beholder and doubtless inspired awe and legend in primitive man.

Despite all our modern research with spacecraft and instrumented rockets, the auroras have not yielded up all their mysteries---even the "normal" auroras. Auroras are loosely associated with solar activity and geomagnetic storms, so we surmise that gusts of electrically charged particles emitted by the sun (the solar wind) help in some way to set fire to the polar heavens. Beyond these generalities, there is much we do not understand. In particular, the anomalous or abnormal auroras described below reveal even deeper layers of ignorance about one of Nature's most spectacular manifestations.

To begin, aurora-like phenomena of uncommon form, such as those that brush the starlit sky with misty parallel bands, pose serious problems of explanation. Why the geometrically arranged bands? Are there regularly spaced conduits in the upper atmosphere for solar electricity to flow or is there a regular sea of gravitational waves in the upper atmosphere? Next, how do some rare auroras seem to approach the earth's surface, even to the point of engulfing observers in luminous mists? Conventional wisdom has it that all auroras weave their luminous magic above 80 kilometers altitude. The abundant records of auroral "fogs", the crackling and hissing sounds, and the occasional acrid odor of ozone demonstrate that some auroras may actually record the slow discharge of terrestrial electricity to the upper atmosphere. It is almost as if a temporary hole had been punched in the planet's magnetic bottle, short-circuiting the earth to the solar-system dynamo, the sun. There are also puzzling observations linking auroras to daytime cloud formations, to thunderstorms, to earthquakes, to mountain-top glows. That the earth is electrically active cannot be denied; it is part of an enveloping cosmos seething with energy.

Auroras, though frequently strange and mystifying, are accepted denizens of the night skies, but there exist even stranger luminous displays that may or may not be related to auroras. What could cause an electric-blue, all-sky flash or expanding bubbles of ghostly light many times the size of the moon? What brightens the entire sky to the point where print can be read outdoors at midnight? For want of a better category, such phenomena are included with anomalous auroras.

GLA1 Auroral Pillars: Natural Searchlight Beams

Description. Isolated, often breath-taking, white-to-greenish-white shafts of light 1-10^{o} wide extending from the horizon to near and occasionally past zenith. Auroral pillars usually appear in the eastern or western horizon, well away from the zone where auroral activity normally occurs. The pillars or beams may remain visible from a few minutes to over an hour, drifting slowly north or south. Wavelets of light may seem to rush up and down the filmy but well-defined beams. Both straight-sided and fan-shaped pillars are known.

Background. Modern observers of the night sky often see beams of light rising from the horizon. Investigation almost always proves them to be searchlights at shopping centers or some other artificial illumination. In this environment, it is not surprising that there are few modern observations of auroral pillars and that most of the scientific discussions regarding their origin are confined to the older literature.

Data Evaluation. Many reports of auroral pillars reside in the older journals. A goodly fraction of these observations were made by scientists who provided direction, angular dimensions, lifetimes, and other pillar characteristics. Rating: 1.

Anomaly Evaluation. The long-lived, isolated auroral pillar with a bearing well away from magnetic north may have a different origin than the ever-changing beams and flickerings associated with the usual auroral display. While auroral pillars are doubtless caused by the channelling of charged particles, the exact mechanism is still controversial, as is the reason for the appearances of pillars so far removed from the scene of most auroral activity. Despite these unresolved problems, auroral pillars represent only minor scientific anomalies. Rating: 3.

Similar and Related Phenomena. The auroral arch (GLA2) is probably closely related to the auroral pillar, the latter being merely an abbreviated arch. Fan-shaped auroral pillars are sometimes confused with comets, but comets almost never appear and disappear in a matter of minutes. The nebulous pyramid of the zodiacal light (AZO) rises from the horizon much like a pillar but is triangular and slanted along the ecliptic. The position of the zodiacal light in the sky is also fixed. Sun pillars bear some resemblence to auroral pillars but can be distinguished because they always appear directly over the position of the setting or rising sun. A rare meteor track may be seen perpendicular to the horizon, but these glowing trails of ionized gases are usually quickly distorted by high altitude winds.

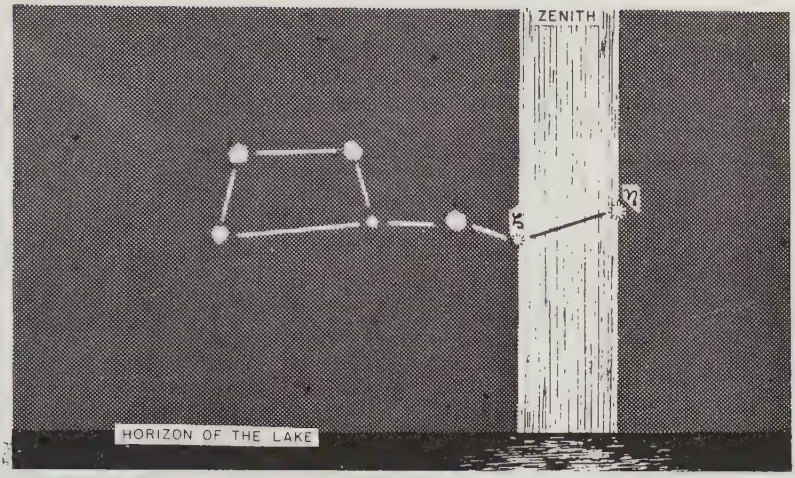
Examples of Auroral Pillars

X1. November 3, 1934. Liverpool, England. "...about 8 o'clock, a singular luminous appearance was seen in the heavens commencing near the western horizon and after extending through the meridian of the heavens, finally losing itself near the brilliant planet Jupiter...It presented the aspect of a beauteous transparent zone of light, of near equal width, from six to seven degrees...The stars were distinctly visible through its filmy structure and here and there a thin vapoury cloud crossed it at right angles." (R1)

X2. May 8, 1837. Bay of Toronto, Canada. R.H. Bonnycastle describes a straight-sided auroral pillar, "...my attention whilst regarding the heavens was forcibly attracted to the sudden appearance due east of a shining broad column of light...I was convinced that the meteor was an effluence of the sky, as I now saw it extend upwards from the eastern water horizon line to the zenith, as a well-defined, equal, broad column of white strong light, resembling in some degree that of the aurora, but of a steady brightness and unchanging body..." The pillar moved slowly northward disappearing in the northeast ten minutes after the first sighting. (R2)

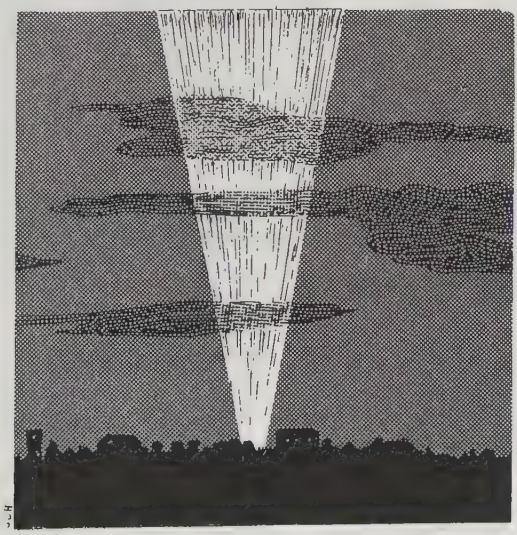
X3. March 4, 1896. Great Britain. Of all the observations of auroral pillars, the extraordinary beam of light appearing in the evening sky on March 4, 1896, evoked the most discussion and scientific controversy. Seen from all over the British Isles, the beam arose bright and sharply defined from a bank of clouds on the western horizon in the early evening. Its initial location was almost coincident with the axis of the zodiacal light, and it pointed along the ecliptic. The March 4 beam, however, moved appreciably southward while in view. A comet was suggested when it became obvious that the phenomenon could not be the zodiacal light. However, the pillar's sudden appearance and disappearance upset that theory. Finally, the general scientific consensus settled on an auroral beam. Depending upon the location of the observer, the beam was straight-sided, fan-shaped, or pointed at both ends. Its duration varied likewise, from a few to many minutes. Some saw lesser beams nearby; others thought they saw transitory projections perpendicular to the beam. (R3-R8, R26)

X4. August 28, 1883. England. "I was just coming out of my observatory when, on the E.N.E. point of the horizon beneath the Pleiades, I saw a bright light. My first thought was that the moon was rising, but an instant's reflection sufficed to remind



A straight-sided auroral pillar seen above the Bay of Toronto. (X2)

me that she would not be up for the next two hours. As I watched the light becoming brighter and brighter, I saw that it threw a kind of radial illumination upward, the effect of which I have tried to reproduce in the accompanying rough little sketch." (R9, R27)



A fan-shaped auroral pillar seen in England. (X4)

X5. March 19, 1847. England. (R7)
X6. March 13, 1895. Kiel, Germany. (R7)
X7. March 17, 1843. Collingswood, England. The beam seemed to accompany the stars in their diurnal motion. (R10)
X8. April 22, 1852. New Haven, Connecticut. (R11)
X9. 1869. Braemar (Scotland?) (R12)
X10. April 1, 1880. Guildown, United Kingdom. (R13)
X11. August 4, 1882. Bloomington, Indiana. (R14)
X12. September 11, 1891. Ryde, Isle of Wight. (R15) Woolford Station, United Kingdom, (R16) Norway, latitude 62° north. (R17)
X13. November 8, 1897. Key West, Florida. (R18)
X14. March 29, 1902. Alta, Iowa. (R19)
X15. July 15, 1893. Alta, Iowa. (R19)
X16. May 3, 1899. Alta, Iowa. (R19)
X17. January 20, 1900. Alta, Iowa. (R19)
X18. October 16, 1903. London, England. A wriggling stream of light. (R20) This may have been rocket lightning (GLL1). (WRC)
X19. March 29, 1905. Cardiff, Wales. (R21)
X20. August 18, 1905. South Birmingham, England. (R22)
X21. October 16, 1916. Cardiff, Wales. Beam shifted north for 10 minutes and then returned to its initial position. (R23)
X22. April 28, 1916. Pittsburgh, Pennsylvania. (R24)
X23. April 27, 1937. Delaware, Ohio. Length 150°, almost a complete auroral arch (GLA2). Streaks of light ran perpendicular to the ray. The observer noted the similarity between the scintillations and flickerings of this auroral beam and those seen in the tails of some comets. (ACO) (R25)

X24. August 21, 1903. Seen from many locations from Maine to Iowa. (R25) See GLA2-X2.

X25. September 9, 1898. Hazelmere, England. Shaft of light rises in southwest to near zenith. It appeared and disappeared at intervals of a few seconds. (R28)

X26. March 5, 1764. Oxford, England. A bright tapering column of light seen to the south, wider at its base, 30^{o} high. After a few minutes several rays darted out horizontally to the west, giving it a ladder-like appearance. (R29)

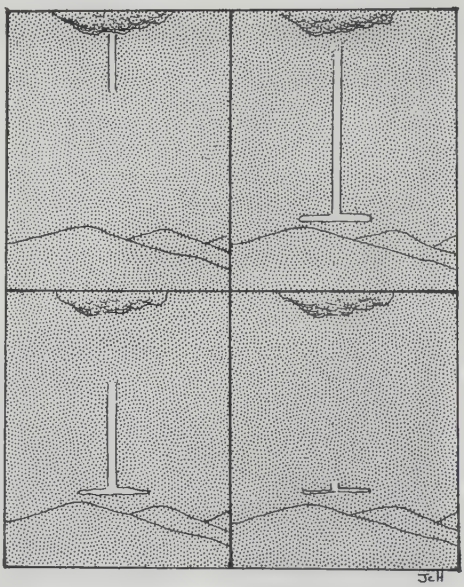
X27. March 15, 1923. Poughkeepsie, New York. A bright purple streak appeared in the northeastern sky after 9:00 PM. "Shaped like a lead pencil with its point up, the streak glowed and faded at intervals." (R30)

X28. December 15, 1932. Langdon, Alberta, Canada. "It emerged from the horizon in a narrow column and spread out fan-wise as it arose. Its direction was from a little south of east to the northwest. As it advanced up and across the sky it thinned out perceptibly and broke into small floating clouds, moving as the Northern Lights often shift. Toward the horizon it remained a rather heavy mist-like light tinged just the slightest with pink, but in its upper areas it thinned to the lightest filmy mist. The entire duration until it had entirely died away was only about fifteen minutes. (R31)

X29. July 12, 1991. Alton Barnes, England. A so-called "luminous-tube" phenomenon was observed by a team that was watching for crop-circle formation.

"Suddenly, at 2.55 a.m., birds began singing which heightened our alertness and made us check wrist watches. It was soon quiet again, but at 3.00 a.m., almost exactly, I spotted a tube of light to the northeast descending vertically beneath a cloud in that part of the sky. Most of the remainder of the sky was clear and starry. The tube extended steadily in length as we watched, and its milky-white colour seemed to be due to a self-luminosity like one might expect from the electrical effect known as plasma. As it came down against the black sky and neared the ground, the tube began to broaden, and branched out to give two opposed arms, as indicated in the drawing, forming a design in the air with rounded ends. Then the tube dissipated from the top downwards, and disappeared into the horizontal arms which themselves proceeded towards the ground out of sight beyond the hill peaks. No noise was heard. The whole phenomenon lasted about six seconds." (R32)

This phenomenon may not be auroral in origin, but its general appearance places it here.



Sketch of the "luminous tube" phenomenon observed in 1991 at Alton Barnes. (X29)

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GLA2 Sky-Spanning Auroral Arches

Description. A narrow, bright arch of light stretching from the eastern to the western horizon passing near zenith. The color of the arch is almost always white or greenish white, although reddish examples are known. The arch may be as narrow as 1° or as wide as 15°. Rapidly moving wavelets or masses of light seem to rush along the beam. Almost always perpendicular to the magnetic meridian, the arch often drifts slowly north or south. Duration: typically 30 minutes or so; rarely, several hours.

Background. Very broad arches of various hues are rather common in the far north. The temperate zone arch is rare, much narrower, and seems a different phenomenon---at least scientist-observers usually separate it from normal polar arches.

Data Evaluation. Dozens of fine observations in the scientific literature. Rating: 1.

Anomaly Evaluation. No specific explanations have been found so far. The low latitudes and narrowness may imply an origin different from polar arches. The drifting, splitting, persistence, and internal motion make the auroral arch a fascinating phenomenon for detailed study, although it presents no special challenge to auroral theory. Rating: 3.

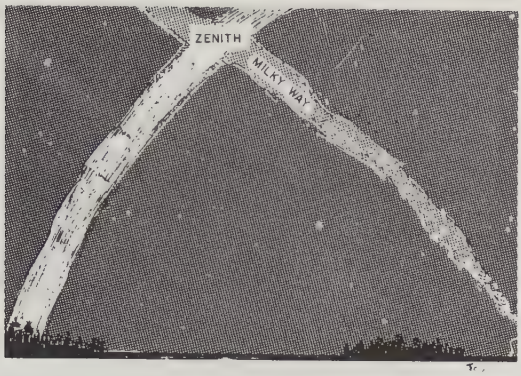
Possible Explanation. Ring current of charged particles.

Similar and Related Phenomena. Auroral arches are difficult to confuse with the zodiacal light because the latter phenomenon does not usually span the heavens. (Note: some tropical observations of the zodiacal light have it visible well beyond zenith. AZO) Lunar rainbows are always associated with the moon. Glowing meteor trails may span the sky but usually break up quickly and would only coincidently be perpendicular to the magnetic meridian. The banded sky phenomenon (GLA23) consists of several filmy, widely separated bands, with no preferred orientation. Finally, curious bands and arches of light are associated with the setting and rising sun; viz., the crepuscular and anticrepuscular rays (GES); but they are always seen emanating from the direction of the sun or the antisolar point.

Examples of Auroral Arches

X1. August 2, 1937. Perkins Observatory, Ohio. "At 1:25 a brilliant white bow was observed projected like the beam of a powerful searchlight across the zenith from west by north to east by south. It extended almost from horizon to horizon. At this instant the western half of the bow was very bright. Gradually this portion split into two fainter bows, while the eastern half increased in intensity until its light predominated. A slow, swirling movement was detected in the portion of the bow overhead as it drifted lazily southward. Fully fifteen minutes passed before the bow disappeared." (R1)

X2. August 21, 1903. Cranberry Lake, 75 miles east of Watertown, New York. "At about half past nine, however, I was suddenly summoned out of doors to witness a spectacle such as I had never looked upon before nor had ever heard or read of. The heavens were spanned by two great bows of light, crossing each other near the zenith by a wide angle. The one was the familiar Milky Way or Galaxy, then in its glory, no Moon being present. The other was a remarkable archway of light, comparable with the Galaxy in width, but much brighter, and seemingly, stretching from horizon to horizon, though in one direction its light, like that of the stars, faded near the horizon, and in the other it was obscured by a small cloudbank. I estimated the width of the arch to be three degrees or that of six full moons placed side by side. This bow stretched from a little north of west, to a little south of east... The arch remained in place for a long time, possibly half an hour or more. It changed very little in appearance or brilliancy. In places it had a fluted, wavy aspect, being completely broken only here and there, and then only by a very narrow interval. The waves appeared as if blowing in the direction of the arch, toward the northwest, like curtains waving in a breeze, or a little like steam being blown along." (R2) Also seen at Cape Porpoise, Maine. (R3)



An auroral arch with a wavy structure as seen from Cranberry Lake in the Adirondacks in 1903. (X2)

X3. January 12, 1890. Texas. "The luminous mist was first observed by the engineer, when it was still several hundred yards ahead of the train, and thinking it a prairie fire, he slowed up, thus arousing the passengers, who, with the crew, crowded to the windows and on to the platforms to look at the vast, hueless rainbow spanning the neavens. As the arch was more closely approached its dim, white radiance was seen to be clearly defined against the sky as though painted there by the sweep of a brush dipped in white fire. The stars could be seen shining close against the rim of it, and all around and under the arch... When the train passed directly under the bridge of light, the surrounding country spanned by it became plainly visible, appearing to be bathed in pale moonlight." (R4) It is more likely that the motion of the arch itself rather than that of the train produced the sensation of passing under the "bridge of light.

X4. March 11, 1929. North Pacific. "From behind Fracto Nimbus cloud stretching from horizon to a height of 11^{O} and bearing S. 75^{O} E. True, a shaft of light appeared, making an angle of 45^{O} with the horizon and following a straight line 45' wide for a distance of 60^{O}; in the sky the light broke off into two curved sections passing through the zenith and finished 3^{O} above the horizon bearing N. 75^{O} W. True. The straight portion of the phenomenon had the appearance of a gigantic searchlight. The whole streak of light was motionless over its arc of 166^{O} and commenced fading away at 10.20 p.m. and finally disappeared entirely ten minutes later." Total duration 30 minutes. (R5) See GLA2-X32 for simultaneous phenomenon in Oregon.

X5. July 16, 1892. Knox College Observatory, Galesburg, Illinois. A peculiar auroral display was seen. "This was a streamer of nearly white light, that, starting in a sharp point almost on the horizon, in the north-west, shot with great velocity north of Arcturus, passed over Corona Borealis, which constellation it equalled in diameter, crossed Hercules and Cerberus, and, passing over Altair, descended almost to Mars in the south-east, terminating also in a fine point. This majestic sword moved bodily 10^{O} to the south, and, after shivering and pulsating throughout its length three times, vanished, after existing fourteen minutes." (R6) Mount Pleasant, Iowa. (R7) Dundas, Canada. (R8) See also GLA15-X1 for a simultaneous phenomenon in Indiana.

X6. June 1, 1961. Indian Ocean. "At 1800 GMT the upper of the two arcs illustrated appeared in the sky; 10 min. later, the lower narrower arc became visible. The upper one was very bright, while the lower was of slightly less intensity; both arcs attained maximum brilliance at 1820 and disappeared at 1832. They extended from 090^{O}, through s, to 240^{O}." Since there was little magnetic activity at the time, an auroral origin for these arcs was considered unlikely. No other explanations were offerred. (R9)

X7. November 10, 1813. Sunderland, England. (R10)

X8. September 29, 1828. Chelmsford, England. Shortened to an auroral pillar. (R11)

X9. March 21, 1833. Athboy, Ireland. Stream-like motion observed in the beam. Also seen in England. (R12)

X10. November 3, 1834. Near Manchester, England. Beam $4\text{-}5^{O}$ wide. (R13)

X11. May 29, 1840. New Haven, Connecticut. Initially 85° above the southern horizon. Drifted south at about 1° per minute. (R14)

X12. April 29, 1859. New Haven, Connecticut. Lasted 46 minutes. Western leg drifted southward. (R15)

X13. April 9, 1863. Newburyport, Connecticut. (R16)

X14. April 15, 1869. Toronto, Ontario. Torrent of luminous material appeared to move "with prodigious velocity." (R17)

X15. 1869. Near Glasgow, Scotland. (R18)

X16. October 24 and 25, 1871. Many observations of this remarkable phenomenon from the northeastern United States. The beam was 15° wide, about three times normal. It was observed in the same position for two nights in a row. Composed of blood-red masses, with waves that moved at about 112° per second. The color and width of this arch suggest that it may have been a normal polar arch located abnormally far to the south. (R19)

X17. February 4, 1872. New Haven, Connecticut. Three parallel arches that persisted over four hours. Northward band was white; rosy red band in between near zenith; white streak south of zenith. (R20)

X18. Fall 1872. Autun, Scotland. (R21)

X19. May 20, 1888. Buffalo, New York. Top located a few degrees south of zenith. Bow became "bent." (R22, R23)

X20. September 9-10, 1891. Lyons, New York. (R24) Nashua, New Hampshire. (R25) Dunecht, Scotland. Beam was only 1° wide. (R26)

X21. September 11, 1891. Cape Breton, Nova Scotia. (R27)

X22. July 15, 1894. Toronto and Bala, Ontario. 166 miles high. (R28)

X23. August 1903. Lincoln, Illinois. Wavy motion progressed east to west. (R29)

X24. July 3, 1907. Bath, Maine. Bow drifted south. (R30)

X25. 1910. Sheffield, England. (R31)

X26. March 18, 1915. Garden Plain, Alberta. Arch lasted 1 hour. (R32)

X27. April 27, 1916. Chippewa Falls, Wisconsin and Northfield, Minnesota. (R33)

X28. May 2, 1919. West Reading, Pennsylvania. Double arch separated by a dark rift. One arch faded away, then the remaining arch split. (R34)

X29. September 18, 1919. Fargo, North Dakota. 15° south of east to 15° north of west. Like a "powerful searchlight." (R35)

X30. May 13, 1921. Wellington, England. A perfect arch, 2-3° wide, passing through zenith. Incomplete arches on either side. (R36) This tendency to split may infer some unrecognized property of the terrestrial magnetic field.

X31. April 14, 1926. Missoula, Montana. Formed and disappeared three times. (R37)

X32. March 11, 1929. Portland, Oregon. (R38) See GLA2-X4.

X33. August 21, 1930. Littleton, New Hampshire. (R39) Greensboro, Vermont. (R40)

X34. March 22, 1841. England. Isolated auroral arch stretching WSW to ENE. (R41)

X35. November 19, 1841. England. Same as X34. (R41)

X36. March 29, 1843. England. Same as X34. (R41)

X37. August 29, 1845. England. Same as X34. (R41)

X38. February 6, 1847. England. Same as X34. (R41)

X39. 1890s. Durham, England. Uniform broad band WSW to ENE. It was motionless and looked like a searchlight. After half an hour it broke up into auroral streamers. (R42)

X40. March 27, 1781. England. Here is the earliest record we have found of an almost-complete auroral arc.

"At about half past 9, March 27, 1781, a white light began to be seen in the sky, which became gradually more and more dense till 10 o'clock, at which time it formed a complete luminous arch from east to west. At that time it appeared to be an arch of about 7 or 8 degrees in breadth, extended nearly from east to west. Its western part quite reached the horizon; but the eastern part of the arch seemed to begin at about 50° or 60° above the horizon. It did not pass through the zenith, but at about 8° or 10° southward of it, and it was nearly perpendicular to the horizon...This extraordinary appearance seemed quite distinct from the aurora borealis, for the following reasons; viz., because it eclipsed the stars over which it passed; because its light, or rather its white

appearance, was stationary and not lambent; and because its direction was from east to west." (R43)

X41. June 17, 1936. Victoria, British Columbia, Canada. The observer of the phenomenon now described termed it "very peculiar." It was that, but it was also an excellent example of the sky-spanning auroral arc.

"At 22.2 the ribbon-like arc was about 4° wide, slightly narrower perhaps directly south, and extending quite uniformly across the sky from about 10° above the horizon in the ESE to near the horizon on the WNW. Colour reddish. Intensity of glow about uniform throughout its length. No movement. At first glance it was similar to a narrow searchlight beam, but the edges were not quite straight. The sky was clear of cloud and stars of mag. 4 were easily seen." (R44)

X42. April 30, 1937. Richmond Hill, Ontario, Canada. An auroral arc seen from the Dunlap Observatory was not stationary like most arcs, but moved south slowly like those cataloged in X1, X11, and X12.

"The second unusual display was seen on the night of Apr. 30. It was first noted at 9.03 p.m. E.S.T. as an isolated luminous band about 20° long and 5° wide just to the south of Corona. This rapidly lengthened in an east-west direction till by 9.30 p.m. it extended in a bright band not quite 3° wide and over 140° long from [delta] Ophiuchi to [epsilon] Geminorum. From 9.05 to 9.40 this display moved south in a direction perpendicular to its length at a speed of very nearly one degree per minute. The only other indication of auroral activity at the time was a few faint but sharp rays near the north horizon. At 9.40 p.m. a series of small dark striations appeared across the eastern half of the bright band and these kept moving along it to the west. Shortly after this the band began to lose it definite form, became fainter, and faded from the eastern end, being last seen as a faint oval patch of luminosity in Cancer at 9.55 p.m. The band, throughout its development, to be of a pure white colour." (R45)

X43. August 28, 1916. Canada. The following sharp and precisely drawn auroral arc is substantially different from the swaying draperies, pulsing arcs, and "merry dancers" that characterize most displays of the Northern Lights.

"The usual Northern Lights were feeble, but at half past ten there grew in the sky an immense arc or ribbon of light---practically a complete semicircle---stretching from a point on the horizon practically due east nearly up to the zenith, but a little to the south of it, and passing down practically to the western point of the horizon. Throngs of people gathered to see it and according to their account the like was never seen before. It was a fairly uniform band of light of about the same width as the rainbow. Its definiteness was surprising, there was very little fading away at the edges; it was as if a paint brush had been drawn across the sky...For about an hour it arched the sky and during that time it was noticeably fixed relative to the earth, for some of the stars as they got higher in the east crossed it from the northern or convex side to the other." (R46)

X44. 1908, 1916, 1926. Okanagan, British Columbia, Canada. An occasional phenomenon that has been observed on still, clear, moonless nights. The so-called Okanagan Arc is a band of light extending from horizon to horizon in the NNW to SSE direction. (R47) Most sky-spanning auroral arcs cross the sky west to east. The Okanagan Arc breaks this rule. It may not be an auroral phenomenon at all.

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GLA3 Auroral Meteors: Moving Luminous Patches

Description. Large, well-defined patches of light that proceed steadily and rather deliberately across the sky. Generally elongate, several degrees wide and several times as long, the patches are white to greenish white, rarely reddish. Some auroral meteors, like true meteors, cross the sky in a few seconds, while others, particularly luminous bands and ripples, drift slowly like clouds.

Background. The absence of clear-cut form and structure, as in the auroral pillars and arches, opens the door to many natural agents capable of creating luminosity; viz., auroras, air glow mechanisms, meteors, electrical storms, etc. The wide range of patch velocities emphasizes the possibility of different causes.

Data Evaluation. Considerable high quality testimony supports the existence of fast-moving auroral meteors. Slow-moving bright patches, ripples, and other shapes have been photographed in modern times in both visible and infrared light. The subject of "nebulous meteors," however, is still controversial. It will be touched upon here and treated more fully later (AYO). Rating: 1.

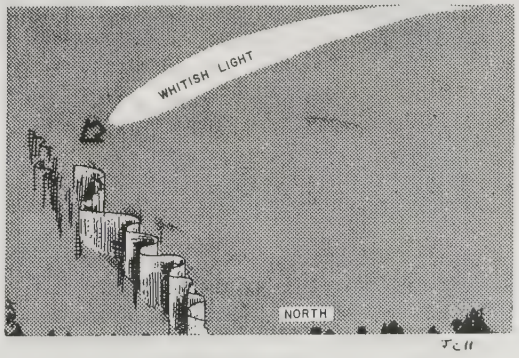
Anomaly Evaluation. There are several reasonable, unmysterious mechanisms for producing luminous patches. The scientific task remaining seems primarily that of working out specific details. Rating: 3.

Possible Explanations. Rapidly moving patches, such as the reknowned "auroral meteor" of November 17, 1882, likely have auroral origins---perhaps some sort of burst of charged particles. The ascending luminosities associated with electrical storms may be electrical discharges of some sort. (GLA9) Slowly moving bright regions, bands and ripples in particular, are probably air-glow events initiated by gravity waves or other atmospheric disturbances.

Similar Phenomena. Normal auroras generate a great variety of rapidly moving beams, arches, rays, draperies, etc., but these cold flames and flickerings are qualitatively different from the isolated, more deliberate auroral meteors. Glowing meteor trails drifting in the upper atmospheric winds may emulate auroral meteors.

Examples of Auroral Meteors

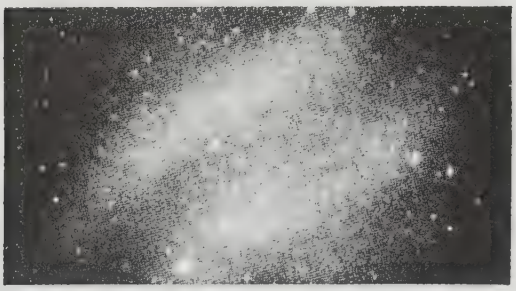
X1. November 17, 1882. Much of Europe. "About 6 P. M., while the aurora was fitfully blazing in the north, north-east, and north-western sky, in the east there rose from the horizon a long beam of detached bright light, which, apparently lengthening as it advanced, crossed rapidly the southern horizon in front of or near the moon, and then sank in the west, shortening in length as it did so. The light emitted from it was described by one observer as of a glowing pearly white; and the general effect of this huge shining mass sailing majestically across the sky, even upon those accustomed to kindred phenomena, was at least one of wonder and surprise, while in the less experienced in such matters it created a feeling of absolute awe." (R1-R11, R20)



The remarkable auroral "meteor" of 1882 sailed "majestically" across the sky. (X1)

X2. July 15, 1893. Adrian, Michigan. "The peculiar feature of this aurora was the movement of a series or succession of whitish flecks across the sky from east to west, resembling somewhat the waves of a body of water... The white flecks or streaks were about 10^{o} in length, strictly parallel north and south, and quite uniform in distance apart. They grew brighter and more distinct as they approached and passed the meridian. Their motion was very regular and quite rapid, ---comparable to the swiftest apparent motion of light clouds." (R12) Note the strong resemblence to the wavelets observed in some auroral arches (GLA2).

X3. April 4, 1978. Haleakala, Hawaii. Two spectacular naked-eye events were observed from the University of Hawaii's zodiacal light observatory. These ripples travelled at about 91 meters per second, with crest-to-crest wavelengths of 16 kilometers. Altitude: about 90 kilometers. (R13)



Two bright ripples in the night sky as seen from Hawaii in 1978. (X3)

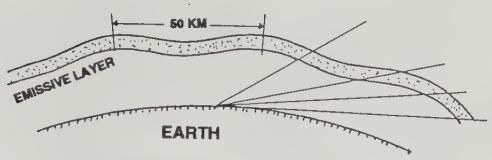
X4. December 30, 1737. Chiloe Island, Chile. A fiery cloud from the north traversed the archipelago. (R14)
X5. September 1828. Lynn Regis, England. White, smoke-like mass. (R15)
X6. July 16, 1850. Manchester, England. Luminous ball-shaped masses moved through the sky. Associated with an electrical storm. (R16)
X7. June 25, 1875. Norfolk, England. Aurora-like blue streaks darted from the earth to the sky. (R17)
X8. January 4, 1891. St. Charles, Missouri. Elliptical, stationary. (R18)
X9. May 1894. Dublin, Ireland. Elongated mass of white light shot west to east and then turned north. Phenomenon repeated three times. Followed by a mass of concentric rings. (R19)
X10. August 21, 1894. England. (R20)
X11. July 24, 1900. England. Dull nebulous meteors. (R20) See AYO for more on the so-called "nebulous meteors."
X12. August 18, 1905. England. Comet-like beam, 1^{o} x 80^{o}, moved south by east. (R21)
X13. May 15, 1909. Blue Hill Observatory, Massachusetts. Comet-like glowing mass moved across sky. In view about two hours. (R22)
X14. July 19, 1916. Huntington, West Virginia. Pulsating, dirigible-like mass, $1/2^{o}$ x 2^{o}. (R23)
X15. October 16, 1916. Glamorgan, Great Britain. Moving, angry-red, cigar-shaped mass. (R24, R25)
X16. March 24, 1920. Limerick, Ireland. Pulsating, bluish-white, elongated patch. Changed shape, split. Highly variable. (R26)
X17. June 27, 1927. Location unknown. (R27)

X18. General observation. When the night sky is photographed in the infrared portion of the spectrum, luminous wave-like structures often appear in the upper atmosphere. The wave crests are about 50 kilometers apart; length-wise, they may stretch up to 1.000 kilometers; altitude, about 85 kilometers. As many as ten waves may be seen at the same time. Morphologically, these waves resemble noctilucent clouds, which are sun-illumined, high-altitude clouds. The infrared waves, however, appear when the sun is well below the horizon. Since these waves are seen only at low angles over the horizon, some geophysicists propose they are the result of a geometric effect produced by viewing a rippled layer of weakly emitting gases in the upper atmosphere.

When one looks at this rippled layer just above the horizon, one sees alternating thick and thin sections due to the perspective. The thick portions will appear brighter than the thin sections. As for the origin of this postulated rippled layer; no one is sure. Gravity

waves may be involved. (R28)

Luminous atmospheric waves are, on rare occasions, visible to the naked eye. It is possible that the banded-sky phenomenon is related to the infra-red waves.



A rippled emissive layer is believed to surround the earth. The varying optical path at low angles above the observer's horizon could create the appearance of luminous ripples in the night sky. (X18)

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GLA4 Low-Level Auroras

Description. Bright streamers, beams, curtains, and other auroral manifestations that seem to descend below the generally accepted lower limit of about 80 kilometers for auroral displays.

Background. Much controversy surrounds the alleged appearance of auroral phenomena below about 80 kilometers. Skeptics cite at least three objections: (1) The physical conditions conducive to the formation of auroras (pressure, etc.) do not exist at very low levels in the atmosphere; (2) Several long series of optical and photographic studies of auroras provide no evidence of low-level auroras; (3) The data supporting the reality of low-level auroras are mostly anecdotal and probably contaminated by illusions (viz., reflections from snow and fog) and nonauroral luminous phenomena (viz., lunar halos).

Data Evaluation. Many experienced observers have been certain they have seen auroras appearing between themselves and nearby terrestrial objects. A few observations with optical instruments have put auroras as low as 1-4 miles above the surface. Coupled with such data are numerous instances of other phenomena suggestive of low-level auroras, such as luminous fogs (GLA21), sounds (GSH), and even odor (GLA5). All in all, the evidence for low-level auroras seems quite good, although it is likely contaminated with some misinterpretations and illusions. Rating: 2.

Anomaly Evaluation. Low-level auroras, if real, directly challenge our concepts of auroral formation, which make auroras wholly a high-altitude phenomenon. If auroras do approach the earth's surface, these concepts must be wrong in some way or, possibly, aurora-like phenomena exist at low altitudes with a different mode of origin. Rating: 2.

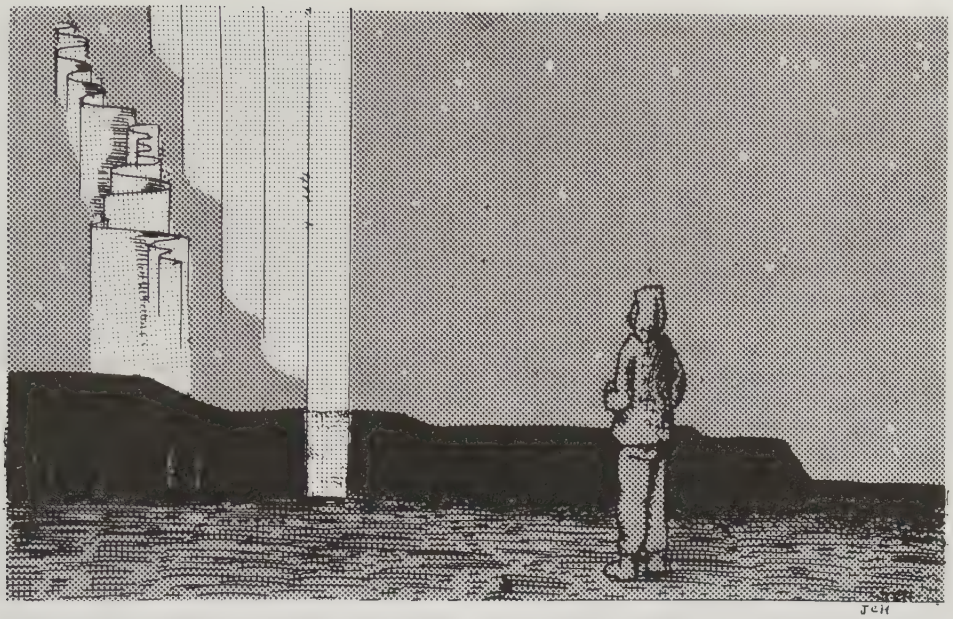
Possible Explanation. Low-level auroras may represent the slow, large-scale discharge of terrestrial electricity to space, perhaps induced by or coincident with normal, high-altitude auroral activity.

Similar and Related Phenomena. Similar phenomena: auroral fogs (GLA21); artificial auroras (GLA6); mountain-top glows (GLD). Related phenomena: auroral sounds (GSH); the possible association of auroras with thunderstorms (GLA9), earthquakes (GLA10), lunar halos (GLA19), surface electrical effects (GLA20).

Examples of Low Auroras

X1. Winter 1901. Eagle, Alaska. On the Yukon River, near a 1200 foot bluff. "One cold night, with the temperature about 45 degrees below zero, (F.), I witnessed a singular aurora---an array of dancing streamers, having prismatic colors---which aurora was in line between me and the bluff. The streamers were about one-quarter of the way down below the summit of the bluff, and no part thereof reached to that summit. There was a swishing sound at times as they moved." (R1)

X2. February 19, 1852. Olean, New York. A low cloud of auroral vapor came from the east. "When it came against us, apparently not over thirty rods from us, it was about half the length of several pine trees which stood in the field, from the ground. There were several of these trees, some were on this side of it, and others were just beyond it, which we could distinctly see, and upon which we remarked at the time. There were no streamers proceeding from it, but a curtain of auroral light slowly passing across the valley, at the distance above stated from the earth.... It must have been ten minutes from the time we first noticed it, before it seemed to strike the hill on the west side of the valley. From the base of this sheet, or curtain of light, the most beautiful, brilliant appearance was seen. Masses of auroral light, like off-shoots from a sky-rocket, would fall towards earth, scattering itself in the air, the largest particles of which would not disappear till they



An aurora "seemed" to descend in front of 1200-foot-high bluff in Alaska. Was this real or illusory? (X1)

were within a few feet, say eight or ten, of the earth. It was the most splendid sight I ever beheld." (R2)

X3. September 2, 1906. On the Yukon River. "I was on the south bank of the Yukon river, which at this point is about half a mile wide. The north shore is high wooded hills. The streamers came between me and the north shore and came right to the water's edge. Of this there was not the slightest doubt, as the trees could be seen through the openings in the auroral streamers." (R3)

X4. October 1925. Fort Smith, Northwest Territory. "Q. M. S. Griswold, engineer at this radio station, states that at about eleven p. m. one night.... he personally saw a curtain of the aurora approach to within four feet of the surface of the earth. The weather at the time was calm, clear and frosty, but not very cold, and the display was particularly brilliant and coloured, though lasting for only about an hour between eleven and twelve. The curtain, which approached the ground, was pale green, and a two-story building could be seen beyond and through the curtain of light. No sensation could be felt on walking right into the curtain, which disappeared from the view of anyone approaching closely; however; other people about a hundred yards from the curtain could see the observer enter and pass through the curtain." (R3)

X5. November 16, 1929. Abisko, Sweden. "I observed a rather intensive auroral ray of about 10^{o} apparent length and about $1/2^{o}$ apparent breadth in the west-south-west below a completely cloudy sky." This ray subsequently disappeared and reappeared several times. (R4-R6)

X6. Early 19th. Century. Scotland. Two-station triangulation on aurora indicated it was 4,000 feet above the earth. (R7)

X7. February 13, 1821. The Arctic. The aurora appeared below a dense layer of cloud. (R8)

X8. February 24, 1842. England. Aurora seen below the clouds. (R9)

X9. 1868. Sweden. Aurora seen below a mountain peak. (R7)
X10. Winter 1878-9. Norway. (R10)
X11. December 8, 1881. Point Barrow, Alaska. Aurora seen below the clouds. (R11)
X12. 1887. Godthaab, Greenland. Simultaneous observations from two stations put the altitude at 2,000 feet. (R7)
X13. 1892. Godthaad (sic), Greenland. Theodolites 4 miles apart produced altitudes between 1 and 4 miles. (R12)
X14. May 23, May 31, June 21, no year given but observations were made in the Antarctic on the First Scott Expedition, 1902-1904. Three observations of auroral streamers descending below Mt. Erebus. (R13)
X15. May 21, June 22, July 19, 1911. Antarctica. Three observations of auroras between observers and Mt. Erebus. Some observers considered these to be illusions, mock moon halos. (R14)
X16. October 31, 1903. Calgary, Alberta. Tips of auroral shafts touched the ground, and objects could be seen through them. (R15)
X17. Winter 1917-8. No location given. Kaleidoscope of colors seen between the hand and body. (R16)
X18. August 8, 1924. Valparaiso, Saskatchewan. Auroral beams seen among trees. (R3)
X19. August 10, 1928. Fort Smith, Canada. Aurora seen against a river bank less than a mile away. (R17)
X20. Winter 1929. Norwood, Ontario. Aurora extended to ground level. Radio receiver went dead. (R18) See GLA20-X2.
X21. March 8, 1932. Tromso, Norway. Photographic measurements of aurora at 65 kilometers. (R19)
X22. September 18, 1941. Cambridge, Massachusetts. Aurora only 20-30 feet overhead moving in waves. Seemed to consist of snow-like particles moving in a severe wind. (R20)
X23. No date. Canada. Engineer sees men walk into aurora. (R21) (Same as X4?)
X24. April 22, 1915. Viking, Alberta. Numerous bright, milky streamers observed against the clouds. (R22)

X25. 1878-1879. Bergen, Norway. A study of low-level-aurora altitudes observed from 139 stations yielded heights as low as 0.24, 0.25, and 0.15 miles. (R23) These figures are consistent with some of the anecdotal evidence compiled in this section but obviously at odds with the usually cited minimum altitude for auroras of 80 kilometers.

X26. No date given. The Arctic. "A similar but more extraordinary phenomenon, which occurred during his third Arctic voyage, is thus related by Capt. Parry. 'While Lieutenants Sherer, Ross, and myself were admiring the extreme beauty of the northern lights, we all simultaneously uttered an exclamation of surprise at seeing a bright ray of the aurora shoot suddenly downward from the general mass of light, and between us and the land, which was there distant only three thousand yards. I have no doubt, that the ray of light actually passed within that distance of us.'" (R24)

X27. Circa 1901-1902. Harstad, Norway. A low-level aurora enveloped the steamship Erling Jarl. Brilliant, colorful, and in rapid motion, it barely cleared the steamship's masts. A peculiar sound was also heard during the display. (R25)

X28. No date given. Lake Scavig, Scotland. Rays of auroral light have been seen to issue from a rock. (R26) This is not as ridiculous as it appears. See GLD for Mountain-Top Glows and other low-level discharge phenomena.

X29. June 10, 1982. Near Sturgis, Michigan. "3:00 A.M., two young women were driving in a semi-rural area. Fog made visibility poor. It began to rain---a brown jelly-like slime that smeared the windshield. A rotten-egg odor pervaded the area. The car engine stopped, and the two began to walk to find assistance. After 50 yards, they encountered millions of small rays of 'lightning' flashing everywhere. They were 2-3 feet long and reached high into the sky. Looking back toward the car, they saw a reddish fluorescent glow with streams of light coming down from the sky to the glowing region. Grass and weeds along the roadside were standing straight up and glowing. Deep-red lines of light were seen danc-

ing on the road. They returned to the car, and it felt hot to the touch! Soon, clouds moved in and the display was over." (R27)

Also pertinent here is the fact that a large solar flare had just occurred, and intense auroral displays had been predicted. Also, the two women were apparently the only witnesses of this phenomenon. See GLD3 and GLD4 for similar electric-discharge phenomena.

X30. Doubts concerning low-level auroras. G.C. Simpson questioned the existence of low-level auroras on three counts: (1) The chief spectrographic line of normal auroras is due to metastable atomic oxygen, but this state occurs only at very low pressures. Near the earth's surface, the atmospheric pressure is much too high. (2) Low-level auroras look exactly like normal auroras that occur perhaps 100 or more kilometers from the observer. From the standpoint of perspective, it is unlikely that a low-level aurora, less than a kilometer or so away, would seem identical. (3) Analysis of reports of low-level auroras suggests that they are optical illusions. (R28) Further negative comments by Simpson in X42.

X31. December 2, 1850. Canadian Rocky Mountains. An aurora appeared between the observer and trees across a river, which could not have been 40 feet above the level of the stream. (R29)

X32. 1821. The Arctic. The following example may be related to X7.

"Perhaps it will be interesting to you to hear that the height of the aurora borealis was measured by two of the officers of the expedition [Franklin Expedition, 1821] while at Cumberland House. They took its altitude at the distance of fifty miles asunder at stated periods with wooden plummet quadrants, and, by the rules of trigonometry, found it to be between six and seven miles high, from three different observations." (R31)

X33. No date or place given. The aurora seemed to reach the tops of nearby trees. All seemed enveloped in a wintry fog. (R32)

X34. A review of low-level-aurora observations appeared in a 1920 number of the Journal of the Royal Astronomical Society of Canada. In general, one must say that anecdotal data differ markedly from those obtained using scientific instruments. Here follow three anecdotes from experienced Arctic explorers and researchers. "Trevelyan, from observations in the Shetland and Faroe Islands, concluded that the aurora often descends to 50 feet above sealevel. Parry, the Arctic explorer, reported seeing an auroral ray projected between his ship and the shore. Similarly, Lemstrom, during the Swedish expedition to Spitzbergen in 1868, several times saw auroral lights projected between himself and the nearby mountains, and once found himself in the midst of an aurora." Contrasting with such anecdotal evidence, simultaneous photographs from geographically separated stations usually put auroras at or above the 80-kilometer level. (R33) It may be, of course, that the anecdotes relate only to exceptional auroras, while scientific attention has been directed at normal manifestations of the phenomena. See X42.

X35. Winter 1899. Yukon Territory, Canada. The dynamics and complexity of some low-level auroras are fascinating, as proven in the quotation below. Of course, distances and heights are difficult to estimate accurately with these rather ethereal phenomena.

"The display consisted primarily of a band of light seemingly two miles broad by ten miles long, lying horizontal with the earth at a height above me of perhaps 3000, perhaps 5000 feet. I hesitate to put down these figures as defining this band of light because of the constant motion of the band itself and of the other features I will mention, but there was a restriction to the extent of the band itself about as I have given it.

"Ascending from this band of light were the commonly seen plumes of light of the Aurora. Also there were pendent plumes. Also there were billowy masses of light, (that's a funny expression, but

I cannot find another more fitting), prismatically tinted, that contributed the twisting feature as they shot toward, into and through the band of light. These twistings travelled toward me from north to south, and were accompanied by the swishing sounds spoken of by others.

"These pendent streamers and the coloured convolutions travel very swiftly and come quite well down to the earth; so close that they prompt one to dodge." (R34)

X36. No date given. English River, Canada. The sometimes frightening appearance of low-level auroras is seen again in this anecdote. "He was travelling in a canoe in the English River, and had landed near the Kettle Falls, when the coruscations of the Aurora Borealis were so vivid and low that the Canadians fell on their faces, and began praying and crying, fearing they should be killed; he himself threw away his gun and knife that they might not attract the flashes, for they were within two feet of the earth, flitting along with incredible swiftness and moving parallel to its surface. They continued for upwards of five minutes, as near as he could judge, and made a loud rustling noise, like the waving of a flag in a strong breeze. (R35)

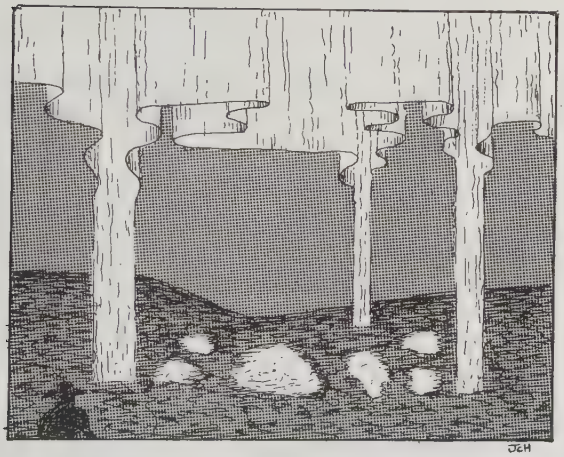
X37. August 1916. Winnipeg, Manitoba, Canada. That low-level auroras may be somehow associated with the electric discharge phenomena of GLD is suggested in this anecdote. "Concentrating my attention upon [the aurora] I was surprised to see tenuous, slanting streamers of light playing upward and downward. They would descend, with a movement that was not particularly swift, touch the earth and retract, much more quickly, some 50 or 60 feet, and then repeat the performance. The lower ends were irregular, not unlike inverted flames, and they played about the surface of the ground much more like a bundle of separate streamers than one of great volume. When I followed the inclination of the rays upward I found that they registered perfectly with the grand design overhead." (R36)

X38. August 26, 1932. Calgary, Alberta, Canada. The ethereal, fog-like nature of low-level auroras was experienced by H. Boyd Brydon. "At midnight I went into the house to get something to eat, after which I came out to continue the observation, when I found myself right in the midst of the Northern Lights---absolutely walking through the whole boiling. I became interested. I have seen them hundreds of times quite close but never before have I been absolutely in the midst of the phenomenon...The walls of the atmosphere were rainbow-fashion, extending from northeast to northwest. It was of a 'nebula' colour running up into the sky. There was not a breath of wind stirring and yet this atmosphere was fluctuating into thick and thin masses hither and thither all along the line. I tried to solve this proposition. I walked 390 feet from the foot of my property to the top of the hill, but, like the elusive pimpernel, it evaded me. In the middle of it and yet not in it. I went along the avenue and walked about a mile or so criss-cross over the prairie in all directions, but it was always in the same place. It followed me when I retired and receded as I advanced." (R37) Again, one is reminded of ground-level electric-discharge effects (GLD) and even those marine phosphorescent displays that appear to be located in the atmosphere immediately above the water (GLW).

X39. Summer 1938. Smiley, Saskatchewan, Canada. Altitude 2300 feet. A warm, calm summer night, and a spectacular, low-level aurora, with apparent ground contact, as reported by H.E. Stumbles.

"On leaving the house at about one a.m., I was surprised to see that the aurora was surrounding me in all directions, as far as I could see, (nearly half a mile). Some streamers extending from the curtains reached to the ground, and others nearly so. Several, a dozen or more, were in contact with the ground within a radius of a hundred yards from me. Overhead the sky appeared to be full of clouds of luminous material, with a frequent ascending and descending movement. Whilst watching this general effect, I saw a streamer drop from the curtain and make contact with the ground less than 50 yards from where I stood, dropping at a speed comparable with that of falling water, and the angle from me to where

it left the curtain was about 25 degrees. There was no distribution of material short of this point of contact with the ground, but to the leeward of the streamer, patches of luminous material formed and drifted in the air, and faded out in the course of a few seconds; this continued for a distance of about 25 yards, and then a patch of luminosity formed close to the ground, and rose with a swift upshooting movement and joined the curtain above, forming a streamer similar to the one that descended. The patches then ceased to form, and both these streamers appeared as being in a state of wavering suspension like unto the other streamers, as shown in the accompanying sketch." (R38, R40)



An apparent low-level auroral display in Saskatchewan. Auroral streamers seemed to descend from the curtain all the way to the ground. In addition, white luminous patches drifted along the surface. (X39)

It certainly seems as though Stumbles was immersed in a weak discharge of electricity occurring between the earth and the high ionosphere where the auroral curtains shone.

The pillar-like streamers in the sketch remind one of the searchlight-like beams of light seen radiating skyward from Andean peaks during electrical storms; i.e., the famous "Andes Lights." (GLD1)

X40. No date given. Finland. The reality of low-level auroras is supported by the observation of a spectral line characteristic of the aurora emitted by the air between the spectroscope and a black cloth a few yards away. (R41)

X41. No date given. Port Bowen, Canada. During the Parry Expedition, an auroral streamer darted down between the ship and land 3,000 feet distant. This is probably the same as X26. (R42)

X42. Review of observations of low-level auroras. 1933. Despite what appears to be massive support for the existence of rare auroras extending down to the earth's surface, mainstream science has never been convinced. After a review of the data, G.C. Simpson, wrote: "It would, however serve no useful purpose to go further into the individual cases, for it is quite impossible to carry conviction by giving explanations which cannot be proved or disproved. I can only hope that I have succeeded in showing that the evidence for low auroras is extremely weak and that when one weighs that evidence against the positive information we have about the nature and position of the aurora, one is justified in denying that auroras have ever been observed below a height of 80 km." (R39) Simpson was casting away the considerable evidence of rare events because it did not agree with the well-confirmed and scientifically acceptable observations of normal auroras. Further comments by Simpson can be read in X30. The same attitude of mainstream science prevails in connection with many phenomena presented in this volume.

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R38. Stumbles, H. Edward; "An Account of Auroral Phenomena Observed in Western Canada," Royal Astronomical Society of Canada, Journal, 32:451, 1938. (X39)
R39. Simpson, G.C.; "Low Auroras," Royal Meteorological Society, Quarterly Journal, 59:185, 1933. (X42)
R40. Anonymous; "The Northern Lights," Royal Meteorological Society, Quarterly Journal, 64:344, 1938. (X19, X39)
R41. Arrhenius, Svante; "Aurorae and Magnetic Storms," Scientific American Supplement, 65:31, 1908. (X40)
R42. Olmstead, Denison; "Recent Secular Period of the Aurora Borealis," Smithsonian Institution Contributions to Knowledge, vol. 8, no. 3, 1856. (X41)

GLA5 The Odor of the Aurora

Description. The odors of ozone, sulfur, and/or "electricity" detected in conjunction with low-level and high active auroras.

Background. The odors accompanying geophysical phenomena are rarely considered seriously, perhaps because instruments and theories are lacking. Nevertheless, a few students of unusual auroral attributes (Beals, Silverman) have recorded some of the sparse though persistent accounts of auroral odors.

Data Evaluation. Reports of auroral odors generally come from the older literature and without much in the way of helpful details. Unquestionably, the data are weak, but they constitute just the kind of supplementary information needed by those who believe that terrestrial electricity may sometimes be discharged during auroral displays. Rating: 2.

Anomaly Evaluation. Since the odors of sulfur and ozone are characteristic of electrical discharges, verification that they occur during auroras, especially low-level auroras, would add support to the hypothesis of large-area (brush) discharges of electricity during some auroras. The current view of the aurora makes it a high-altitude (over 80 kilometer) phenomenon with little room for accompanying terrestrial electrical activity. Rating: 2.

Possible Explanation. Low-level, active auroras may sometimes be associated with large-area discharges of terrestrial electricity.

Similar and Related Phenomena. Similar phenomena: the odors detected during lightning and brush discharge phenomena, such as ball lightning and corona discharge. Related phenomena: odor detected in mountain-top glows (GLD1).

Examples of Auroral Odors

X1. No date. Great Britain. "Mr. Trevelyan observed, that the Aurora borealis in Faroe and Shetland was often seen very low, not more than 40 or 50 feet above the level of the sea; and he learned that it both countries it is frequently heard. In Faroe Mr. T. met one person who stated, that when the colour of the Aurora borealis is dark red, and extends from west to east with a violent motion, he had experienced a smell similar to that which is perceived when an electric machine is in action. (R1, R3)

X2. September 18, 1941. Radburn, New Jersey. "The odor of ozone was reported by several persons in the vicinity of Radburn, N.J., during the great auroral display of Sept. 18.....The sensation was strongest when the auroral display was at its height, entering the zenith with coronal light and spreading toward the horizon in sheets. Odors have been reported occasionally from earlier displays." (R2)

X3. 1870. Norway. "In 1870, Rollier, the balloonist, descended on a mountain in Norway 1300 meters high, saw auroral rays across a thin mist, and heard a muttering. When the sound ceased he perceived a very strong smell of sulfur." (R3, R4)

X4. October 19, 1726. London, England. (R3)

X5. No date. Sweden. Aurora accompanied by the smell of smoke or burnt salt. (R5)

X6. No date. Canada. (R6)

References

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R2. "Ozone Odor Detected during Auroral Display," Science News Letter, 40:295, 1941. (X2)

R3. Silverman, S.M., and Tuan, T.F.; "Auroral Audibility," Advances in Geophysics, 16:193, 1973. (X1, X3, X4)

R4. Rufus, W. Carl; "The Beauty and Mystery of the Northern Lights," Sky and

Telescope, 5:3, September 1946. (X3)
R5. "On the Noises That Sometimes Accompany the Aurora Borealis," Edinburgh New Philosophical Journal, 1:156-1826. (X5)
R6. Beals, C.S.; "Low Auroras and Terrestrial Discharges," Nature, 132:245, 1933. (X6)

GLA6 Artificial Low-Level Auroras

Description. Terrestrial pillars or streamers of aurora-like light stimulated by the presence of man-made terrestrial electrodes, acting in conjunction with active natural displays of auroras.

Background. The 1881-1882 experiments of Selim Lemstrom in Lapland are the only attempts found so far at inducing artificial low-level auroras. There have been, however, a number of artificial auroras created at normal auroral heights by the high-altitude detonation of nuclear explosives, the release of chemicals (barium), and electron accelerators.

Data Evaluation. Lemstrom's experiments were widely reported but apparently never replicated. Rating: 2.

Anomaly Evaluation. Artificial low-level auroras basically have the same significance as natural low-level auroras (GLA5); that is, they suggest the possibility that very active auroras may be accompanied by large-area terrestrial discharges. Brush discharge and St. Elmo's Fire are related types of discharge and, like corona discharges, do not constitute anomalies. It is the appearance of aurora-like luminous phenomena in concert with normal auroral activity that signifies an unknown dimension to auroral processes. Rating: 2.

Possible Explanation. Large-scale discharges of terrestrial electricity to space.

Similar and Related Phenomena. "Pseudo-auroras" occasionally rise over powerful artificial lights, but these are not self-luminous and are instead akin to sun pillars.

Example of an Artificial Aurora

X1. 1881-1882. Several mountain tops in Lapland. Selim Lemstrom mounted arrays of wires studded with sharp points atop insulated posts. His most successful experiment was on Mount Pietarintunturi, about 40 miles west of Sodankyla. "Here experiments were possible on only two days, but on the first of them, December 29th, 1882, an auroral streamer 400 feet long was formed, which observations from several azimuths proved to be exactly over the apparatus." (R1-R3)

References

R1. Lemstrom, Prof.; "An Artificial Aurora," Symons's Monthly Meteorological Magazine, 18:51, 1883. (X1)

R2. "Artificial Aurorae," Symons's Monthly Meteorological Magazine, 18:33, 1883. (X1)
R3. Science, 4:465, 1884. (X1)

1881-1882. Lemstrom induced an artificial aurora on a hilltop in Lapland. (X1) Note the similarity to the illustration of the Andes glow (GLD1-X8).

GLA7 Geographically Displaced Auroras

Description. Auroras seen exclusively to the south in the North Temperate Zone and vice versa in the South Temperate Zone, with little or no activity in the direction that auroras usually appear.

Background. Auroras concentrate in annular regions centered on the earth's magnetic poles. With exceptionally active auroras, this region may expand toward the Equator, thus pushing luminous phenomena in the same direction.

Data Evaluation. Southward auroras are very rare in the latitudes of the United States. Only a few cases have been discovered in the literature. Rating: 1.

Anomaly Evaluation. Our understanding of the aurora is not challenged by geographically displaced auroras; they are really extreme instances of auroral activity rather then anything fundamentally different. Rating: 3.

Possible Explanation. Exceptionally powerful magnetic storms push the visible auroras Equator-ward.

Similar and Related Phenomena. Auroral pillars (GLA1) and arches (GLA2) frequently drift south of zenith---usually with significant "normal" auroral activity remaining in the polar direction.

Examples of Geographically Displaced Auroras

X1. March 30, 1894. Lyons, New York. "The aurora of Friday evening, March 30, was first seen at Lyons, N.Y., at 7.40 P.M. It then consisted of flickering, irregular patches which filled the entire heavens from the zenith down to the southern horizon, there being nothing whatever to be seen in the usual location of auroras toward the north... From the reports thus far received, it appears that at the hour above indicated, the aurora was seen toward the south exclusively at stations directly north

of Lyons, while southward in Pennsylvania the entire sky was more or less covered with flickering patches and masses of light, and still further south the aurora was seen toward the north exclusively, at Charleston, S.C., rising about 25° above the northern horizon." (R1)

X2. May 29, 1932. Ottawa, Ontario. "The remarkable thing about it was that the northern part of the sky seemed entirely clear while the rest of the sky was in great turmoil." (R2)

X3. May 15, 1909. Blue Hills Observatory, Massachusetts. Entirely to the south. (R3)

X4. September 18, 1941. Mount Washington, New Hampshire. Aurora to the south; accompanied by mountain-top glows. (R4)

X5. No date given. Grand Lake, Maine. "An aurora was observed by the writer some years ago, on September 11, at Grand Lake, Maine, which completely arched the southern sky with bright streamers. That display began about 8 o'clock p.m. and lasted several hours. At first, no auroral phenomenon appeared north of the zenith, but as the evening advanced a faint glow was seen in the north. Particular note was made at the time that the streamers in the southern as well as the northern sky appeared to meet a considerable number of degrees to the southeast of the zenith, but the exact location was not observed." (R5)

X6. July 12, 1917. Canada. An auroral display began in the southwest. "There were no upright streamers such as those with which everyone is familiar, but instead of them there were faint horizontal bands of light changing their forms and places with the same rate of speed as that of ordinary upright streamers. Associated with these, there was a feeble rose tint in the same parts of the sky." (R6)

X7. September 18, 1941. Montreal, Quebec, Canada. An aurora in the south. (R7)

X8. July 26, 1946. Ste.-Therese de Blainville, Quebec, Canada. An aurora in the south. (R8)

References.

R1. Veeder, M.A.; "The Aurora of March 30, 1894," American Meteorological Journal, 11:77, 1894. (X1)

R2. McFarlane, G.; "The Aurora of May 29, 1932," Popular Astronomy, 40:590, 1932. (X2)

R3. Palmer, Andrew H.; "A Remarkable Aurora Borealis," Science, 30:57, 1909. (X3)

R4. Botley, Cicely M., and Howell, W.E.; "Mystery on Mount Adams," Mount Washington Observatory News Bulletin, 8:9, 1967. (X4)

R5. Anonymous; "The Great Aurora of August 26, 1916," Royal Astronomical Society of Canada, Journal, 11:16, 1917. (X5)

R6. Hunter, A.F.; "An Auroral Display Beginning in the South," Royal Astronomical Society of Canada, Journal, 11:258, 1917. (X6)

R7. Guimont, Jos. Edgar; "Aurore Boréale Venant du Sud," Royal Astronomical Society of Canada, Journal, 36:409, 1942. (X7)

R8. Guimont, J. Edgar; "Aurore Boréale du 26 Juillet 1946, Venant du Sud," Royal Astronomical Society of Canada, Journal, 41:175, 1947. (X8)

GLA8 Auroras with Unusual Geometries

Description. Auroras with geometries that are difficult-to-explain in terms of present-day theories about the origin of auroras

Background. Aurora geometries are usually characterized as arches, rays, draperies, etc. Beyond these common shapes, which are not necessarily well-understood, are many curious and unusual configurations. Most are unique; some are bizarre; all seem to challenge students of auroras.

Data Evaluation. The observations reported here are mostly one-of-a-kind; that is, without confirming testimony. Rating: 3.

Anomaly Evaluation. A superficial judgment would be that all of the phenomena cited below might force aurora theorists to do some rethinking. Rating: 3.

Possible Explanations. None.

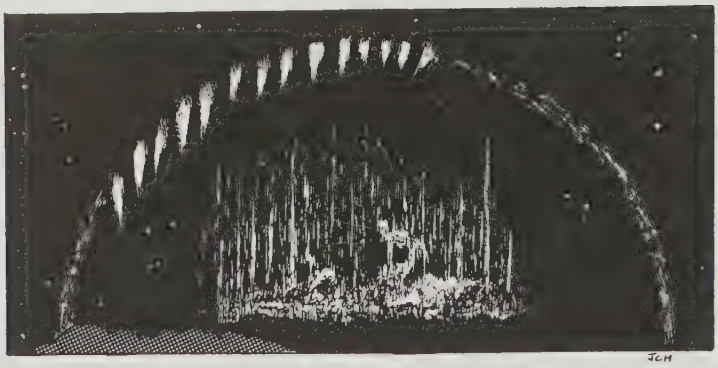
Similar and Related Phenomena. Speaking in generalities, most complex natural phenomena are characterized by rare "wild points" and observations that do not fit the mold. Ball lightning (GLB), halos (GEH), and marine light wheels (GLW), for example, offer just as many unique and unexpected varieties.

Examples of Auroras with Unusual Shapes

X1. November 16, 1871. Finland. "Fig. 3 gives an idea of the variety of forms that the phenomenon may effect. It represents an aurora that was observed at the presbytery of Enare on the 16th of November, 1871. The aurora this time took on the form of a glowing red band, curved as shown in the figure. The two extremities bordered on yellow and green." (R1)

This unlikely auroral "loop" could be an illusion of perspective. (X1)

X2. August 21, 1903. York Harbor, Maine. "Beginning a little east of the zenith and continuing almost to the western horizon, there appeared what might easily be likened to a string of tremendous comets. These pennants of light, however---unlike comets ---were more brilliant at their apices. Their bases were directed upwards, their points down. They were constantly changing, appearing and disappearing, but not very rapidly. Some would remain a minute or more without much variation. The number varied from ten to fifteen. They were shorter toward the zenith, longer toward the horizon. At the western end of the arch, one long half-luminous streak shot upward obliquely (as shown in the figure) and remained for some minutes after the arch itself had disappeared. The arch lasted from 9.30 to nearly 10 P. M. In size the comet-like pendants appeared about as wide at their bases as the diameter of a full moon, and four or five times such a diameter in length." (R2)



Pennants of light seem suspended from this auroral arch observed from the Maine coast. (X2)

X3. September 12, 1881. Off Newfoundland. "A peculiar and interesting auroral phenomenon witnessed from the steamship Atlantic off the Newfoundland coast on September 12 last year, has been described by Mr. Engler to the St. Louis Academy. While an aurora of normal type was clearly seen in the northern sky, there appeared in the southeast, about 30 to 35 deg. above the horizon two horizontal streaks of light, about 5 deg. apart, and 15 or 20 deg. in length. Their pale hazy light resembled moonlight. From the upper streak were suspended, by small cords of light, a number of balls, brighter than either of the streaks, which were continually jumping up and down in vertical lines much like pith-balls when charged with electricity." (R3)

X4. Circa 1930. Colorado. "Shortly after midnight, away to the south, there arose from the crest of a long high mountain, the trend of which was east and west, a curtain of fire several miles long and from the ground straight upwards to a very great height. It seemed to be made up of threads of fire rising rapidly upward, and at the extreme top of this curtain of fire all of these threads turned abruptly at right angles and flowed rapidly westward. Immediately the conclusion was that this curtain had reached the top of the air and that its rapid movement westward was a visual demonstration that the earth had a tail like a comet, and further that the outer so-called void was not a void at all but contained sufficient of a gaseous filling to cause this drag on our outer air as a result of the great speed of the earth on its way around the sun" (R4) This phenomenon might have been a mountain-top glow (GLD1) or a low-level aurora.

X5. 1849. Cincinnati, Ohio. On the western horizon a streak of light shot up to 45° and burst, spreading across the heavens. (R5)

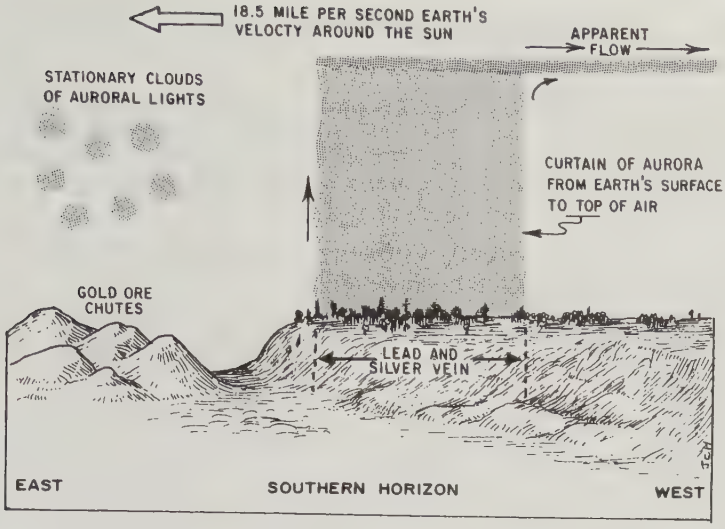
X6. June 26, 1873. North America. Observers in several places saw bars of light moving rapidly from south to north. (R6)

X7. June 25, 1875. Norfolk, England. Very narrow blue streaks darted up from the ESE horizon. (R7)

X8. August 12, 1892. Dewsbury, England. Waves of phosphorescent light, like billows of smoke, swept through zenith and were lost in the south. (R8)

X9. September 25, 1926. North Atlantic. A ball of bluish light, altitude 5°, bearing 345°, emitted a fan of rays across the sky. The rays were bright and illuminated the cloud layers. Four minutes later, the rays disappeared and an auroral arch was observed. (R9)

X10. General feature of auroras. Satellite photos have revealed a sawtooth structure to the aurora. The teeth have amplitudes of about 250 miles and probably cannot be distinguished on the ground. (R10)



Circa 1930. A fiery auroral curtain seems to rise above a Colorado mountain. (X4)

References

R1. "The Northern Lights," Scientific American, 56:135, 1887. (X1)
R2. King, A. F. A.; "An Unusual Aurora Borealis," Popular Science Monthly, 63:563, 1903. (X2)
R3. Nature, 26:160, 1882. (X3)
R4. Finn, Oliver B.; "A Very Unusual Auroral Display," Popular Astronomy, 41:287, 1933. (X4)
R5. "Singular Phenomena," Scientific American, 4:193, 1849. (X5)
R6. "The Auroral Phenomenon of June 26," Scientific American, 29:49, 1873. (X6)
R7. Gape, Charles; "A Singular Phenomenon," English Mechanic, 21:488, 1875. (X7)
R8. Blakeley, E. Reginald; "Peculiar Auroral Phenomenon," English Mechanic, 56:15, 1892. (X8)
R9. Quirk, W. E.; Marine Observer, 27: 147, 1957. (X9)
R10. Sehlstedt, Albert, Jr.; "Study of Satellite Pictures Reveals Saw-Tooth Pattern in Aurora Borealis," Baltimore Sun, May 31, 1981, p. B2. (X10)

GLA9 Auroras Correlated with Thunderstorms

Description. Auroral activity associated with thunderstorms in any of three ways: (1) The direct visual observation of auroral displays over active thunderstorms; (2) The temporal and geographic coincidence of auroras and thunderstorms; and (3) Statistical observations that thunderstorms are frequent when auroras are rare and vice versa---a reciprocal relationship.

Background. Prevailing theory has auroral phenomena originating in the thin reaches of the outer atmosphere and magnetosphere beyond heights of 50 miles. Thunderstorms, on the other hand, are denizens of the lower atmosphere. Furthermore, the energies involved in kindling auroras are many times less than those involved in active thunderstorms. (R11) The issue here is whether such disparate phenomena can exert coupling forces on one another.

Data Evaluation. (1) Only one account has been found of apparent direct association between an active thunderstorm and auroral phenomena; (2) A few not-too-convincing circumstantial accounts of coincident auroras and thunderstorms exist; and (3) A very few observers of the two phenomena have suggested, with no published backup data, that a reciprocal relation prevails between aurora and thunderstorm frequencies. In other words, the relationship between auroras and thunderstorms is rather tenuous. Rating: 2.

Anomaly Evaluation. As discussed under "background" any verified connection between auroras and thunderstorms cannot be accounted for by prevailing models. Rating: 2.

Possible Explanation. It is possible that the distance separating thunderstorms and auroral phenomena might somehow be short-circuited. In fact, the recent correlations of penetrating solar radiation and thunderstorms (GWT) is suggestive of such action.

Similar and Related Phenomena. Low-level auroras (GLA4), auroral mists and fogs (GLA21), and other GLA phenomena imply some sort of short-circuiting of the atmosphere.

Examples of Auroras Correlated with Thunderstorms

X1. February 4, 1893. Queensland, Australia. Observer was watching a distant thunderstorm. "I was sitting on the lawn watching the distant flashes, when suddenly a patch or cloud of rosy light---5° to 6° in diameter---rose up from above the thunderstorm and mounted upwards, disappearing at an elevation of from 40°-45°. There were about twenty to twenty-five of these patches in the course of half an hour, sometimes three or four in quick succession; they took from one to two seconds to mount, and were not associated with any particular flash; the rosy colour contrasted strangely with the silvery light of Nubecula Major just above. There were also occasional streamers, sometimes bifurcated, of 2° in breadth, which shot up in the same way as the auroral streamers, which I have seen both in the arctic and antarctic zones." (R1)

X2. July 26, 1895. Charleston, South Carolina and Greendale, Kentucky. Two suggestive instances of aurora-thunderstorm correlation. "These widely separated stations certainly experienced two independent auroral displays. Both stations were near areas of thunderstorm development. No other stations near by record having seen an aurora." (R2)

X3. A general observation. "During September just past sun-spots were very numerous and large. Nevertheless, auroras during the month were without exception comparatively inconspicuous. In this case certainly large sun-spots have not been attended by bright auroras, as some have held to be the rule. The explanation of this

anomaly, which appears to be justified by systematic records in my possession, is that thunderstorms took the place of auroras. It has been found that not unfrequently thunder-storms become widely prevalent upon dates upon which auroras should fall in accordance with their periodicity corresponding to the time of a synodic revolution of the sun. When this happens, it robs them of their brightness, wholly or in part. The relation between these two classes of phenomena appears to be reciprocal or substitutive, the one taking the place of the other under conditions which are only just beginning to be understood, and which are in the process of investigation." (R3)

X4. August 23, 1821. Inverness-shire, Great Britain. Thunderstorm accompanied by sheet lightning and luminous aurora-like masses in the sky. (R4)

X5. July 5, 1883. Lewiston, Maine. Heavy thunderstorm and an auroral glow in the sky. (R5)

X6. April 17, 1888. Orebro, Sweden. A horizontal flash of lightning followed by an aurora. (R6)

X7. June 12, 1915. Athelstan, Quebec. A spectacular aurora followed by a violent thunderstorm. (R7)

X8. June 27, 1952. South Indian Ocean. An aurora was followed by intense lightning, with some of the flashes arcing through zenith. More auroral activity came on the heels of the thunderstorm. (R8)

X9. A general observation. Reciprocal relationship between auroras and thunder storms. (R9)

X10. A general observation. Auroras and thunderstorms wax and wane together. (R10) A contradiction of X9.

X11. 1875. An old statistical analysis. "In years when the temperature is high and the sun's surface relatively free from spots, thunderstorms are abundant. Since, moreover, the maxima of the sunspots coincide with the greatest intensity of auroral displays, it follows that both groups of phenomena, thunderstorms and auroras, to a certain extent supplement each other so that years of frequent storms correspond to those auroras, and vice versa. He (von Bezold) observes that such a connection between sunspots and storms does not by any means sanction the supposition of a direct electrical interaction between the earth and sun, but may be simply a consequence of a degree of insolation dependent upon the sunspots. (R12, R13) Of course, in 1875, the electrically charged solar wind was unknown.

X12. 1887. Another old statistical study. "...it has been found in general that whenever groups of faculae, with or without dark spots, are appearing by rotation or are bursting forth upon the eastward side of the sun, there is an immediate increase in thunderstorms in the lower latitudes, and probably of auroras in the higher latitudes. If, however, the aurora becomes visible nearer the equator at such times, there is an immediate, though perhaps temporary, decrease in thunderstorms, as though the aurora had taken their place. In short, the aurora and thunderstorms appear to have a common origin, and in certain localities at least, a reciprocal relation to each other. Instances have been noted also in which aurora in the United States have been coincident with unusual electrical storms in Europe, and vice versa. (R14) In other words, both auroras and thunderstorms are mechanisms by which electrical charge is transferred between the earth and ionosphere. When one phenomenon in active, the other is suppressed, assuming a fixed flow of charge. In X11, the implication is that an increase in solar activity requires a higher rate of charge transfer, and that both auroras and thunderstorms may become more frequent so as to increase the flow of electricity between the earth and the ionosphere. Thus, correlation of the two phenomena (X11) and also their anticorrelation (X12) are neither anomalous nor contradictory.

References

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R2. "An Aurora in South Carolina and Kentucky," Monthly Weather Review, 23: 297, 1895. (X2)

R3. Veeder, M.A.; "Auroras Versus Thunderstorms," Science, 20:221, 1892. (X3)

R4. B., D.; "Remarkable Aurora Seen at Belleville, Inverness-Shire, in a Thunderstorm," Edinburgh Philosophical Journal, 6:175, 1821. (X4)
R5. Chadbourn, E.H.; "Thunderstorms and Aurorae," Nature, 28:388, 1883. (X5)
R6. Nature, 38:16, 1888. (X6)
R7. C., W.T.B.; "The Aurora and Lightning," English Mechanic, 101:514, 1915. (X7)
R8. Riley, F.N.; "Aurora and Remarkable Lightning," Marine Observer, 23:81, 1953. (X8)
R9. "Lightning's Connection with Aurora and Sun-Spots If Time Be Allowed," Sidereal Messenger, 8:395, 1889. (X9)
R10. Birt, W.R.; "The Aurora and Electricity," English Mechanic, 16:505, 1873. (X10)
R11. Southwood, D.J.; "Thunderstorms and Substorms: Any Connection?" Nature, 284:599, 1980.
R12. von Bezold, W.; "On the Periodicity of Thunder-Storms," American Journal of Science, 3:9:408, 1875. (X11)
R13. Anonymous; "Periodicity of Thunderstorms," Popular Science Monthly, 7:629, 1875. (X11)
R14. Veeder, M.A.; "Coincidence of Sun Spots with Thunderstorms and Auroras," Monthly Weather Review, 15: 206, 1887. (X12)

GLA10 Auroras Correlated with Earthquakes

Description. Auroral activity associated with earthquakes in two ways: (1) The direct observation of auroral phenomena around the epicenter; and (2) The statistical association of auroral and earthquake activities.

Background. The history of earthquake lights, some of which are auroral in character, is a long one and is buttressed by a considerable literature. For convenience aurora-like earthquake lights are included with other luminous quake phenomena (GLD8). In the matter of the statistical association of auroras and earthquakes, scientists do have reason to expect a correlation. Solar activity can apparently trigger both auroras and earthquakes (GQS), thus linking the two phenomena by a common cause.

Data Evaluation. Despite the expectation that aurora frequency might be correlated with earthquake frequency, practically no serious work has been done in this area. (R1) Rating: 3.

Anomaly Evaluation. A statistical correlation of the two phenomena would not be anomalous, but aurora-like earthquake lights would be. See GLD8. Rating: 2.

Possible Explanations. (1) Earthquake lights may be caused by piezoelectricity, gas releases etc. See GLD8. (2) Auroras and earthquakes may be linked by a common cause---solar activity---as indicated above.

Similar and Related Phenomena. The possible association of thunderstorms with auroral activity (GLD9), both of which may be caused by space radiation.

Examples of Auroras Correlated with Earthquakes

X1. October 19-20, 1848. New Zealand. In Section 10 of his massive 1850 compilation of earthquake phenomena, Mallet wrote as follows:

"The Aurora. This phenomenon, now so well ascertained to be in direct sympathy with terrestrial magnetism, has often been observed before and after earthquakes. I have found no instance in which it was remarked during an earthquake-shock, but it might then easily escape observation.

"On the 19th and 20th of October 1848, during the New Zealand earthquake, the aurora was very bright in the south-east (the direction nearly toward which the shock travelled); but there was nothing to show any connexion, in this or any other case, with the forces concerned directly in the shock." (R2)

X2. 396. Istambul, Turkey. During this earthquake, the heavens seemed to be on fire, (R3)

X3. January 28, 1551. Lisbon, Portugal. A great earthquake preceded by a remarkable aurora. (R3)

X4. December 27, 1560. Zurich, Switzerland. The earthquake was followed by an aurora of great brilliancy. (R3)

Generally speaking, Mallet's great catalogs suggest that auroras and earthquakes are physically decoupled.

References

R1. Veeder, M. A.; "Aurora," Nature, 35: 54, 1886.

R2. Mallet, Robert; "First Report on the Facts of Earthquake Phenomena," Reports of the British Association, p. 74, 1850. (X1)

R3. Mallet, Robert; "On the Facts of Earthquake Phenomena," Reports of the British Association, pp., 7, 57, 59, 1852. (X2-X4)

GLA11 Auroras Correlated with Meteors

Description. The apparent stimulation or enhancement of auroral activity by the passage of meteors. Meteors may intensify or extend auroral displays if their ionized trails pass near an active aurora. Aurora-like streamers may also develop along the path of a meteor. More rarely, meteors seem to burst forth from auroral clouds and arches already formed.

Background. The coincidence of meteor and auroral displays has been recognized for nearly two centuries, but little detailed work has been done to date.

Data Evaluation. The observations of meteoric enhancement of auroras is fairly good; but the alleged origin of meteors in already formed auroral structures seems mainly circumstantial. Rating: 2.

Anomaly Evaluation. Meteors and auroras occupy the same region of the atmosphere and magnetosphere. In addition, ionized meteor trails constitute a reasonable physical mechanism for stimulating auroral activity. For these reasons, the meteoric enhancement of auroral activity is primarily a curiosity. If, however, meteors really do originate in auroral structures, a different explanation is required. Rating: 3.

Possible Explanation. The eruption of meteors from already existing auroral structures could be due either to: (1) The mere coincidence of an auroral structure with a meteor radiant; or (2) The actual creation of the auroral structure by incoming meteoric material from a radiant point, followed by additional meteors from the same radiant point.

Similar and Related Phenomena. Nebulous meteors (AYO) leave diffuse luminous streaks that may resemble auroral phenomena. Very large meteors, such as the 1908 Tunguska Meteor, produce a wide variety of luminous effects, some of which may be taken for auroras. At times, auroras and lunar halos seem to mutually enhance one another. (GLA19) A further connection between meteors and auroras is their apparent mutual capability of generating anomalous sounds (GSH) and electrical effects (GLA20) at the earth's surface.

Examples of Auroras Correlated with Meteor Activity

X1. February 22, 1909. Great Britain. A remarkable meteor left a bright streak that was seen from many locations. "Several observers noted flashes like very faint lightning during the early period of the projection of the streak. Others allude to the fact that it exhibited bright pulsations, as though the lingering embers were fanned into brilliancy by the breeze. A few of the most careful spectators state that they noticed scintillations of the beam similar to the temporary light-waves which affect the streamers of Aurorae." (R1)

X2. September 4, 1908. Worcestershire, England. A bright, aurora-like cloud appeared. "The bright cloud was in a constant state of fluctuation, flashing up and fading with almost the same rapidity as the well-known scintillation effect observed in bright stars. The colour was pale white, and as far as could be judged, the cloud was stationary over the magnetic meridian during the whole period of observation. At 8.45 a meteor from Perseus approached it, and on entering the cloud at its eastern extremity burst out with extraordinary splendor, far surpassing Venus in lustre, and exhibiting a string of many smaller nuclei on each side of the main nucleus. At 8.50 the cloud at this point had thrown out a streamer, which was traceable between Auriga and Perseus into Aries." (R2)

X3. February 19, 1852. Wyoming, New York. A spectacular aurora with an arch south of zenith. "On turning to the south again, they saw a number of meteors shoot off from the circumference of the corona, some west, some north, and in all direc-

tions. They appeared in succession, a minute or two apart. He is familiar with the flashes of light seen at times during the aurora, and said the meteors had no resemblence to it. They appeared as bodies or masses shot off from the corona, and had trains after them, though they were not very bright, the auroral light itself being too intense to permit them to appear as bright as in the dark. The number seen in fifteen or twenty minutes was ten or twelve." (R3)

X4. A general observation. "Hoffmeister has collected various instances of auroral-like glows connected with meteoric showers, Perseids, Leonids, 1872 Bielids. Such was also noted in Germany and England during the famous Leonid shower of November 13-14. It was indeed remarked it might be possible that 'brilliant meteor streams electrify the higher regions of the atmosphere and produce phenomena analogous to the aurora borealis.' The detection of H and the red line of NI is interesting in view of the observation by von Wrangel in Siberian waters 1820-1824 that dark areas of aurora traversed by meteors lighted up and continued to glow. (R4)

X5. November 13, 1833. Eastern North America. One of the greatest meteor showers in historical times. Auroras observed in many places, but totally absent elsewhere. (R5)

X6. November 17, 1848. France. (R6)

X7. February 20, 1849. Edinburgh, Scotland. Meteor-like objects in an auroral arch. (R7)

X8. 1852. Galveston, Texas. A pale blue light traversed a meteor trail from the terminus back to the starting point. (R8)

X9. March 30, 1922. Wick, England. (R9)

X10. A general observation. Great auroras tend to coincide with the larger meteor showers, especially the Leonids, during the Nineteenth Century. (R10)

X11. 1941. Near Ithaca, New York. Bright meteor followed by aurora. (R11)

X12. 1889 survey. "It is now many years since the idea was first thrown out that the aurora was in some way connected with shooting stars.

"M. Zenger has prepared a catalogue of aurorae observed from 1800 to 1877, in which he shows an apparent connection between the brightest displays and the appearance of large numbers of shooting stars.

"M. Denza noted the same connection on November 27, 1872, and remarked that he had noted it before.

"Admiral Wrangel, as quoted by Humboldt, observed that in the auroras so constantly seen on the Siberian coast, the passage of a meteor never failed to extend the luminosity to parts of the sky previously dark." (R12)

X13. June 30, 1908. Antarctica. "An exceptional aurora was seen about seven hours prior to the [Tunguska] explosion, and it is suggested that this may have been due to an anti-solar comet-like ion tail producing that auroral display whilst the impactor was still far from earth." (R13) Europe experienced extremely bright nights following the Tunguska event. (GLA15-X23) These, however, were not attributed to auroras but rather debris in the atmopshere.

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GLA12 The Close Relationship between Auroral Displays and Clouds

Description. The apparent physical association between some auroral displays and high-altitude clouds and haze, as in the following types of observations: (1) The seeming conversion of auroral displays into similarly configured clouds at daybreak and vice versa at nightfall; (2) The apparent origin of radiating auroral streamers in luminous clouds; (3) The formation of high hazes after auroral displays; (4) The increased incidence of halo phenomena during and after auroral displays (GLA19); and (5) The increased twinkling of stars during auroral displays.

Background. Several Nineteenth Century observers, particularly some arctic explorers, were quite certain that auroral displays turned into cloud formations during the day. Some insisted that the aurora was "material" in nature. (R1)

Data Evaluation. Almost all the relevant data are pre-1900. Furthermore, this phenomenon is not clear-cut due to the large number of similar phenomena. (See: Similar and Related Phenomena below.) Rating: 3

Anomaly Evaluation. Since conventional scientific wisdom locates auroral displays above 80 kilometers, any intimate connection between auroras and clouds, which are much lower, would be sharply anomalous. Rating: 2.

Possible Explanations. The precipitating particles that apparently initiate auroras may penetrate far enough into the denser atmosphere to act as nuclei for water vapor condensation, producing clouds with a superficial resemblence to higher altitude auroras. Both the auroras and clouds might be stimulated by meteoric debris. (GLA11)

Similar and Related Phenomena. Magnetically aligned cirrus clouds (GWC); banded skies (GLA23); steady night sky glows (GLA13); auroral meteors (GLA3); low-level auroras (GLA4); auroras and meteor activity GLA11); auroras interacting with lunar halos (GLA19); black auroras (GLA22); and just possibly the strange sky-spanning bands seen rarely at sunset and sunrise (GES).

Examples of Auroral Displays Associated with Clouds

X1. General observations. "The records of the great nineteenth century Arctic expeditions contain many accounts of 'clouds' becoming aurorae after dark, and aurorae becoming 'clouds' at dawn. Indeed A. Paulsen regarded the presence of such clouds as an indicator of daylight aurora; the opinion has also been expressed that the aurora is a material object: the clouds luminous by night and white by day are an aerosol, formed in the ionosphere. Indeed the formation was actually seen during the second Franklin expedition 1826-1827, with active aurorae, haziness developing around the coruscations.....As regards the classic observation of Usher (1788) a strong proof of its reality is the accompanying strong scintillation of the stars the association of which with aurora had recently been discovered by W. Herschel, and was confirmed in the following century by Montigny. It would be interesting to confirm the opinion of Forbes that at Edinburgh the stars never twinkle save during aurora." (R1)

X2. General observations. "Cirrostrati. These clouds resemble cirri in their tendency to an arrangement in long parallel bands; they differ, however, from them in not being composed of ice-crystals. They appear very frequently as concomitants of the aurora, so much so as to leave no doubt of a connecting influence between them and that phaenomenon.....Cirrostrati as well as cirri exhibit very decided luminosity at night. I have often observed the luminosity between the dark cirrostratus bands nearly equal to that of a faint aurora." (R2)

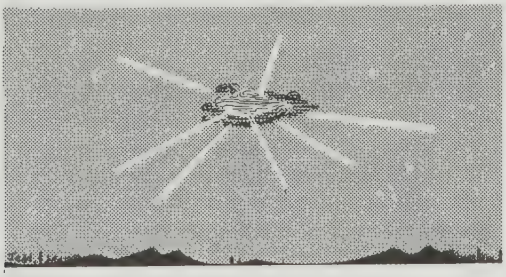
X3. January 28, 1841. England. "From the N.N.W. point, dark continuous cirrous (sic) bands extended across the sky to S.S.E. Between the bands throughout their whole extent a very decided luminosity prevailed, of a fine deep yellow tint, like that of the aurora. The luminous bands did not, however, show any tendency to converge to the coronal point, which the streamers of the aurora always do, but kept distantly separate to near the S.S.E. point. The light was strongest between the dark rays in N.N.W., but was very distinct throughout the whole extent of the bands. The absence of moonlight rendered the phaenomenon much more striking and unequivocal."(R2)

X4. March 14, 1841. England. "A splendid display of luminous cirri or cirrostrati? From the N.N.W. point proceeded dark lines or bands, which extended across the sky and appeared to converge to the S.S.E. point. These were apparently at a much inferior altitude than that of true cirri. They sometimes appeared to shoot suddenly over a large area of the sky. Between them a very distinct luminosity was apparent, which from the N.N.W. point, up to nearly 45^{o}, equalled in brightness that of an ordinary aurora....The light emitted by this phenomenon was very considerable, and exactly resembled the pale greenish light of phosphorescent substances." (R2)

X5. General observations. England. "The allusions to self-luminous night haze remind me of some phenomena which I witnessed on the Durham coast between the years 1895 and 1900. On several occasions I noticed that slight displays of aurora seemed to associate themselves with a certain form of cirrostratus cloud. On one night I watched from a back yard in Sunderland curved auroral streamers shooting up the Northern heavens in pairs, each pair enclosing a lens-shaped space of clear sky. But within a few seconds a cloud would form in the enclosed space and persist long after the enclosing streamers had faded. This occurred several times in the course of two hours. There could be no doubt about the association between the luminous bands and the cloud." (R3)

X6. January 25, 1881. Folkestone, England. "It is perhaps worth a note that my daughter saw at Folkestone a very unusual phenomenon on the evening of January 25, a little before 6.30. Some distance to the left of Orion (for the night was clear and starry) she observed a small cloud of a bright golden hue, from which streamers of great brilliancy darted in various directions, the

cloud alternately paling and brightening. She describes the streamers as like small meteors, leaving trails of light behind them." (R4)



Brilliant streamers darted from this bright golden cloud over England in 1881. (X6) This was designated an "auroral phenomenon" in Nature, but this seems debatable.

X7. September 9, 1827. Canonmills, Great Britain. "The morning of Sunday the 9th September was rainy, with a light gale from the north-east. Before midday the wind began to veer to the west, and the clouds in the north-western horizon cleared away: the blue sky in that quarter assumed the form of a segment of a very large circle, with a well defined line, the clouds above continuing dense, and covering the rest of the heavens. The centre of the azure arch gradually inclined more to the north, and reached an elevation of nearly 20°. In a short time very thin fleecy clouds began to rise from the horizon, within the blue arch; and, through these, very faint perpendicular streaks of a sort of milky light could be perceived shooting: the eye being thus guided, could likewise detect the same pale streaks passing over the intense azure arch; but they were extremely slight and evanescent. Between 9 and 10 in the evening of the same day, the aurora borealis was very brilliant: so that there is no reason to doubt that the azure arch in the morning, and the pale light seen shooting across it, were connect- with the same phenomenon." (R11)

X8. April 8, 1880. Great Britain. White, self-luminous haze covered the entire sky, brightening and fading. Radiating beams shot up from the northeast. (R5)

X9. February 19, 1882. Germany. Peculiar cloud on southwest horizon emitting bright, aurora-like beams. (R6)

X10. September 9, 1898. New Zealand. Luminous cloud near zenith shot forth streamers of light. (R7)

X11. May 30, 1901. Braidentown, Florida. Thin streamers of cloud pulsing with auroral light. (R8)

X12. April 22, 1915. Viking, Alberta, Canada. Numbers of bright, hazy, milk-like streamers darting from a source just below a cloud. (R9)

X13. February 2, 1978. Minnesota. Beams of light emanating from the center of a cirrus cloud. (R10)

X14. General observations. Siberia, by von Wrangel. "When the streamers extend to the zenith or nearly so, they sometimes resolve themselves into small luminous and cloud-like patches of milk white colour, which not infrequently continue to be visible on the following day in the shape of white, wave-like clouds." (R12)

X15. General observation. Several comments by European observers to the effect that the stars twinkle only or mainly during auroras, possibly indicating the presence of refracting matter. (R13)

X16. 1908. General observation. Arrhenius, the famous Swedish scientist and Nobel Prize winner, attempted to explain the cloud-aurora connection. "When the air contains much dust and is strongly ionized by cathode rays, conditions are favorable for the formation of clouds. For example, auroral discharges are regularly accompanied by characteristic cloud formations. Klein has traced this connection between the number of sunspots and the frequency of high cirrus clouds from 1850 to 1900, and has found simultaneous maxima and simultaneous minima for the two phenomena. (R14)

X17. General observation. F. Nansen, the famed Norwegian Arctic explorer, remarked that auroral streamers usually follow the direction of the wind. (R15) This meteorological observation bears

an indirect relationship to the claimed aurora-cloud connection.

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GLA13 Glowing Night Skies

Description. Strongly enhanced general illumination of all or most of the night sky, exclusive of starlight, auroral light, and the normal airglow due to the bombardment of the solar wind and micrometeoroids. These rare milky-white enhancements may be strong enough to permit the reading of newspapers outdoors at midnight. The Milky Way and Zodiacal Light are usually obliterated. The increased levels of brightness may last several hours or persist for several nights.

Background. Country dwellers have always been aware that some moonless nights are much brighter than others. The observations recorded here, however, are so striking that they found their way into many scientific journals, as in the case of the long series of remarkably bright nights in England from 1916 through 1919.

Data Evaluation. Many naked-eye observations by scientists and amateur astronomers plus a few photometric determinations. Rating: 1.

Anomaly Evaluation. Bursts of solar wind or micrometeoroids provide a reasonable physical explanation of night sky enhancements. Some bright nights are probably auroral in nature. The real challenge here is most likely in correlating the bright nights with some astronomical event. The English bright nights of 1916-1919 must have had some specific geo-astronomical cause. Rating: 3.

Possible Explanations. Sudden (but unexplained) increases in the solar wind and micrometeoroid flux probably suffice in most instances. The long 1916-1919 episode might conceivably be connected with fine particulate matter raised by the war, but this is speculation. Bright nights and high winds might be linked by solar activity changes. See, for example, weather lights, GLA16.

Similar and Related Phenomena. Transient sky brightenings (GLA14); restricted sky glows (GLA15 and 16); banded skies (GLA23); and episodes of milky sky (GWC).

Examples of Bright Night Skies

X1. November 8, 1929. Essex, England. "The moon had set, and the sky was clear, which it had not been on several previous nights. On looking out from a north window it was noticed at once without instrumental aid that the sky was exceptionally bright, and on going out into the open the exceptional brightness was seen all over the visible hemisphere, no direction being obviously favored. Although the sky was apparently quite clear, and the brighter stars gave the impression of being very bright, the luminous background was strong enough to make it difficult to distinguish the Milky Way, which, it was judged, was invisible for the same reason that it invisible when the moon is up---namely, that there is too much "false light" superposed upon it." Lord Rayleigh made photometric measurements that indicated the sky was four times its normal brightness. The auroral line was not conspicuous and no magnetic disturbances were recorded. (R1, R2)

X2. October 9, 1931. No location given, but probably England. "A misty, white light filled the northern horizon, obliterating the Zodiacal Band limit on the northern side, and so intense that it almost obliterated the Galaxy itself, where it arched up on the northern side. The sky itself was cloudless and filled with stars, which shone through this strange nebulosity. But though cloudless this white mistiness entirely destroyed the normal bluish-black contrast between the Galaxy and the night sky." (R3)

X3. About 1886. Florida. "I awoke a little before 3:00 A.M. and noticed that it was very light, and as there was no moon, got up and went out on the deck, and to my surprise saw everything illuminated with a pale greenish light so intense that we could read by it.....The atmosphere was hazy, and we could not make out the stars, and the light seemed to be general and from no particular direction." (R4)

X4. Late 1916 through 1919. England. Many reports of very bright nights during this extended period. December 23, 1916; bright sky, especially in the northeast. (R5) December 23, 1916. Much lighter than a summer solstice night. (R6) Year ending September 30, 1918. Unusual quantity of light in night skies. Astronomical photography adversely affected. (R7) September 30, 1918. Bright night. (R8) Winter nights of 1918, especially December 14, 1917 and January 13, 1918. Luminous skies. (R9) December 5, 7, and 14, 1918. Entire sky glowing with a soft white light. (R10) December 14, 1919. A remarkably light night. "On several nights the earlier hours were intensely dark, but toward midnight a soft twilight suffused the sky, which, as there was no moon, was very remarkable." (R11) November 25, 1919. Remarkable sky luminosity. Brightest moonless night ever recorded. (R12)

X5. Fall 1453. Constantinople. A dazzling light covered the town all night. (R13)
X6. June 18, 1783. (R14)
X7. January 7, 1831. Europe. Print could be read outdoors. (R14, R16)
X8. August 3, 1831. (R14)
X9. October 1855. (R14)
X10. November 18, 1859. (R14)
X11. November 26, 1859. (R14)
X12. June 30, 1861. Earth supposed to have passed through tail of Comet I 1861. (R14, R15)
X13. October 24, 1862. (X14)
X14. November 14, 1871. (X14)
X15. 1788. Mount Blanc. Whole horizon was bright, decreasing toward zenith. (R15)

X16. November 13 and 14, 1866. Attributed to Leonids. (R17)
X17. 1872. Attributed to Bielids. (R17)
X18. August 1880. Sky unusually bright the entire month. (R18)
X19. July 31, 1908. England. Sky bright, especially toward the north. (R19)
X20. August 4, 1908. England. Bright night, clouds illumined by a pink light. (R19)
X21. October 17, 1949, through the rest of the month. England. On the 17th., the whole sky was as bright as the Milky Way from 2340-0055. (R20)
X22. May 20, 1958. Indian Ocean. Whole sky bright, particularly toward the north. (R21)
X23. General observation. "When the sky is clear during a very high wind, a faint diffused luminosity has been often observed covering the whole sky." (R22, R23)
X24. General observation. Spring nights are the darkest of the year. (R24)

X25. September 29, 1910. Yerkes Observatory, Williams Bay, Wisconsin. "This was one of the brightest of the luminous nights that I have even seen. The matter seemed to be only ordinary haze but luminous for some reason. There was no trace of aurora. The sky on which the luminous haze was seen was, at this time, brightened with a pale uniform illumination covering the entire heavens and nearly blotting out the milky way." (R25)

X26. January 26, 1857. Quito, Ecuador, Sky was mostly clouded over, but it was bright enough outside to read print easily. The atmosphere itself seemed luminous. (R26, R27)
X27. July 1, 1859. St. Louis, Missouri. Everything outdoors seemed luminous. The air seemed made up of luminous particles. (R26)
X28. December 26, 1737. Kilkenny, Ireland. Much of Southern Europe was covered by a reddish, luminous haze. At Kilkenny it appeared like a globe of fire in the air, which lasted about an hour and then burst into pieces. (R28)

X29. July 1908. Europe. The bright night skies of Europe in early July, 1908, even made news in America via a cable to the New York Times from London.

"Several nights through the week were marked by strange atmospheric effects which Dr. Norman Lockyer of the South Kensington Solar Physics Laboratory believes to be a display of the aurora borealis, though personally I have not observed any colored streamers.

"Following sunsets of exceptional beauty and twilight effects remarkable even in England, the northern sky at midnight became light blue, as if the dawn were breaking, and the clouds were touched with pink, in so marked a fashion that police headquarters was rung up by several people, who believed a big fire was raging in the north of London." (R29)

X30. July 1908. Europe. Almost a century after the Tunguska event a writer in the New York Times remarked again upon the bright nights that followed in Europe. "Among the remaining mysteries, Dr. [H.J.] Melosh wrote, is why the night skies western Europe were strangely bright after the blast." Referring to a scientific paper by C.F. Chyba et al (R31), Melosh suggested that the blast had injected enough water vapor into the upper atmosphere to create noctilucent clouds. (R30) Noctilucent clouds occur at auroral heights and are poorly understood. (GWC6 in Tornados, Dark Days...) Again, we see the possible cloud-aurora connection mentioned in GLA12.

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GLA14 Transient Sky Brightenings

Description. Sudden, bright flashes of light covering all or most of the sky, lasting from one to several seconds. The landscape may be lit briefly as bright as day by these generally bluish flashes.

Data Evaluation. The observations of this phenomenon are rare but of rather good quality, many being reported by scientists and amateur astronomers familiar with meteors and other luminous phenomena. The data, however, are often complicated by the presence of clouds which might conceal bright fireballs. Rating: 2.

Anomaly Evaluation. If meteors and lightning can be truly eliminated, sudden all-sky flashes constitute an important geophysical enigma. Rating: 2.

Possible Explanations. The available data are best explained by hypothesizing large, unseen meteors, possibly hidden by clouds. In most reports, however, the observers can exclude the possibility of meteors. If meteors are not the answer, sharp bursts of solar wind or micrometeoroid flux might trigger pulses of auroral or air-glow light.

Similar and Related Phenomena. Steady glows in the night sky (GLA13); superbolts of lightning (GLL); and possibly unannounced tests of nuclear weapons, such as that of September 22, 1979. (R9)

Examples of Transient Sky Brightenings

X1. May 24, 1931. North Atlantic. "Sea and sky were suddenly quite brilliantly lit for about three seconds with a flickering purplish light, which did not appear to emanate from any particular point." The sky was overcast, so an unseen meteor is a possibility. (R1)

X2. December 5, 1956. South Pacific. "At 0643 G.M.T. a harsh, brilliant flash, bluish white in appearance, covering the whole of the night sky, appeared, lasting for approximately 1 1/2 sec. The sky was completely covered by a thick layer of Sc. The possibility of a meteor was ruled out as the cloud would not have permitted it to be visible, and the character and intensity of the flash did not conform to lightning or other electric phenomena. The forecastle head was plainly visible from the bridge and the horizon clearly defined. The source of the light appeared to issue from the NE. sky at an altitude of approximately 60^{0}." (R2)

X3. December 1, 1959. North Atlantic. "About 2000 G.M.T. when low cloud was passing across, a bright blue diffused light suddenly grew, as from the clouds overhead.....No actual flash was seen---it was as though a diffused blue light had been gradually unshaded behind the clouds and then gradually covered again." (R3)

X4. June 9, 1970. Uttar Pradesh, India. "On a moonless and cloudless night, two Indian astronomers at a Smithsonian affiliated observatory noticed a sudden and extraordinary sky brightening. 'For about one second,' one scientist said, 'the total local sky suddenly brightened up to an intensity comparable to that of the Milky Way during these summer months.' According to the report, the event took place in two stages: first, the sky became bright; then, immediately thereafter, the brightening intensified momentarily. No explanation of the phenomenon was given." (R4)

X5. May 15, 1972. Western Alaska. The weather: overcast. "The sky suddenly brightened to what eyewitnesses call daylight intensity, remaining illuminated for approximately two seconds. Reports have come in to us from Saint Lawrence Island, Tin City (at the tip of Seward Peninsula), Galena, Bethel, and villages in between. Although the entire sky was affected, some witnesses say that the light was most intense in the west. It appeared suddenly,

'like a flashbulb,' changing color from bluish through green to white, fading to orange or reddish. Estimates of duration range from one to seven seconds. Two observers claim to have seen two closely spaced flashes..... Could this phenomenon have been a great fireball, so brilliant as to light up the clouds that hid it from view?" (R5)

X6. December 2, 1814. Peckham, England. "The night was cloudy and dark, the lower part of the atmosphere clear and calm, a very slight wind blowing from the E. Suddenly I was surrounded by a great light. I remember that at the instant I shrunk downward and stooped forward; as I was apprehensive of some danger behind me, I instantly ran a few paces..... I saw nothing to cause this light. It did not give me the idea of the force and intensity of lightning; its brilliancy was not so instantaneous and fierce; but it was a softer and paler kind of light, and lasted perhaps three seconds. I could discover no noise, though immediately I expected an explosion. The strength of the light was nearly equal to that of common day-light; all near objects were distinctly visible." (R6)

X7. February 3, 1873. Huddersfield, England. "Shortly after ten o'clock the heavens were suddenly suffused with a brilliant bluish-purple colour; the greatest degree of intensity was in the zenith, gradually fading till, at the horizon, the colour was scarcely perceptible. The phenomenon lasted only a few seconds; but in a few moments a sound great resembling thunder, was heard, and this was followed in about three minutes afterwards, by the wind 'rising' and blowing with considerable force for about ten minutes." (R7) The thunder sound suggests a large unseen meteor, but the accompanying burst of wind is harder to explain.

X8. 1884. England. "Whilst walking in the country last Monday evening, at about 10.20, I saw the following strange phenomenon. The night was dark and calm, and a drizzling misty rain was falling, when suddenly the whole heavens became illuminated for about two seconds, and then all was darkness again. The light was not vivid, but soft, and bright enough to show clearly the surrounding objects." (R8)

X9. April 24, 1894. Glasgow, Scotland. "The night of the 24th inst. was, to begin with, intensely dark. The sky was very clear, and the air cold and damp. Suddenly, however, the whole sky began to soften in aspect (if I may use the phrase), and a delicate glimmering light overspread the whole, or nearly the whole, of the heavens. This brightness increased perceptibly, and the stars paled visibly in lustre. In some ten minutes the light was gone, and the sky as black, and the stars as vivid as before. The illumination seemed to come from the N. W. I have often witnessed phenomena of this kind, the whole heavens appearing to become suffused with light which afterwards faded." (R10)

X10. December 28, 1980. South Atlantic Ocean. "At approximately 2245 GMT on a moonless night the entire ship and immediate surrounding area were illuminated by what can be best described as a great camera flash. The flash was bluish white and a small bolt of lightning appeared to be centered just above the vessel's samson posts. No noise was heard and the flash lasted only a second. The sky was clear at the time and stars of all magnitudes were clearly visible. The only clouds that could be seen were two or three small cumulus clouds; one of these was above the vessel and the others were moving towards us from the south, our course being 142°(T) and the wind being S'E, force 3. The cloud above the vessel was at a height of about 600 feet." (R11)

X11. July 27, 1981. Norman, Oklahoma After a flash of lightning:

"...the sky took on a continuous, unflickering aquamarine glow. The sky was nearly as bright as it is on a cloudy afternoon (time: 2316), much like a neon light behind frosted glass. There were no lightning flashes and absolutely no sound other than the falling rain. The glow extended uniformly in all directions to the horizon (as visible in a housing

development), and persisted for 45 s. After it terminated, a similar light, now colored a reddish-orange and emanating from the cloud followed immediately. This new light persisted for 10 s and went out." (R12)

X12. November 9, 1971. Dover, England. Excellent visibility, very cold, a few small patches of cloud.

"Walking along the street at 19h 30m U.T., a bright flash in the sky was noted and suspected of being a fireball. A watch on the sky revealed another flash at 19h 32m U.T. This was an intense electric blue colour. The flash commenced in the S.S.W., extended rapidly across the starlit, moon-free sky (peak altitude 15° in S.E.) to reach the E. horizon below Saturn and Aldebran. Time for this process (which occurred once each time) was approx. 0.4 sec (± 0.1 sec). The general appearance was like that of an electric arc. No sound was heard, either at the time, or afterwards. The flash occurred over a sea horizon." (R13)

X13. Spring 1972. Great Hasely, England.

"One late spring evening about 1 AM, a severe thunderstorm broke while my wife and I were in bed. Suddenly a bolt of lightning hit nearby, but the light did not subside. The bedroom was quite bright as we had light curtains and no shade. After a while, I said that something very weird was going on and we both jumped out of bed. I grabbed my watch and went to the window. Outside, extending to the horizon in all directions, there was a steady bluish glow. On could easily have read a newspaper in the street below. The overall quality of the light was that of a bluish fluorescent lamp. There was no noise (over the rain) and the light did not waver at all. We walked around to the other side of the house and saw a similar sight. Suddenly, the light cut off everywhere at once, as though someone had pulled a light cord. It has lasted 28 seconds since I had grabbed my watch, and we estimated that it had persisted for 20-30 seconds prior to that. (R14)

X14. January 23, 1984, Salonta, Romania The observations of Attila Kosakiss, a Romanian scientist, as communicated by P. Hedervari:

"During the whole day we experienced snow which finally stopped at 23h 00m. The temperature was 1°C, when I experienced a few pale flashings from the top of the sky. The lights were seen from 18h 15m to 18h 30m, Universal Time. Their number was four, and they appeared with equal intensity with pauses in between, each pause lasting for 3-5 minutes. All were white in color. At 18h 31m, a new flashing was seen; this was the fifth flash in the series, and it had higher intensity than the previous ones. I have not been able to discover the source of these strange lights. Each flashing was very short-lived, lasting less than a second." (R15)

X15. March 25, 1984, Indian Ocean. "Two successive 'green flashes' were observed. The first, at 2100 Ship's Time or 1530 GMT, was a bright green and bore 240° at an altitude of 75°; it moved vertically downwards to an altitude of approximately 20° over a period lasting about 3 seconds. The second flash was observed at 2250 Ship's Time. It was green/white and was first observed at an altitude of 40°, bearing approximately 340°. It moved diagonally across the sky before disappearing behind low cloud at an altitude of 30°,

Sketches of two "objects" associated with flashes of rather long duration seen over the Indian Ocean. Their diameters were 5' and 3', respectively. The observers doubted that these were ordinary meteors. (X15)

bearing 310°. This time the duration was 1-2 seconds. In both cases the ship's radars were turned on but nothing was observed other than rain showers between 4 and 12 n. mile from the ship, mainly forward of the beam. Both flashes were of about the same brightness as that of lightning, the first being brighter than the second. In both cases it was difficult to judge the distance. The phenomenon was thought to have possibly been some form of lightning as its appearance was unliike that of any flare and in both cases the distance from the ship did not appear great enough to be compatible with a meteor or other object entering the earth's atmosphere." (R16)

Quite possibly these were low-altitude fireballs.

X16. March 22, 1999. South Atlantic Ocean. Three observers aboard the R.R.S. Bransfield, a vessel engaged in research work in the Antarctic. A remarkable sky flash.

"At 0030 UTC, shortly after arriving on the bridge for handing over the watch, all three observers were momentarily stunned as the eastern half of the sky (on the starboard side) lit up in a single, uniform flash of very bright greenish-white light lasting no more than 3 seconds. During this time the snow and ice-covered peaks of the mountains on the Christmas Islands, about 12 n.miles away on the starboard bow, were clearly visible, as well as what appeared to be thin ribbon of altostratus on the horizon ahead. The light appeared to emanate from abaft the starboard beam.

"This brief experience was simultaneously spectacular and somewhat unnerving; none of the observers could recall even having witnessed anything remotely similar before, certainly nothing involving conventional pyrotechnics, anyway. When considering the source of the light, it was noted that there was only one research station in the vicinity, namely the Argentine 'Primavera' Base, in Cierva Cove some 22 n.miles to the east, but its operational status could not be confirmed." (R17)

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GLA15 Bright, Luminous Patches on the Horizon

Description. Bright, luminous regions or patches on or close to the horizon. These bright areas may wax and wane in intensity as well as move along the horizon. Some patches rise above the horizon as expanding discs of light; others form arches. The duration of these phenomena ranges from several minutes to several days. When sharp weather changes follow, these apparitions are classified (rather arbitrarily) as Weather Lights (GLA16).

Background. This type of phenomenon is complex with several reasonable physical causes. Luminous horizon phenomena were much discussed in the older scientific literature under such headings as "weather lights," feux d'horizon (fires on the horizon), etc. The most spectacular observation in this category occurred June 30-July 2, 1908, in conjunction with the famous Tunguska Event.

Data Evaluation. The older data are primarily testimonial with limited scientific content. The 1908 series, however, and most modern shipboard observations contain substantial detail. Rating: 2.

Anomaly Evaluation. So many likely physical explanations exist for this phenomenon (see below) that it must be rated low on the anomaly scale. Some features of the observations remain enigmatic; e.g., the possible precursors of the 1908 Tunguska Event (sky glows and halos) and the curious arches that are sometimes formed. Rating: 3.

Possible Explanations. (1) Unseen meteors, comets, and space debris; (2) Auroral phenomena (usually eliminated by spectroscopic and magnetic tests); (3) Spacecraft and rocket launches (a common cause after 1950); (4) Volcanos; (5) Distant conflagrations; (6) Steady sheet lightning beyond the horizon; (7) Refraction phenomena, especially for bright areas close to the horizon.

Similar and Related Phenomena. Weather Lights (GLA16), steady night sky glows (GLA13), transient sky brightenings (GLA14), earthquake lights (GLD8), false dawns (GLA25), the post-Krakatoa sunsets (GES), halos presumably due to the introduction of nuclei by meteors and comets.

Examples of Luminous Patches

X1. July 16, 1892. Indiana. "As we were ascending the hill on the east side of the creek and near its summit, we saw in our front the reflection of a great light from behind us. It was so noticable as to cause us both to turn about on our buggy seat and look backward. There, at a bearing S. 60° W. (that is the bearing of the road, with which the light was in alinement), we saw a great white light radiating from a point at the horizon where it was brightest, right, left, and upward to a height of 10° to 15°, weakening in brilliancy as it radiated and terminated in a dark band or segment of rainbow shape, some 10° wide. The light seemed to radiate from a point a half-radius above the centre of the circle which the black segment would indicate. Above the dark segment another segment or band of light, not so bright as the one at the horizon, formed a rainbow, or arch, some 10° to 15° wide. Above that second band of light was a light haze, or mist, through which the stars could be easily distinguished. Some 10° up in that mist, and directly over the centre of the light at the horizon, was a light about as large as a man would appear to be if suspended from a balloon a thousand feet distant. It was about four times as long vertically as wide horizontally.... When I first caught sight of it, it had the appearance of the head of a comet, only it was long vertically. When young McIntosh first saw it, it seemed to be a blaze such as large meteor appears to carry at its front. We halted and watched it about ten minutes, during which time it (the small light) slowly faded till only its locality could barely be noticed, then suddenly loomed bright almost to a white blaze, then slowly faded as before. It would loom up in five seconds, and consume five minutes in fading away. It kept the same position all the time, for we watched its position with relation to the stars to see if it moved..... This little

light loomed up and faded four times when the big light under it faded also and made it dark there." (R1) See also GLA2-X5 for a simultaneous phenomenon.

X2. June 30, July 1-3, 1908. The British Isles and northern Europe. Glowing night skies to the north, unrecognized at the time as due to the Tunguska Meteor fall. "On the night of June 30, and to some extent on the nights succeeding, brilliant skyglows were observed in various parts of the country, and lasted throughout the night. At 9h 30m P. M. at Greenwich on June 30, the sky along the northwest and north horizon was of brilliant red, in fact there was what is usually termed a 'brilliant sunset,' the only peculiarity being that the brightness stretched more to the north than is usual, and endured, so that at one o'clock in the morning it extended well across the north of the horizon, and the northern sky above was of a brightness approaching that of the southern sky at the time of Full Moon. The light, indeed, was sufficient to take photographs of terrestrial objects." There was no sign of the auroral spectrum. "A long-lasting solar halo was seen in the forenoon and afternoon of June 30, and another on July 1. (R2) "In common with many, I observed the brilliant skies, June 30-July 1 and July 1-2. The colour was nearly or quite white, except close down to the northern horizon, where it was rosy. Also, an occasional high cirrus reflected reddish light. The dark segment and the radial lights of the aurora were absent. The point of greatest brilliance followed the sun, whilst aurora radiates about the magnetic North. The spectroscope gave negative results..... The magnets at the time were in a state of restfulness---not disturbed, as in the case of aurora..... All through June and early in July the upper atmosphere has contained a very considerable amount of ice crystal, which made itself visible by producing solar and lunar halos." (R3) "..... June 29 already giving signs of something unusual at night, but nothing like the night of June 30, or even that of July 1." (R4) (Could the muted display of June 29 and the earlier halos been precursors?
Peculiar clouds were also seen in the United States. (R5) Many other observations of the nocturnal glows are on record. (R6-R21, R39)

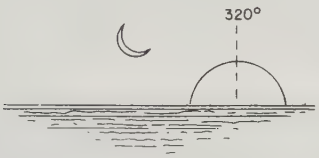
X3. July 31, 1916. Ireland. "On the night of July 31 a wonderful light appeared in the sky just above the horizon. I saw it a little after 11 p. m., and it looked like an immense fire. At 11.15 p. m. the light moved along the sky to the North-east, and then appeared as a great luminous star. At 12 p. m. it moved back again in a Northerly direction, and showed as a great blaze of fire in the same place as I first saw it, and there it shone until 4 a. m. the following morning, when it disappeared." (R22)

X4. September 1922. Sussex, England. "While standing about twenty yards from the seashore and looking south out to sea, the horizon and a region slightly above it (elevation only about 1^{o} or 2^{o}) were lit up by a faint white light which extended laterally over a segment subtending an angle of about 30^{o}..... The appearances of the light were not the same to my wife as to myself. Her impression of it was that it was a light which she saw only if her eyes followed it, yet it consisted of a long streak of light parallel to the horizon with a break in it and then another small streak. My impression was that of a light which appeared to flash up over the horizon, subtending the angles already noted, the flashes not succeeding each other regularly." (R23)

X5. March 1, 1941. North Carolina. "A sky phenomenon, which attracted considerable attention, was observed here and at other places in the vicinity of Raleigh on the evening of March 1. It was a striking light effect visible in the western sky from 7:00 to 9:00 P. M. As I observed it about 8:00 o'clock its position and form were almost identical with that of the Zodiacal Light. Its appearance as to brightness and color was similar to that of a solar corona at the time of an eclipse. It was brightest just above the horizon. It was triangular shaped, as the Zodiacal Light, and the new moon was almost in the center of the apex towards the top. Numbers of our students here saw it and they report that it reached its maximum brightness about 7:30. Some of them reported coloring effects associated with it, and some observed a luminous patch in the East." The author also noted communications problems due to magnetic storms at the time. (R24)

X6. October 13, 1951. South Atlantic. "Between sunset at 1954 G.M.T. and 2040, a reddish glare spread from the western horizon until it covered the sky half-way to the zenith over an arc of 90°. The glare was reflected on the sea surface and combined with the silvery light from the moon gave an eerie effect which was most unusual." (R25)

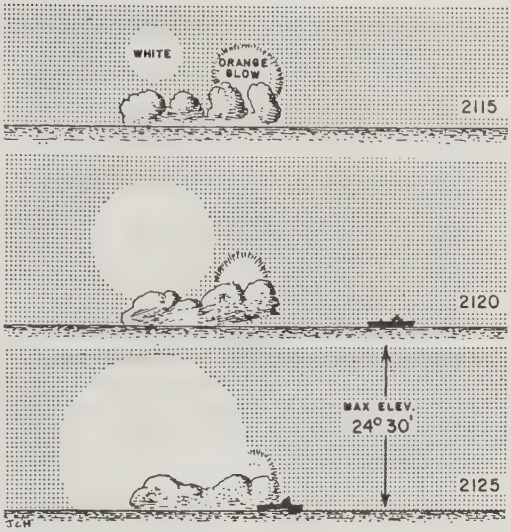
X7. March 20, 1969. Caribbean Sea and Western North Atlantic. "At 2315 GMT, almost an hour after sunset, a semicircle of milky-white light became visible in the western sky and rapidly expanded upward and outward during the next 10 min. When first seen it was quite bright (e.g., as clearly defined as a high cloud across the face of a full moon) but, as it expanded, it became more diffuse. It was possible to follow the expansion to an altitude of 50°



March 20, 1969. A semicircle of light expanded in the western sky over the Atlantic Ocean. (X7)

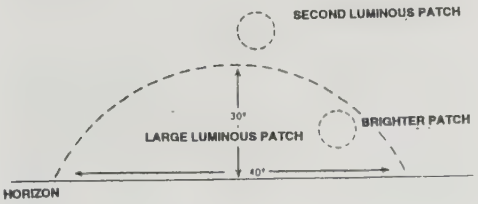
when the circumference of the arc of the light cut the horizon at points bearing 280° and 350° respectively." (R26) This and the following example may be spacecraft launches.

X8. June 22, 1976. North Atlantic. "At 2113 GMT a pale orange glow was seen to be coming from behind a bank of towering cumulus to the west. At 2115 a ghostly white disc, see sketches, was observed at an approximate altitude of 10° and bearing 290°. The glow from behind the cloud persisted." The glowing region developed as indicated in the figure. Stars could be seen through the disc at all times. By 2140 the disc had disappeared. (R27)



This expanding, ghostly white disc was observed over the Atlantic in 1976. (X8)

X9. March 24, 1977. North Atlantic. "At 0855 the look-out observed what appeared to be a searchlight shining downwards for about 10 seconds on a bearing of 300°T and 20° above the horizon. This light was extinguished and was replaced by a luminescent patch of approximately one degree in diameter. A semi-circular area of overall moderate luminosity formed about the luminescent patch. This took about three minutes to form and the dimensions are shown in the sketch. When this had



One large and two small luminous patches observed near the horizon over the Atlantic in 1977. (X9)

formed another luminescent patch was also observed above the semi-circular area and after a total period of seven minutes the phenomenon dispersed completely." (R28)

X10. General observation. "Mr. C. Atwater has communicated an account of a spot or spots, near the horizon, appearing as if lighted, and giving rise to a belief that there was a great fire in that direction. He remarks that he has often noticed these light spots in Ohio, but not on the east of the Alleghanies. I would only remark that I have observed similar phenomena in New-England." (R29)

X11. September 11, 1898. West Virginia. Oval luminous "cloud" 5-6° long appeared and disappeared 10-20 times. No auroral activity noted. (R30)

X12. December 1915. England. A glow in the northern sky, but no magnetic activity to suggest an aurora. (R31)

X13. February 11, 1930. South Pacific. A bright light on the southern horizon after 30 seconds formed into an arc, which moved about 10° southward along the horizon. (R32)

X14. October 7, 1957. Aden. Pale green glow in sky over Indian Ocean, 25° high. Lasted 2.25 hours. (R33)

X15. August 22, 1969. West Indies. Luminous area bearing 310° grew in size and rose in altitude, then turned into an arch or crescent. (R34)

X16. June 30, 1970. Six locations in the Caribbean and Atlantic. Semicircle of milk-white light appeared on horizon and grew rapidly in size. Correlated with a spacecraft launch from Florida. (R35)

X17. September 25, 1972. North Atlantic. Expanding luminous area on horizon, bearing 310°. (R36)

X18. September 20, 1977. Northwestern Soviet Union. Huge flare of light in the sky, spreading like a "jellyfish." Thin light rays emanated from the central mass. Correlated with Soviet satellite launch. (R37, R38)

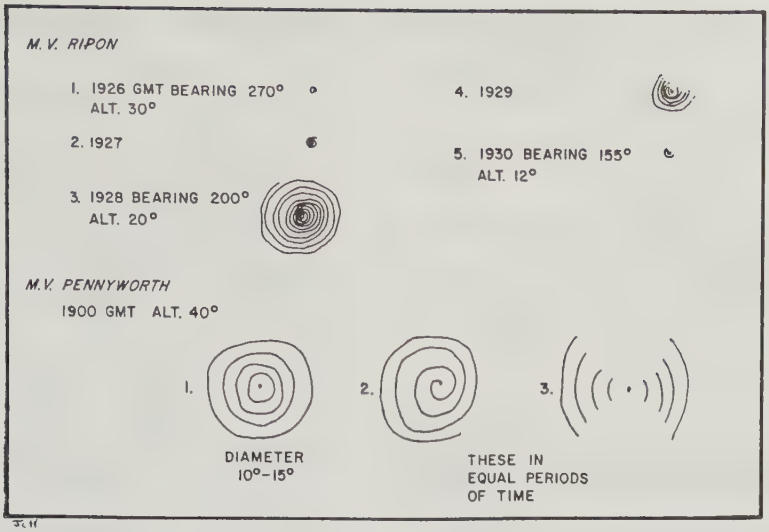
X19. November 27, 1963. North Atlantic Ocean. "At 1926 GMT an illuminated body was observed bearing 270°, altitude 30°. It appeared at first to have a suffused glow about it, but as the object moved parallel with the ship's course, the glow assumed the definite form of a tight spiral of blue-white light. The spiral expanded to a maximum radius of about 5° with about 12 turns visible at one time.... The whole phenomenon gave the impression of looking into a conically formed spring and was indeed a most sensational sight." This phenomenon was correlated with the Florida launch of the Centaur 2 rocket. (R40)

X20. December 1, 1959. North Atlantic. "Bright diffused light appeared then disappeared very slowly."(R41)

This event is the first in a series of 15 phenomena categorized as "expanding balls of light" (EBL). We have already cataloged six of these events above and attend to the remaining eight below (X21-X28). The EBLs seem to fit comfortably in this section, as we can see in their general description provided by R.F. Haines.

"According to several pilot witnesses, the center of the EBL is at relatively high altitude while it is forming. Its color is evenly whitish or yellowish and becomes increasingly transparent to background stars as it expands. As it enlarges it appears to maintain a sharply defined edge. At some point it fades completely from sight. The rate of boundary interface expansion is impossible to determine without knowing its distance from the observer. It is also of interest to note that most EBL events have taken place after dark. If EBL phenomena are associated with an advanced weapons test, one wonders why it would be conducted (a) after dark, and (b) in so many geographic areas. Both (a) and (b) tend to make EBL phenomena more conspicuous than otherwise." (R41)

M.B. Aymerich has commented on the events described in Haines' paper (R41) as follows: "At least eight of the fifteen cases compiled by Haines supply enough data so as to allow calculation of the Sun's position during the event. The results consistently support the presence of gaseous clouds in the upper atmosphere illuminated by the Sun." (R42)



Luminous phenomena associated with a Centaur-2 launch in November 1963, as observed from two vessels far out at sea. (X19)

X21. June 1, 1961. Indian Ocean. "Two thin concentric arcs, 150° tip to tip, required 20 min to reach max. intensity." (R41)

X22. June 17, 1966. Tehran, Iran. "Seen by two aircrews in flight." (R41)

X23. September 1979. Northeast Afghanistan. "Huge luminous hemisphere over USSR." (R41)

X24. June 22, 1980. Kuwait. "10 mi. (est.) diam., flat base, probably in Caucasus region." (R41)

X25. June 18, 1982. China. "Yellowish-white, 18-27 (est.) km. diam., covered 90° arc along horizon." (R41)

X26. April 9, 1984. Japan. "Sphere enlarged and rose from 14,000 ft to 60,000 ft in 2 min." (R41)

X27. July 27, 1984. Kuril Islands. "Huge expanding shell of whitish light, faded gradually, no radioactivity or turbulence." (R41)

X28. June 11, 1985. Lanzhou, China. "Huge yellowish glow, expanding, with very intense spot at center." (R41)

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GLA16 Weather Lights or Storm Lights

Description. Luminous whitish or reddish patches on the horizon, often mobile, and located at any azimuth. The appearance of weather lights is by definition followed by a sharp weather change, generally a storm with high winds.

Background. European folklore and local belief has long held that the aurora presages stormy weather, as elaborated upon in the examples below. The Nineteenth Century American concept of weather lights or storm lights is closely related, perhaps identical in terms of geophysical phenomena. It should be noted that the artificial illumination of modern civilization almost precludes the detection and study of weather lights, assuming they exist.

Data Evaluation. No satisfactory scientific studies of the aurora-weather relationship and weather lights have been discovered. Only general, qualitative, rather old observations support the existence of this class of phenomena. Rating: 3.

Anomaly Evaluation. If storms or sharp weather changes are truly announced by luminous appearances on the horizon, this is an unrecognized phenomenon in meteorology. Rating: 2.

Possible Explanations. Solar activity is strongly correlated with auroral activity and rather weakly related to terrestrial weather. There is, in consequence, a recognized link between general auroral activity and weather, though not necessarily weather lights. If weather lights are not auroral in nature, they could be associated with distant sheet lightning or other electrical phenomena. Another possibility is that advancing weather changes modify the optical conditions of the atmosphere, refracting light, mirage-like, over the horizon. Finally, some nocturnal lights (GLN1) seem to presage storms. See especially GLN1-X42.

Similar and Related Phenomena. Auroras correlated with thunderstorms. (GLA9) The post-auroral appearance of cirrus clouds and high hazes. (GLA12) The purported brightness of windy nights. (GLA13) See also silent lightning (GLL4).

Examples of Weather Lights

X1. General observation. "Before a storm here, I have often noticed, in an evening of the latter part of autumn, and sometimes in the winter, a phenomenon not recollected by me to have been seen on the east side of the Alleghanies: Some one spot or spots near the horizon, in a cloudy night, appeared so lighted up, that the common people believed there was some great fire in the direction from which the light came. I have seen at once, two or three of these luminous spots, not far from each other: generally there is but one, and a storm invariably proceeding from the same point near the horizon, succeeds in a few hours. (R1)

X2. General observation. There is a phenomenon of common occurrence in this part of the country, connected with the atmospheric influences that move about the earth during the seasons of mild temperature, which I had never been able to explain according to any laws with which I was acquainted. I allude to the lights frequently seen in a clouded sky at night in advance of storms. These lights, some suppose, are caused by fire on the prairies; while by others they are called storm lights, and are said to indicate snow. They differ somewhat from the Aurora Borealis, but still are analogous." (R2)

X3. General observation. "An old friend of mine told me 40 years ago that a relation of his, who commanded for two or three years a cruiser in the Channel, had observed that whenever an aurora appeared the wind would blow hard from the S. W. in 48 hours. I have myself verified this as the unfailing result of my own observation ever since." (R3)

X4. General observations. "Amongst peoples living in the auroral zone there has always been some association between the aurora and the weather, much of it confused and contradictory, but none the less with what seems to have been sound observation. A Finnish name for the aurora is Vindlys = Windlight. Scottish farmers of the last century held that the first great storm of the year was heralded by an aurora. Observations between 1843 and 1870 at Uckfield, Sussex (lat. 51°N), made during an aurorally 'rich period', showed that after the brilliant displays occasionally seen, very stormy weather followed almost invariably after 10 to 14 days. The Southern Cross Expedition, which wintered at Cape Adare, Ross Dependency (72° S), in 1899-1900 found that brilliant and active aurora, observed to the north, was followed, too often for coincidence, by a violent storm from the southeast." (R4)

X5. Circa 1873. Tennessee. Weather lights seen to southwest. Violent whirlwind passed over town. (R5)

X6. February 26, 1884. Fayetteville, Arkansas. Weather lights on horizon were the precursor of a violent snowstorm. (R6)

X7. General observation. Major auroral displays followed by gale in 48 hours. (R7)

X8. General observation. Auroras often followed by wind and rain. (R8)

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GLA17 Curious Folklore: Auroras and Silken Threads

Description. Folklore and some questionable testimony claim that silken threads sometimes fall during auroral displays.

Background. This charming thought seems to owe its origin to the analogy between the aurora's motions and patterns and the operation of a loom, perhaps reinforced by the occasional swishing sounds accompanying active auroras (GSH).

Data Evaluation. Obviously the testimony is highly questionable. This "phenomenon" is included only because of its similarity to other phenomena, as described below. Rating: 4.

Anomaly Evaluation. If true, a most remarkable event. Rating: 2.

Possible Explanations. None.

Similar and Related Phenomena. There are so many seemingly related phenomena that this little tale about auroras and silken threads, though ridiculous on the surface, must be included in this catalog. (1) Gelatinous meteors or pwdre ser events involve luminous phenomena and the fall of strange substances (GWF); (2) The folk tales relating the anomalous appearance of fibers after earthquakes, which of course may be accompanied by luminous phenomena(GQE); (3) Many remarkable falls of silken threads or gossamer, as produced by several species of spiders; and (4) The belief by some scientists in the past that auroras are "material" things (GLA12).

Example

X1. General observation. "The auroral light sometimes is composed of threads like the silken warp of a web; these sometimes become broken and fall to the earth, and possess exquisite softness and a silver luster, and I denominate these as the products of the silkery of the skies. I once obtained a small piece, which I preserved." (R1)

References

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GLA18 Correlation with Lunar Phase

Description. The dependence of auroral frequency upon the phase of the moon, with minimum auroral frequency occurring at full moon. Analysis with modern instruments confirm that this phenomenon is real and not subjective due to the moonlight masking auroral light.

Background. For over a century, observers have maintained that auroras are less frequent during full moons. (R1)

Data Evaluation. This correlation, originally based upon simple visual observation, has now been fairly well established by optical instrumentation. Rating: 2.

Anomaly Evaluation. Some reasonable physical mechanisms have been proposed to explain this phenomenon; only the details are in question. Rating: 3.

Possible Explanation. The passage of the moon through the solar plasma streaming toward the earth may delay or deflect some of the particles that would otherwise contribute to the formation of auroras.

Similar and Related Phenomena. The correlation of precipitation with lunar phase (GWP). The effect of the moon on geomagnetic parameters (GMS).

Examples

X1. General observations. "A significant periodicity in the occurrence frequency of aurora has been reported by Stoffregen. Not only does the length of the period (29.5 days) correspond to the synodical period of the moon, but there is consistently less aurora during periods of full moon." (R2)

References

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GLA19 Auroras Interacting with Lunar Halos

Description. Apparent physical interactions between auroral displays and lunar halos. One type of interaction occurs when the two luminous phenomena overlap and the points of intersection exhibit enhanced luminosity or, in the case of dark spaces between auroral streamers, reduced halo luminosity. A second type of relationship is seen in the appearance of halos of unusual radii during auroral displays or shortly thereafter.

Data Evaluation. A few rather vague general observations, mostly rather old, plus a single well-observed example from the Twentieth Century. Rating: 3.

Anomaly Evaluation. One would expect to observe some enhancement of light where the two displays overlap, but the dark spaces between auroral streamers should not mask any lunar halos. The reason for this is that auroras are basically very high altitude phenomena that are separated from the realm of lunar halos by hundreds of miles of altitude. Likewise, one would not expect auroras to be correlated with the appearance of halos of any radius, much less those of unusual radii. Rating: 2.

Possible Explanation. Only very low auroras (GLA4) could obscure portions of a lunar halo display, and even here obscuration is difficult to understand if low-level auroras are caused by precipitating particles, which should not absorb the halo's light. If, however, low-level auroras involve a different mechanism, say one dependent upon ice crystals or other nuclei, the aurora-halo interaction phenomena might be explained.

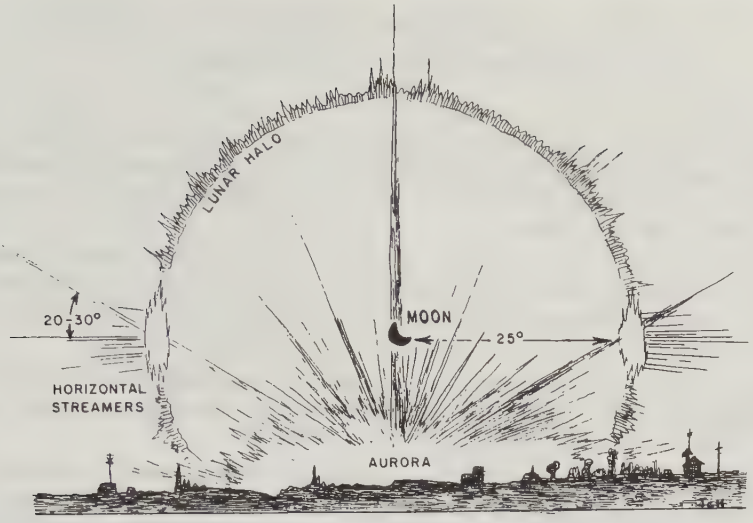
Similar and Related Phenomena. The relationship between auroras and clouds/haze (GLA12); low-level auroras (GLA4), auroral fogs and mists (GLA21), black auroras (GLA22), and halos of unusual geometries (GEH).

Examples of Interactions between Auroras and Lunar Halos

X1. March 28, 1928. Cambridge, Massachusetts. "The lunar halo first attracted my attention about 11 P. M., Eastern Standard Time. A few minutes later the halo bore a fringe strikingly suggestive of a solar corona. By 11:30 a well-defined auroral fan was centered at a point on the horizon directly under the moon (at first quarter) with a streamer extending from the horizon directly past the moon and vertically upward. Oblique streamers arranged themselves approximately symmetrically about this line. One of these passed above Capella and at 11:50 P. M. extended across Polaris, and between Vega and Hercules to the eastern horizon. A similar brilliant streamer mounting from the auroral center extended southward, passing Procyron and Regulus in Leo. These two streamers crossed the lunar halo very nearly on the same circle of altitude as the moon and the crossing points were marked by exceptionally brilliant patches of auroral light. The outstanding feature of the phenomenon was the existence of horizontal streamers extending several degrees through the patches and diverted away from the moon as an apparent radiant point. These horizontal streamers with an apparent radiant at the center of the halo made angles of 20°-30° with the long auroral streamers but gave every appearance of a true auroral effect." (R1)

X2. 1894. Louth, England. During an auroral display. "At this time there was a brilliant halo around the moon, about 20° in diam., and a noticable feature was that the dark spaces between some of the streamers obliterated the halo where they crossed it. I paid most particular attention to this point, and am certain that it was not an effect of contrast alone, but an actual cutting out of the light of the halo." (R2)

X3. General observation. "Also in association with the aurora, halos of the unusual radii 10° and 15° were noticed by Richardson (1855) and on the 1820 Franklin expedi-



Apparent interactions between an aurora and lunar halo observed at Cambridge, Massachusetts, in 1928. Note especially the auroral streamer crossing the moon and those streamers that seem to enhance the two mock moons. (X1)

tion. Other halo observations include a greenish halo noted at Uppsala on 4 February 1874, a 'peculiar' corona recorded on 3 March in the same year at Peckloh in 'cirrus' of radius 20°. A particularly interesting observation was made at Bossekop on 2 November 1838 when an auroral ray reached the ordinary halo of 22° radius, 'this is wider and its light appears more condensed.'" (R4) "Baron Wrangel remarks, that, in Siberia, when shooting stars pass across the space occupied by polar lights, that fiery beams suddenly arise in the place traversed by the shooting star. Further, that, when a polar beam rises high, it gradually forms a luminous circle around the moon, at a distance from her of from 20° to 30°; remains in this form for a short time, and then disappears." (R3)

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GLA20 Electrical Effects of Auroras at the Earth's Surface

Description. Surface electrical phenomena coincident with auroral activity, including physiological effects reported by observers, suppression of radio reception, fluorescence of minerals, strong perturbations of atmospheric electrical fields, and strong currents induced in long terrestrial conductors.

Background. The detection of appreciable electrical effects at the earth's surface during strong auroras supports the claims that visible auroras sometimes descend below the 80 kilometer limit usually assigned (GLA4), except in the case of induced currents in long conductors which are observed frequently during normal auroras.

Data Evaluation. Modern quantitative studies have firmly established the reality of induced currents in conductors and electric field changes, but the other potential effects mentioned above have not been well-substantiated. Overall rating: 2.

Anomaly Evaluation. When auroral action occurs there are normally powerful electric currents in the high atmosphere; thus, some induced surface electrical effects should be expected. The disruption of terrestrial communications, for example, is common when geomagnetic activity is high. The issue here is whether these surface electrical effects are strong enough to suppress radio reception, to be felt physiologically, to cause minerals to fluoresce and (especially) to help account for the numerous reports of low-level visible auroras (GLA4). Rating: 2.

Possible Explanations. As mentioned above, some surface electrical effects are to be expected, but it is not clear that they can be strong enough to create low-level auroras, the electrical odor occasionally experienced, and other electrical phenomena which seem best explained in terms of the slow, large-area discharge of electricity to space.

Similar and Related Phenomena. Low-level auroras (GLA4), the disruption of terrestrial communications during geomagnetic storms, the surface electrical effects of meteors (AYO), and the oft-reported suppression of radio reception and other electrical disorders during UFO sightings.

Examples of Auroral Electrical Effects

X1. Circa 1883. Human physiological effects. "There was an unusually brilliant aurora, and it was remarked by several that the streamers seemed to be very near to us; and presently, as we stood in the open air with heads uncovered, we began to feel the sensations produced by proximity to a body charged with electricity. The fact that such a sensation had actually been produced by the aurora was doubted by some scientific men to whom I mentioned it; and it was attributed to imagination, which, I fear, is guilty of much, and often accused of more." (R1)

X2. Winter 1929, Norwood, Ontario. Auroral effects on a radio receiver. "He observed that his radio set was 'dead', though the valves were alight and the aerial and ground wires were connected; no reason for the absolute quietness of the set was apparent. Looking out, he saw that a bright aurora was in progress; going outside to get a better view he found, to his astonishment, that a curtain of streamers extended from the sky to the ground and completely surrounded the house but at a distance of several feet. The curtain was many-coloured and unsteady, its scintillations being accompanied by 'visible sparking' and by 'snapping sounds.'" (R2) Radio suppression has also been noticed during milky seas (GLW9-X32).

X3. March 14, 1858. Armagh, Northern Ireland. Possible fluorescence during an aurora. "I availed myself of the opportunity to try whether this light was rich in those highly refrangible rays which produce

fluorescence, and which are so abundant in the light of electric discharges; and I found it to be so. A drop of disulphate of quinine on a porcelain tablet seemed like a luminous patch on a faint ground; and crystals of platinocyanide of potassium were so bright, that the label on the tube which contained them (and which by lamplight could not be distinguished from the salt at a little distance) seemed almost black by contrast. These effects were so strong in relation to the actual intensity of the light, that they appear to afford an additional evidence of the electric origin of this phaenomenon, and as such I hope they may be of some interest to your readers." (R3)

X4. Auroral effects on terrestrial electric fields. "Evidence is presented here for coupling between the upper and lower atmosphere by electrical means related to aurorae. Electric field data obtained with rocket-launched parachute-borne probes are shown to be consistent with the hypothesis that aurorally-produced radiation can short out vertical electric field 'cells' in the mesosphere, with corresponding effects on the lower atmosphere electric field." (R4, R5)

X5. Auroral effects on power lines. "As human activity advanced northwards, its supporting systems, such as power transmission lines and oil/gas pipelines, extend across the auroral zone. As the auroral electrojet, a concentrated ionospheric current along the auroral zone, induces a potential of up to 1 V km^{-1} on the Earth's surface, a significant amount of electric current can be induced in long conductors which are grounded at points separated by a long distance." (R6, R7)

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GLA21 Auroras and Surface Fogs and Mists

Description. Luminous fogs and mists observed at the earth's surface, usually during auroral activity. This phenomenon may be identical to low-level auroras (GLA4), with the observer being actually immersed in the active auroral region instead of viewing it from afar.

Data Evaluation. Enough reliable reports of luminous fogs and mists exist in the scientific literature to lend this phenomenon credibility. It is the interpretation of these observations that is controversial. Rating: 2.

Anomaly Evaluation. If luminous fogs and mists are actually created by the same physical process responsible for normal, high altitude auroras, they represent an important class of

anomalies because auroral activity is supposedly limited to 80 kilometers and higher. See the discussion under low-level auroras (GLA4). Rating: 2.

Possible Explanations. As in the case of low-level auroras, some scientists suggest that luminous fogs and mists derive from light originating in normal auroras that is reflected and scattered by ordinary, nonluminous mists. A more radical interpretation is that the observer is actually in the midst of a large-area brush discharge (GLD).

Similar and Related Phenomena. Mountain-top glows (GLD1); brush discharge; large-scale St. Elmo's Fire (GLD3), those marine phosphorescent displays that seem to transpire well above the ocean's surface, sweeping past the observer in waves (GLW3). The older literature tells of luminous "dry fogs," blasting fogs, and strange mountain fogs (pogonips in which it is difficult to breathe, GWF). Low-level auroras (GLA4) may be closely related to luminous fogs, the latter being an example of an aurora at ground level.

Examples of Auroral Fogs and Mists

X1. General observations. "'I must yet add, says Gisler, 'that people who had travelled in Norway, informed me they have sometimes been overtaken, on the top of mountains, by a thin fog, very similar to the northern lights, and which set the air in motion; they called it Sildebleket (Haring's Lightning), and said that it was attended by a piercing cold, and impeded respiration.'" (R1)

X2. Winter of 1878-1879. The Arctic. I can maintain with full certitude, Baron Nordenskjold says, that the lighted segment of clouds which we saw during the winter of 1878-1879 had this origin; and most probably, several luminous mists which we saw during the nights of March 18 and 20, close by our ship, close by the ice, were due to the same cause; but I cannot affirm that quite certainly." Nordenskjold thought the luminous mists were perhaps ordinary mists lit up by the aurora. (R2)

X3. No date. Cape Breton, Canada. "It was my good fortune to observe an aurora, which to my eyes was embodied in and swept the earth with successive banks of Cape Breton fog....In this fog bank hung, as it were, a brilliant curtain of light, with a wide fringe or flounce of maximum brilliancy, along the bottom edge, the light fading upwards along the curtain, but traceable to the very zenith, and the curtain stretching from the eastern horizon out at sea to the western horizon on the low hill tops. The curtain was evidently vertical, thin, straight, long enough to reach from one limit of the vision to the other, and floating broadside before the south wind towards the north. No reasoning could convince us (he had a companion) that these were not elements of the phenomenon, and, moreover, that the lower edge of the bright fringe was more than one or two hundred yards away at its nearest point when we first saw it." The observer here was Professor J. P. Lesley. (R3)

X4. Winter 1908-1909. Hartford, Connecticut. "During the winter of 1908-1909, while attending Trinity College at Hartford, Conn., I observed a magnificent aurora. The light effects gave me the impression that the atmosphere was filled with fog, and that someone was illuminating it by playing a searchlight back and forth. The effect was very striking because the display was so close to the ground that I seemed to walk right through the illuminated fog." (R4)

X5. Winter 1917-1918. No location given. "Some of the accounts of low aurorae seen between the observer and terrestrial objects are very striking and circumstantial. One writer states that he and his party (members of a government radio station, in the winter of 1917-18) were enveloped in 'a light mist or fog-like substance in the aurora'; a hand extended could be seen as if in a coloured fog and a kaleidoscope of colours was visible between the hand and the body. It was impossible to feel this visible fog or mist, and there was no dampness. By stooping close to the ground it was possible to see under this light, which did not go below four feet from the ground." (R5)

X6. 1783. No location given. Dry fog luminous at night. (R6)
X7. 1831. No location given. Dry fog luminous at night. (R6) January 7, 1831. Italy. A luminous mist so bright that print could be read at midnight. (R7)
X8. February 19, 1852. Wyoming, New York. Auroral vapor near ground. (R8)
X9. July 7, 1928. Big Sauble Point, Lake Michigan. Auroral display associated with fog and high wind. Bright enough to read fine divisions on watch. (R9)
X10. No date. Canada. Engineer sees some of his men walk into an aurora. (R10)

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GLA22 Black Auroras

Description. Intensely black, well-defined arches and streamers analogous to the normal luminous features of auroral displays.

Background. Occasional black patches appear in auroral displays, but "negative" displays are very rare and may, in fact, not be objective phenomena.

Data Evaluation. The observations of black auroras on record are few in number and all more than a half century old. Further, contrast effects and illusions may play important roles in this phenomenon. Rating: 3.

Anomaly Evaluation. If black auroras are not subjective and/or illusory, they may indicate the presence of geometrically arrayed streaks of opaque material, supporting the often-suggested link between auroras and daytime clouds (GLA12). Such a notion is contrary to modern theories of the aurora. Rating: 2.

Possible Explanation. Subjective contrast effects may be to blame, although experienced observers deny this. Radical though the idea may be, the presence of bands of absorbing material (possibly ice crystals) could help explain the similar phenomena cited below.

Similar and Related Phenomena. Banded skies (GLA23); the relationships between auroras and clouds (GLA12) as well as halo phenomena (GLA19); polar-aligned cirrus clouds (GWC); and some of the strange sunset band effects (GES).

Examples of Black Auroras

X1. March 25, 1894. Croydon, England. "It consisted of five dark rays or streamers, which emanated from a point over the northern horizon at or near the true north, and radiated like the spokes of a wheel towards the zenith, or it might be the magnetic zenith. The rays were clearly defined against a hazy sky, which was faintly illuminated by the glare of the metropolis, and resembled five blades of a black outstretched fan. As I looked, the whole system wheeled slowly through an arc of 30^{o} or 40^{o} towards the east, and then faded out. The rays did not seem to quiver or change colour, but remained black or smoky, and reminded me of streaks made by a hair pencil dipped in Chinese ink. I regard the phenomenon as a black aurora, because of its behavior and the collateral phenomena. Black or smoky pillars and patches have been observed in auroras, but although I have examined the records of hundreds of displays, I have seen no account of a similar effect." (R1)

X2. August 26, 1894. Maidenhead, England. "From near the Pleiades, then just rising, two pairs of parallel rays of luminosity proceeded, one stretching towards the celestial pole, the other following approximately the course of the Ecliptic. Each luminous band was about 5^{o} in breadth, very straight, the light patchy and without any well-defined edges. The dark spaces between the parallel rays were of about the same width, and of a most curious and intense blackness. The light of the luminous portion was quite steady, without any sensible shooting or flickering, such as is usually seen in auroral displays. Where the northern rays crossed the Milky Way near Cassiopeia, the light was very similar both in brightness and general appearance to that of this brilliant portion of the Galaxy. What most struck my attention was the singular blackness of the intervening spaces. This may have been an optical illusion, due to contrast; but I think not. It looked like an intensely black cloud; but on sweeping with the telescope over the regions where it was most conspicuous I observed that the definition and seeing were unusually good. I have frequently observed similar dark rays. Can these be anything in the idea of a 'black aurora'?" (R2)

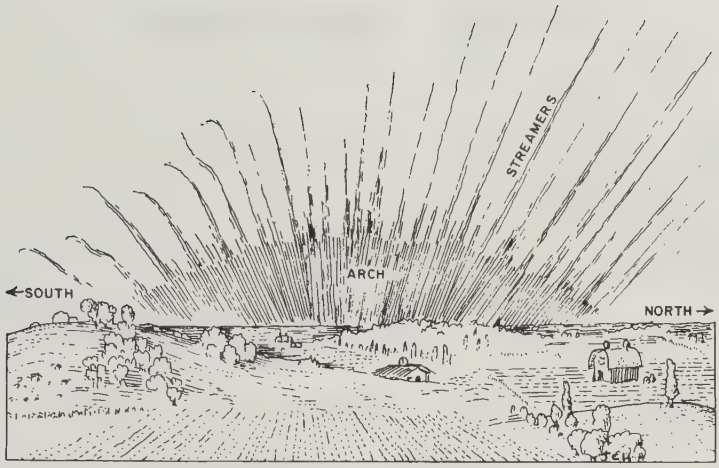
X3. March 24, 1903. Somerset, England. "Has any member of the B. A. A. ever seen a 'Black Aurora,' or an aurora in the negative? One was seen here (Frome, Somerset) to-day March 24, at 1:40 p. m. This meteoric effect, situated in the western part of the sky, which, for want of a better name, I have called a 'black aurora,' consisted of a black arch with streamers radiating upwards from it; in short it was precisely like the commonest form of auroral display, as seen in high latitudes, only in negative, the streamers and arch being black instead of white, and the background blue sky instead of a night sky. The streamers to the north were fine and straight, and about double the length of those towards the south, which were thicker and bent at the top like the handle of a walking stick. The sun was shining at the time, and some bright white clouds were being driven in front of the aurora at a rapid rate by a fresh breeze." (R3)

X4. No date. England. "Now with regard to the Derby earthquake, some ten or fifteen years ago, I was coming into luncheon a little late and saw a most curious arch in the N. E., it was precisely like an aurora in negative, instead of the lines being white they were black. It seemed so remarkable that the people were fetched out from lunch to look at it. The next day the newspapers reported an earthquake at Derby at that hours." (R4)

X5. General observation. "The black rays of the northern lights, first noticed by Professor Hanstein, i.e. sharply bounded stripes, surrounded by masses of light, which, however, are quite detached from them, are a not unfrequent, but extremely striking phenomenon." (R5)

X6. July 23/24, 1998. Gulf of St. Lawrence. Aboard the m.v. Appleby, Port Cartier enroute to to Immingham.

"The aurora borealis was sighted at 0330 UTC. There was a band measuring 35° long in azimuth, with deep blue almost black vertical bands lying between the altitudes of 15° and 25°. The



Apparent black arch and black streamers appeared over England in 1903. The effect resembled a photographic negative of a normal aurora. (X3)

colour changed to brilliant blue at 0335, lasting for about 15 minutes before cloud began to obscure it." (R6)

What were the "almost black" vertical bands embedded in the main band? Aurora expert R. Livesey replied as follows.

"There is a phenomenon called the 'black aurora' which consists of small regions of very low luminosity embedded in brighter auroral light; the 'black' rays reported from the Appleby could have been a phenomenon of this type." (R6) In other words: a contrast phenomenon.

X7. General observations. Black auroras may actually be more than just the contrast effect suggested by Livesey. (X6) Low-light TV systems detect clockwise vorticity in the black bands, and the bands seem to be associated with upward electron beams. In other words, black auroras are apparently a distinct phenomeon in their own right and not just non-luminous parts of the visible aurora. (R7, R9) However, Livesey's explanation is seconded by another study also using low-light TV systems.

"Characteristics of eastward drifting forms described in the literature as black aurorae, have been identified in low-light-level TV camera data...On the basis of these observations, we propose that these auroral forms are a manifestation of folds of waves on the borders of auroral bands. (R8)

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R3. Nelson, Edward M.; "A Black Aurora," English Mechanic, 77:168, 1903. (X3)
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R8. Schoute-Vanneck, H., and Scourfield, M.W.J.; "Drifting Black Aurorae?" Journal of Geophysical Research, 95:241, 1990. (X7)
R9. Stenbaek-Nielsen, H.C., et al; "Why Do Auroras Look the Way They Do?" Eos, 80:193, 1999. (X7)

GLA23 Banded Skies

Description. Arrays of luminous stripes or bands radiating from one horizon and converging on the opposite horizon. (They are, of course, actually parallel.) The filmy, hazy stripes may number from three to a dozen or more. Widths range from 2^{o} to about 5^{o}, with dark intervening spaces of approximately the same width. The bands may be oriented in any direction. Slow movement perpendicular to the lengths of the lines is often observed. Stars shine through these gauze-like structures, which may pulsate, disappear, and reappear like many other aurora-like phenomena.

Background. Some obvious contradictions appear in the several specific examples presented below. This is a clue that we may be dealing with two or three different but geometrically similar phenomena.

Data Evaluation. Many highly qualified sky observers have seen and described banded skies. Rating: 1.

Anomaly Evaluation. If auroral in nature, the variable geometry and orientation are puzzling. If the banded sky is a cloud phenomenon, the origin of the pattern of ice nuclei presents a problem. If we are contending with an air-glow phenomenon, how does one account for such regularity over the hemisphere of the sky? Composite rating: 2.

Possible explanations. Many possibilities exist and they may not be mutually exclusive: (1) Systems of gravity waves create the glowing stripes; (2) Banded skies are simply remarkable auroral displays; (3) The bands are formed from meteoric or cometary debris arranged in windrows by gravity waves or circulation patterns (See R9 and X16.); (4) Aligned bands of cirrus clouds (GWC) are mistaken for an auroral display.

Similar and Related Phenomena. Related phenomena: auroral pillars (GLA1); auroral arches (GLA2); auroral meteors (GLA3), especially some of the air-glow events; possible identity of auroral displays and daytime clouds (GLA12); black auroras (GLA22). Similar phenomena: magnetically aligned cirrus clouds (GWC); radial spokes and similar atmospheric disturbances on Venus (AVO).

Examples of Banded Skies

X1. July 10, 1874. Halifax, Nova Scotia. "On looking towards the comet about a quarter to one o'clock on the morning of the 10th of July, long lines of dark and luminous clouds lay across the sky, diverging from the N.N.E. and S.S.W. points of the horizon. They lay on the west of the zenith chiefly, and their distance apart, or the width of the dark bands, was about 2^{o} near the zenith. After careful observation for some minutes the bright bands were seen to change in brightness two or three times a minute. Soon the dark spaces were crossed by scores of narrow bright bands, thus covering the sky as with the most delicate lattice work." (R1)

X2. December 5, 1892. Honeymeadbrook Station, New York. "I will add that at 10:45 P.M., Dec. 5, 1892, I saw, to me, an unique phenomenon. The moon was shining brightly, when diverging bands from the horizon in the north-north west spread at the zenith 60^{o} wide and converged again at the horizon in the south-south east. They were like thin clouds, through which the stars were easily seen. The belt of Orion was exactly then in their midst. I can liken their shapes to nothing more than the vibrations of a cord, stretched from horizon, over zenith, to horizon again. But they were stationary, and had so far disappeared at 11.30 P.M. standard time, that only curious traces and patches remained. I fancy that had not the moon been shining, these beautiful bands would have shown luminosity. I judged that the radiating point in the north north-west was a trifle west of the magnetic meridian there; but our western declination here is some nine degrees. These were, of course, parallel bands, the divergence and convergence points being the effect of perspective." (R2)

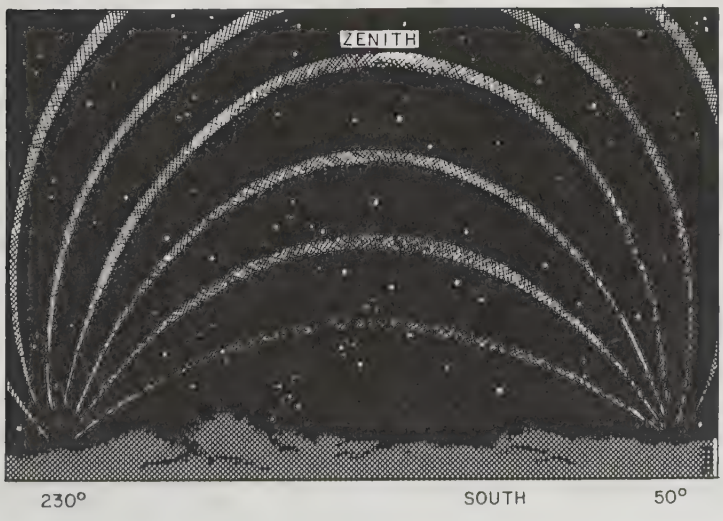
X3. October 11, 1903. England. "On the evening of October 11, 1903, after a fairly active display, the aurora disappeared, but its place was taken by a system of narrow bands of cirrus clouds stretching right across the sky, which, being illuminated by the bright moon, had all the appearances of the aurora. That they did not form part of the aurora could only be decided at first owing to no line appearing in the spectroscope when pointed at them; but later there could be no doubt, as they partly obscured the moon." (R3)

X4. October 2, 1921. England. "At 8.12 P.M. a fan-shaped white cloud was seen radiating from S.S.E. It spread into streamers with dark sky spaces between. The clouds crossed to W. of N.; the stars shown through them, and as they sank in the north they had all the appearance of auroral lights. These long parallel clouds with clear sky spaces between have been seen on many occasions and always moving to or from north. They move very slowly and seem to be at a higher level than ordinary clouds. They do not show the diffraction colours of a lunar corona, and they do not always cause a lunar halo." (R4)

X5. January 30, 1922. Cumberland, England. "Instead of the usual streamers, with radiant in N. moving across the sky, which were quite absent, faint parallel bands of luminosity crossed the heavens in a due E. and W. direction, and these never moved. I counted ten such bands between the Dipper and Ursa Major and Leo, with dark spaces between of about equal width, and they seemed to extend also N. and S. of this region indefinitely. They were of pale white colour, but at 1.30, suddenly, an exquisite crimson glow filled the sky, the colour occurring in large areas that seemed to shift continually, while the pale bands shone immovable over all." (R5)

X6. September 9, 1932. Cumberland, England. "There was a very definite display of banded sky on this date. Irregular bands, fainter and narrower than the Galaxy, radiated from horizon points B 50^{o} and 230^{o}, but were almost entirely absent from W. area of sky. About 6 bands were counted at 00 30, the most conspicuous and broadest following closely the ecliptic. From Vega to Ursa Major the sky was clear and dark. From Aries to Aquarius, including the great square of Pegasus, was also dark, but a luminous patch was seen at times within the square of Pegasus. The rest of the sky was luminous and banded, of intensity estimated to be about half that of the Galaxy in Cygnus." (R6, R7)

X7. February 1, 1950. North Atlantic. "Three bands of light of a uniform width of about 2^{o} were observed apparently radia-



Six luminous bands crossed the English skies in an east-west direction in 1932. (X6)

ting from a point on the SW horizon and passing vertically overhead. The direction in which they were lying was roughly 220°. The bands were quite distinct even though the moon was shining brightly. The two lower, or S'ly ones stretched from the point on the horizon to a position 20° to the south of the zenith, beyond which they were obscured by cumulus. The third one lay to the north of the others and was much shorter, starting from a position directly overhead and fading away in a 040° direction, leaving a band of light which gradually diminished in intensity, the whole representing an angular distance of 15°." (R8)

X8. General observation. "At times there is a strange luminosity in the sky at night. More or less extended areas glow faintly or stretch in bands across the sky. Such bands have been observed simultaneously at widely separated points, such as in Middle-Europe and in Scotland. Although occurring prevailingly in the northern sky, and often mistaken for some form of auroral effect, these bright areas are evidently not of that nature, because the light is steady, the streaks run prevailing from east to west, and the phenomenon is not accompanied with marked magnetic disturbances as in the case with the aurora." (R9, R10)

X9. General observation. "There is another phenomenon that has been visible on a number of nights of last year, and also in the present year, of which I have seen no record. This consists usually of long strips of diffused luminous haze. I believe that this is really ordinary haze, which for some reason becomes self-luminous. It is not confined to any particular region of the sky nor to any hour of the night. It always has a slow drifting motion among the stars. This motion is comparable with that of the ordinary hazy streaky clouds that are often seen in the daytime. They are usually straight and diffused and as much as 50° or more in length and 3° or 4° or more in width. In some cases they are as bright, or nearly as bright, as the average portions of the Milky Way---that is, they are decidedly noticable when one's attention is called to them. They apparently are about as transparent as ordinary haze. Sometimes, when near the horizon, where they may be quite broad, they have strongly suggested the 'dawn' or glow that precedes a bright moonrise. Their luminosity is uniformly steady." (R11-R13)

X10. General observation. Banded skies often called 'non-polar auroras.' Some displays seem unrelated to auroras. May be due to waves in the atmosphere. (R14)

X11. March 14, 1841. England. A splendid display of luminous cirri (?). The streaks would sometimes shoot across the sky. (R15)

X12. 1894. Louth, England. White streamers radiated from north through zenith to southern horizon. Disappeared and then reappeared. (R16)

X13. October 11, 1897. Balmain, U.K. Beams of light radiated from a point south of the moon. (R17)

X14. 1920. Stowmarket, England. Curious bands of clouds radiated from magnetic north, converging on SSE horizon. (R18)

X15. August 4, 1921. England. Luminous streaks with dark gaps in south. (R19)

X16. August 8, 1921. Germany. Luminous bands seen in sky. (R20) These bands appeared in Germany at the same time a mysterious bright object was seen near the sun from California. (R21) See AEO.

X17. October 7, 1956. Equatorial Pacific. Streaks of milky-white light ran east and west across the sky at an altitude of 50°. Horizontal width was 30°; bands 1-2° wide. Sky was completely overcast. The moon had not risen yet. (R23)

X18. July 7, 1914. Stowmarket, England. "About 9 P.M. in the north-west, where the light of the sun was still reflected from below the horizon, steady beams of white light were projected up into the sky like searchlights and remained stationary for nearly two hours. From the south-east the light of the rising Moon (Moon-rise 8.57 P.M. and Moon 'Full' at 2 A.M.) projected another series of white beams, whose focus remained the same after the Moon's altitude had increased. Between each distinctly defined beam the stars could be clearly discerned." Some of the rays from the northwest and southeast met at zenith. As the moon rose it became obvious that it was not the center of the southeast rays. (R24)

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R15. Stevenson, William; "Abstract of Observations on the Aurora....," Philosophical Magazine, 4:6:20, 1853. (X11)
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GLA24 Millisecond Brightness Pulsations of the Night Sky

Description. Flickers of light in the night sky in the millisecond range. This category may include more than one distinct phenomena.

Data Evaluation. The millisecond flickers or pulsations are well-established phenomena that have been detected by a variety of optical equipment. They have been duly recorded in the science literature. Rating: 1.

Anomaly Evaluation. The origin(s) of the millisecond brightness pulsations are

unknown. Their sources are likely terrestrial, but solar activity could be involved, too. Rating: 2.

Similar and Related Phenomena. Transient sky-brightenings (GLA14); rocket-lightning, sprites, etc. (GLL1).

Examples

X1. General observation. About 1970, during a search for pulses of fluorescence caused by cosmic-ray photons, short atmospheric brightness pulsations were discovered. These lasted about 1 millisecond and consisted of damped oscillations at a frequency of about 10 kilohertz. These pulsations are not visible to the naked eye. Origin unknown, although they seem to have a terrestrial origin. (R1)

X2. Study results. The brightness pulsations mentioned in X1, were studied over a period of 4 years (1972-1976) using a wide-angle photomultipler system. The pulsations were concentrated in the autumn and winter months and seemed to be related in some way to solar activity. (R2)

X3. September 22-23, 1989. North America. Anomalous light flashes were detected above Hurricane Hugo by the Minnesota-based SKYFLASH equipment. Hurricanes, of course, are accompanied by thunderstorm activity, but curious "long" events of unknown origin were also recorded. GLA24 seems to be the proper category for these events.

SKYFLASH apparatus consisted of three photmetric telescopes using photomultiplier tubes with 19-inch parabolic mirrors. A variety of light pulses appearing in the night sky have been recorded during SKYFLASH surveys, including some related to a class of thunder-storm luminous phenomena now called "sprites," "elves," etc. (GLL1)

The most puzzling types of flashes detected during Hurricane Hugo were these "long" events, which lasted about 20 milliseconds, with slow rises and falls. During the "long" flashes, no sferics (radio disturbances associated with lightning) are detected, whereas the more common shorter flashes are accompanied by sferics. During Hurricane Hugo, these mysterious "long" flashes occurred much more frequently than usual. The origin of these "long" flashes remains unknown. (R3)

The millisecond brightness pulsations recorded in X1 and X2 may or may not be related to the "long" events detected by SKYFLASH.

References

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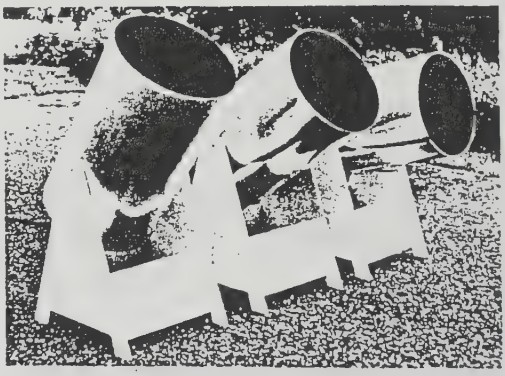

SKYFLASH photometric telescopes monitoring three different elevation angles. (X3)

GLA25 False Dawn

Description. A transient brightening of the eastern sky one to two hours before the true dawn. Perhaps related is the popular observation that the night is darkest just before dawn.

Data Evaluation. Most support for this predawn sequence comes from folklore and popular belief. Little scientific observation has been discovered. Rating: 3.

Anomaly Evaluation. If, as some maintain, the false dawn is simply the zodiacal light, there is no real anomaly. However, one would not expect the zodiacal light to disappear suddenly and completely before the true dawn. Rating: 3.

Possible Explanations. The zodiacal light probably accounts for this phenomenon. Subjective considerations are important in such low levels of illumination. Little objective work has been done here. See AZO for zodiacal light anomalies.

Similar and Related Phenomena. The zodiacal light (AZO); transient sky brightenings (GLA14)

Examples of the False Dawn

X1. General observations. "The first line of the second quatrain of the Rubaiyat of Omar Khayyam (Fitzgerald's translation) runs as follows: 'Before the phantom of False Morning died.' In the commentary by H. M. Batson on the Fitzgerald translation of the poem, the following remark is made regarding the line just quoted: 'Before the dawn comes the false dawn, a transient light on the horizon which Persians call blue dawn or morning grey; it appears an hour before daybreak, and is a well-known phenomenon in the East." Based on personal observations in South Africa, the author identified the false dawn with the zodiacal light. (R1)

X2. January 7, 1933. England. "I got out of the car and found the rain had ceased and strolled up and down for a few minutes, when I suddenly realised that it was getting light, and at first I thought it was the dawn, but knowing it was only about 5 a.m. I realised I was mistaken, but very unfortunately I cannot give exact times. But the time was almost certainly about 5.10 a.m.. It became so light that I was able to see the surrounding countryside. I could see the Dorsetshire hills sufficiently plainly to see that the clouds lay on their tops and that they were clear below, and I was able to turn off my headlights. The light was a general diffused light with no apparent focal point, but I should say it was lighter towards the south and east, although I could quite well see towards the north and west, and here again I failed to note times; but this condition lasted for probably about 20 minutes, after which period, and almost as suddenly as it appeared, it became quite dark again." True dawn commenced about 7.30 a.m. (R2)

X3. General observation. The following is attributed to W. F. Denning, the English meteor authority: "Before dawn a greater darkness seems to drop down like a mantle upon the immediate surroundings. Objects which were plainly observable during the previous hours of the night are blotted out, and a nervous feeling is sometimes induced by the dense opacity of the air." (R3)

References

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R2. Cumming, J. H.; "False Dawn," Meteorological Magazine, 71:189, 1936. (X2)
R3. "Darkness before Dawn," Scientific American, 111:331, 1914. (X3)

GLA26 Auroras Following Coastlines

Description. The tendency of auroras to align with seacoasts.

Data Evaluation. Our sole source so far is an article in a science magazine, which is based upon the conclusions of two teams of scientists. Said conclusions and supporting data were presented at a 1998 meeting of the American Geophysical Union. Rating: 2.

Anomaly Evaluation. The mainstream view has long been that auroras are decoupled from influences of the earth's surface by distances greater than 70 kilometers. The claimed influence of terrestrial topography upon auroral shapes severely undermines this belief. Rating: 2.

Possible Explanation. Some auroras, particularly the very intense ones, involve a flow of electrical charge between the earth's surface and the ionosphere. This flow of charge would obviously be influenced by mountains and coastlines.

Similar and Related Phenomena. Low-level auroras (GLA4); rocket lightning (sprites, etc.) (GLL1); mountain-top glows (GLD1); auroral sounds (GSH3 in Earthquakes, Tides...)

Examples

X1. General observations. Auroral arcs are thought to be created by electrical currents flowing high in the ionosphere ---usually higher than 80 kilometers according to current [!] thinking. Therefore, scientists do not really expect to see terrestrial topography reflected in auroral geometry. Nevertheless, T. Pulkkinen of the Finnish Meterological Institute reported to the May 1998 meeting of the American Geophysical Union that coastlines somehow coax auroral arcs to align with them. In some 200 hours of observation along the Norwegian coast, there were nine clear-cut cases where auroral arcs lined up north-south directly above the coastline. These alignments lasted 5-10 minutes.

L. Frank (of icy-comet notoriety) confirmed this effect with observations from NASA's Polar satellite. Sometimes auroral arcs aligned themselves parallel to the Greenland coast for hundreds of kilometers. Auroral arcs that fanned out east-to-west seemed to hit a barrier when they reached the Greenland coastline; they seemed to be deflected by it, even though the coast was more than 100 kilometers beneath them. (R1)

Reference

R1. Hecht, Jeff; "Leading Lights," New Scientist, p. 16, May 30, 1998. (X1)

GLA27 Challenges to the Theory of Aurora Origin

Description. Satellite observations that deny the existence of: (1) the long-accepted charge-accelerating mechanism for aurora production; and (2) the assumed positive correlation of auroras with solar activity (the accepted source of aurora-producing particles).

Data Evaluation. Results of satellite observations as reported in science journals and magazines. Rating: 2.

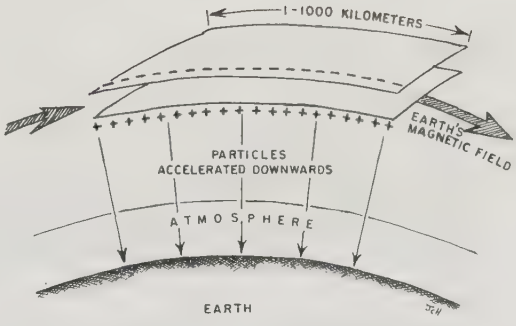
Anomaly Evaluation. The accepted origin of auroral displays is severely challenged. Rating: 1.

Possible Explanations. Most auroras are slow electrical discharges between the earth and ionosphere.

Similar and Related Phenomena. Low-level auroras (GLA4); rocket lightning (sprites, etc.) (GLL1); mountain-top glows (GLD1); auroras following coastlines (GLA26); auroral sounds (GSH3 in Earthquakes, Tides...).

Examples

X1. Absence of double-charge layer. "For the past 20 years, most atmospheric physicists have believed that auroras are generated by 'double layers' of electric charge (see diagram). The layers lie parallel to the earth's magnetic-field lines, which are themselves parallel to the earth's surface at high latitudes. According to the theory, the layers are between a kilometre and a thousand kilometres across. The potential difference across the double layer would accelerate particles down into the atmosphere, producing the auroras." But data from the Chemical Release and Radiation Effects Satellite (CRRES) belie the existence of these postulated double layers of charge. (R1) The fundamental aurora-generation mechanism, therefore, seems to be missing. But the following anomaly leads to a radically different potential mechanism.



One theory of auroral origin envisages a double layer of electrical charge above the earth's atmosphere. (X1)

X2. Lack of correlation between intense auroras and solar activity. Down the centuries, observers in the Temperate Zones have recorded many great auroras. These do appear to be well correlated with increased solar activity, as determined by the number of sunspots. However, these auroras are only a small minority of the intense auroras, most of which are confined to polar regions and, therefore, go unrecorded. In fact, the auroras seen in the Temperate Zones contribute only a negligible amount of energy to the upper atmosphere compared to the total.

When all auroras are included in the correlations, a completely different picture emerges. Based upon data from the U.S. Air Force Defense Meteorological Satellite Program, P.T. Newell et al reported as follows:

"We find that contrary to expectations, the total number of intense aurorae is uncorrelated with solar activity in darkness, and is negatively correlated with solar activity in sunlit conditions. These findings imply a causal relationship between aurorae and ionospheric conductivity (the latter is maximal at solar maximum) and therefore indicate that the occurrence of intense aurorae is a discharge phenomenon, similar to lightning." (R2)

Low-conductivity channels in the atmosphere and ionosphere might explain the anomalous electrical discharge phenomena listed above under Similar and Related Phenomena.

References

R1. Bown, William; "Theory of Aurora Comes into Question," New Scientist, p. 23, November 23, 1991. (X1)
R2. Newell, Patrick T., et al; "Relation to Solar Activity of Intense Aurorae in Sunlight and Darkness," Nature, 393:342, 1998. (X2)

GLA28 Flash Auroras

GLA28 FLASH AURORAS

Description. Short-lived, aurora-like luminous phenomena in the night sky, such as ephemeral rays and patches of light.

Data Evaluation. Evidently, flash auroras are rather common but rarely reported in the literature. We have only one article from a British journal for amateur astronomers. Since flash auroras last only a few seconds and appear randomly in various parts of the night sky, they are obviously poor subjects for research. Rating: 3.

Anomaly Evaluation. The cause of flash auroras is unknown, but this phenomenon seems to be only a minor mystery of auroral science---"noise" in the auroral record! Rating: 2.

Possible Explanation. None offered.

Similar and Related Phenomena. Transient sky brightenings (GLA14); millisecond brightness pulsations of the night sky (GLA24); longer-lived transient luminous patches of light (GLA31).

Examples

X0. Flash auroras are ephemeral auroral displays that last only a few seconds. They occur when auroral and geomagnetic activity is otherwise subdued worldwide. Under such quiet conditions, scientists do not expect to see auroras of any kind. Yet, experienced aurora observers keep reporting these strange transient events, two of which follow.

X1. June 13/14, 1987. Winnipeg, Saskatchewan, Canada. T. Lohvinenko saw a fragmentary active rayed arc in a clear sky at 0644 UT. It lasted for only a few seconds. (R1)

X2. February 13/14, 1991. Near Glasgow, Scotland. While facing south, A. Simmons observed rays and a luminous patch at an altitude of 45°. The phenomenon lasted only 2 minutes. (R1)

In both of the above instances, the geomagnetic field was quiet and auroral activity virtually zero worldwide. The origin of flash auroras remains mysterious.

Reference

R1. Livesey, R.J.; "The Flash Aurora," British Astronomical Association, Journal, 107:36, 1997. (X1, X2)

GLA29 Possible Atmospheric-Laser Emission Accompanying Auroras

Description. Strong electromagnetic emissions in the micron range associated with auroras.

Data Evaluation. We have only a brief mention of the phenomenon in a 1982 issue of a science magazine. It is likely that more information on this subject is now available elsewhere. Rating: 3.

Anomaly Evaluation. The most probable source of the microwave emission from the earth's atmosphere would be a laser. However, as of 1982, none had been found, although a laser optically pumped by the sun had been identified in the atmosphere of Mars. Of course, there might be some other unsuspected source of the emissions. One also must ask why there is a strong association with the occurrence of auroras---usually observed only at night---if the postulated laser is optically pumped. Rating: 2.

Possible Explanations. A terrestrial atmospheric laser somehow responding to the same energy influx that causes auroras.

Similar and Related Phenomena. Atmospheric lasers on other planets.

Examples

X1. General observation. The following quotation attributed to M. Mumma appeared as an aside in a long article on planetary lasers. "It is interesting to note that terrestrial aurorae are accompanied by very intense molecular emission near 4.3 microns, suggesting that a search for lasers in the earth's atmosphere is warranted." (R1)

Reference

R1. Raloff, J.; "Gould Laser Patent Ruled Valid---So Far," Science News, 121:199, 1982. (X1)

GLA30 Mysterious Bright Streaks in the Sky

Description. Roughly parallel streaks on the horizon consisting of luminous dashes all moving in the same direction. (See sketch.) The phenomenon recurred on four successive nights while flying over the Pacific but not on the fifth night when flying over the continental United States.

Data Evaluation. A letter from an Air Force officer who was piloting an aircraft when the phenomenon was observed. The phenomenon was observed by the rest of the crew, but it was not reported by any of the many other aircraft that must have been flying over the Pacific on the four days mentioned in the letter. Rating: 3.

Anomaly Evaluation. This is a unique and bizarre observation completely at odds with all other luminous phenomena collected in the volume. Rating: 1.

Possible Explanation. One is tempted to associate the phenomena with aircraft itself, perhaps defects of the cockpit windows, or perhaps condensation of some kind on the windows.

Similar and Related Phenomena. None known.

Example

X0. Background. Our general policy admits preferentially those phenomena described in the scientific literature, but here we make an exception. The account below (X1) was submitted by a retired Air Force colonel. It is unlike anything we have found before---either meteorological or auroral.

X1. August 1970. North Pacific Ocean.

"During the last week of August 1970 I was on a trip from Viet Nam to Clark AFB, Philippines. We were cruising at 9000 feet. We had departed Camron Bay between 2 and 3 AM. Upon reaching cruise altitude, I noticed a rather un-

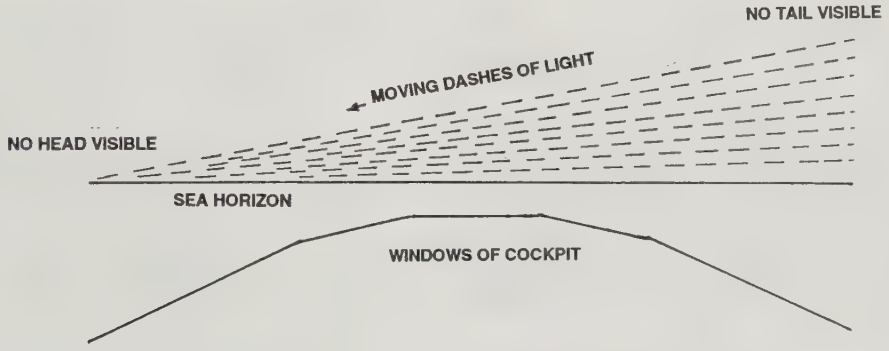
usual display in the sky. Our magnetic heading from V.N. to Clark was approximately 155°. The display appeared on the horizon in an easterly direction. It consisted of a series of dashes perhaps the color of the moon with a south-to-north directional flow. There was no visible beginning of this display,such as you would see in a comet.....

"The awesome feature of this display was its magnitude. I thought if whatever was creating the display collided with our Earth, then we would no longer exist. I also feel that I was seeing only a small portion of the whole. As hindsight I can only regret that I did not report this sighting through Air Traffic Control channels. The crew discussed and speculated on what we had seen, then promptly forgot about it." (R1)

The account continues, relating how on the next night, when the aircraft departed the Philippines for Guam and Wake Island, the same phenomenon appeared in the east, although the plane's heading was then about 60°. The display appeared unchanged on two more nights on the legs from Wake to Hawaii and Hawaii to California. On the fifth night, however, from California to Washington, DC, nothing was seen. (R1)

Reference

R1. Silva, John J.; personal communication, December 28, 1985. (X1)



On four successive nights in 1970, the crew of a U.S. Air Force plane observed arrays of moving dashes of light over the Pacific Ocean. (X1)

GLA31 Short-Lived, Bright, Cloud-Like Patches High in the Sky

Description. Bright patches high in the night sky that appear suddenly and dissipate in a few minutes.

Data Evaluation. Two high-quality records from ships in the Caribbean. Rating: 1.

Anomaly Evaluation. Since our two records occurred after 1960 east of Kennedy Space Center, it is very probable that the phenomena are related to rocket launches or satellite operations. Indeed, one event seems synchronous with a barium release from a satellite. With such ready explanations, this type of luminous phenomenon cannot be classified as anomalous. Rating: 4.

Possible Explanations. See above.

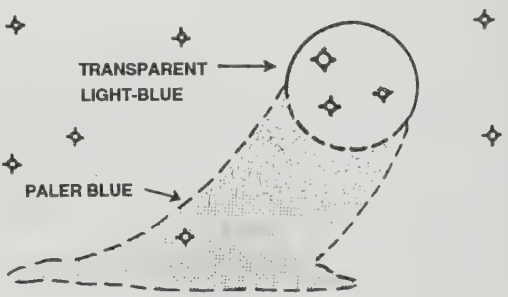
Similar and Related Phenomena. Bright luminous patches on the horizon, some of which can be related to rocket launches (GLA15).

Examples

X1. January 13, 1991. Caribbean Sea. Aboard the m.v. Trinidad and Tobago.

"At 0210 UTC whilst the ship was proceeding eastwards along the north coast of Trinidad, a relatively bright patch was noticed in the almost cloudless sky and was thought to be a cluster of stars. Its bearing was approximately 300° at an elevation of about 50°, and closer inspection through binoculars revealed a rather strange phenomenon, as shown in the sketch.

"The bright patch was a perfect circle of a bright, light-blue colour and was transparent as stars could be seen through it. There was also a trail from the circle which looked like the track a disc would describe if it moved through an arc. This trail was also of light-blue colouration but was not nearly so bright as the circle. The entire phenomenon dissipated after about five minutes. " (R1)



A strange optical phenomenon seen off the coast of Trinidad in 1991. (X1)

The strange optical phenomenon reported above may have been the consequence of a barium release from a NASA satellite. At 9:17 PM EST, on January 13, 1991, the Combined Release and Radiation Effects Satellite (CRRES) detonated a small canister of barium over South America. The greenish glow was visible from the U.S. southeast coast in the southwestern sky.

X2. June 6, 1992. Caribbean Sea near Puerto Rico. Aboard the Eye of the Wind. About an hour before sunrise, a luminous white "cloud" was noticed directly overhead. It was about 10° across and had the appearance of cirrostratus lit by the moon. As this "cloud" was fading and dispersing a second phenomenon like it appeared to the southwest of the first. (R2)

X3. September 17, 1982. South Atlantic Ocean. 2103 GMT on a clear dark night.

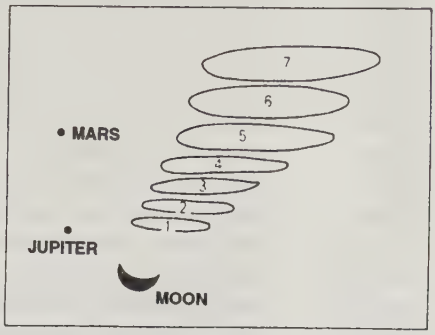
"The first thing noticed was the formation of a bright patch of white light in the general area between Rasalhague and Alphecca. Gradually a dark eye formed in the centre of the patch in which shortly afterwards a very bright object appeared like a star of magnitude -2. After one or two seconds this object appeared to undergo a tremendous explosion and became a large bright orange gaseous fireball, which appeared to be hurled earthwards directly down the observer's line of sight, growing constantly larger and larger. One witness described the fireball as resembling rolling orange smoke. The ball then ceased to increase in size, giving the impression that it had stopped. Its orange colour rapidly gave way to rainbow colours which gradually gave way to white and faded in brilliance until all that remained were several patches of luminous white light, although these were impressive in their own right." (R3)

A similar phenomenon was noted the following night, although the ship was 7° farther south.

X4. September 18, 1982. South Atlantic Ocean. From a different ship in the same area as the one above.

"The altitude of the first sighting was approximately 24°, level with the planet Jupiter and offset to its right. The six subsequent bursts were above the first, and slightly to the right, leaving a fantail of purple/white lenticular clouds which leaned to the right as shown in the sketch. Although they all kept their lenticular shape, the final burst did break up, giving the appearance of being in a gaseous state. Each burst commenced as a pinprick of bright, white light expanding rapidly to at least 2½ times the diameter of the sun." (R3)

The above observations were made aboard ships 300-400 miles off the coast of Brazil. The only event correlated with the phenomena was a meteorological rocket said to have been launched on September 18. Rocket launches do provide spectacular luminous phenomena offshore from Cape Kennedy, but the above phenomena do not seem consistent with small meteorological rockets.



The sequence of expanding, white lenticular luminosities observed at sea off the coast of Brazil in 1982. (X4)

References

R1. Knight, M.; "Unidentified Light," Marine Observer, 62:22, 1992. (X1)
R2. Timbs, A.R.; "Unidentified Light," Marine Observer, 63:69, 1993. (X2)
R3. Anonymous; "Unidentified Phenomena," Marine Observer, 53:132, 1983. (X3, X4)

GLB BALL LIGHTNING

Key to Phenomena

GLB0 Introduction

Ball lightning is one of nature's most mysterious manifestations. Basically, ball lightning is a mobile, luminous mass, usually spherical in shape, that accompanies such violent natural phenomena as thunderstorms, tornados, and earthquakes. It is one of those rare natural anomalies recognized by science as real but which eludes all attempts at explanation.

One reason ball lightning resists explanation is that it is so variable. It may be as small as a pea or larger than a house. It may be violet, red, or yellow, or even change colors during its brief life. Ball lightning is generally spherical, but rods, dumbbells, spiked balls, and other shapes have been sighted. Sometimes ball lightning appears to have a snake-like internal structure; long crinkled tails may be attached to the balls.

Ball lightning is a dynamic entity. It may glide silently and disinterestedly past an observer or it may inquisitively explore a room as if directed by intelligence. While a few of these enigmatic apparitions dematerialize silently, most explode violently. One has to hedge about the location of the sound for the actual explosion sometimes seems to occur elsewhere---outside the house in which the ball has appeared for example. This observation plus the frequent materialization of ball lightning in closed rooms and metal aircraft suggest that electrical induction may be involved in some cases. In other words, electrical forces from an enveloping thunderstorm may create a glowing ball of plasma in the air inside a closed container similar to the St. Elmo's Fire induced on pointed objects. When the electrical forces disappear (usually with a peal of thunder), the ball lightning vanishes, too. Observers, however, have no doubt that something palpable has visited them because the room is usually filled with the smell of electricity (ozone), and there may be smoke and much material damage.

No reasonable explanation exists for ball lightning. Glowing spheres of plasma created by natural electromagnetic forces have been proposed and found wanting. Antimatter meteorites, chemical reactions in the atmosphere, and intense cosmic radiation have also been proposed. None seems adequate. The sheer difficulty of accounting for ball lightning has led some scientists to assert that all observations of this phenomenon are illusory---aberrations of the eye and brain. But photographs of ball lightning do exist, and thousands of seemingly sound observations exist in the literature. Ball lightning seems very real.

GLB1 "Ordinary" Ball Lightning

Description. Luminous spheres or near-spheres with diameters between roughly 1 inch and 5 feet, with 5-15 inches being most common. Ball lightning moves freely in the atmosphere, descending from clouds and following tortuous paths in the open air, sometimes against the wind, and wending its way around rooms in buildings almost as if it were inspecting the premises. The color is often yellowish, reddish, and bluish white, but purple and green fireballs have also been seen. The luminous spheroids may be sharply defined, fuzzy, or surrounded by a sort of halo. A hissing or buzzing sound sometimes accompanies them. Although ball lightning often appears silently it almost always disappears with an explosion. In its wake, it may leave a sulfurous or "electricity" smell. Lifetimes range from a few seconds to 10 minutes and more. Ball lightning is almost always associated with thunderstorm activity.

Background. Ball lightning or globe lightning was long doubted by scientists. Observations, even by reliable and competent individuals, were rejected as optical illusions or misidentifications of other natural phenomena. Yet, so many good observations have occurred in recent years and our knowledge of plasma phsyics has advanced so much farther that the reality of ball lightning is now generally accepted. The explanation of this phenomenon, however, still eludes us.

Data Evaluation. Hundreds of good reports, many by physical scientists, make ball lightning one of the best documented of all scientific anomalies. Rating: 1.

Anomaly Evaluation. Ball lightning is still an enigma to physicists. Scientists do not yet know how so much energy, as evidenced by its tremendous destructive power, can be confined so long in a detached, freely moving sphere. Rating: 2.

Possible Explanations. The explanation of ball lightning's shape and stability probably resides in the relatively new field of plasma physics. In other words, some sort of electromagnetic bottle confines the essential substance and energy. Early scientists thought that the substance of ball lightning was probably only combustible gas, but calculations show that much higher energy densities than those in, say, methane, are needed. It is fashionable now to talk in terms of highly energetic metastable states of molecules. So energetic are

some examples of ball lightning that one investigator even proposed antimatter meteoroids! Some of the examples classified as ball lightning below may actually be only unusual cases of St. Elmo's Fire and corona discharge---especially those that seem to simply fade away without a detonation.

Similar and Related Phenomena. All of the other types of ball lightning described in this section are probably generically related. Also related are: St. Elmo's Fire (GLD); bead lightning (GLL), and corona discharge. Low-level meteors (GLM) and will o' the wisps (GLN) sometimes emulate ball lightning.

Examples of "Ordinary" Ball Lightning

X1. March 1731 or 1732. No place given. "On Sunday the 12th of March, 1731 or 1732 (the exact year seems to be uncertain) while walking in his garden between one and two o'clock in the afternoon he (Rev. A. Vievar) heard as it were a loud clap of thunder from the northeast. While looking into the air the noise was repeated very loud, but seemed more like the violent fall of a house, so that he expected every moment an outcry from the town; but he was soon undeceived when it began again, and he found it made towards him, with a different noise from the former, being like the grinding of flint stones, but very loud. The object seemed to be about three feet wide. He found it sink in the air and as it seemed to point directly at his head, he laid himself down on a grass slope to let it pass over. However, at the upper end of the walk it fell to the ground and came rolling down the grass walk and he can compare it to nothing better than to that of a violent grinding of flint stones, or a coach and six at full speed on a causeway of loose stones. He lay attentive, expecting to see something, and saw a piece of wood come running before it. When the phenomenon came to the water side it twisted up a large stake that stood in its way and tossed it toward him with much violence, and immediately fell into the water, with the violence and noise of a red-hot millstone."(R1) Unlike most examples of ball lightning, this one relates little about the luminous aspects. The phrasing and punctuation are typical of the period.

X2. 1843. France. "After a loud thunderclap, the tailor being finishing his meal, saw the chimney-board fall down, as if overset by a slight gust of wind, and a globe of fire, the size of a child's head, come out quietly and move slowly about the room, at a small height above the floor. The tailor said it looked like a good-sized kitten, rolled up into a ball, and moving without showing its paws. It was bright and shining, but he felt no sensation of heat. The globe came near his feet, like a young cat that wants to rub itself against its master's legs; but by moving them aside gently, he avoided the contact. It appears to have played for several seconds about his feet, he bending his body over it and examining it attentively. After trying some excursions in different directions, it rose vertically to the height of his head, which he threw back to avoid its touching his face. The globe, elongating a little, then steering towards a hole in the chimney above the mantlepiece, which hole received a stove pipe in winter, but was now pasted over with paper. 'The thunder,' he said, 'could not see the hole;' but, nevertheless, the ball went straight to the aperture, removing the paper without hurting it, and made its way into the chimney. Shortly afterwards, and when he supposed it had time to reach the top, it made a dreadful explosion, which destroyed the upper part of the chimney, and threw the fragments on the roofs of smaller buildings, which they broke through." (R2, R17)

X3. July 11, 1874. England. "On July 11th, 1874, whilst occupying my sitting room, which is at the back of the house and above the level of the wall abutting on the fields, I heard a clap of distant thunder, and noticed the sky to be darkened by clouds. At a quarter to four, I noticed that the sky was covered with dense dark thunder clouds, and heard a loud peal of thunder; the wind rose rapidly, and then occurred a most violent storm of wind, accompanied by a deluge of rain, extremely loud thunder, flashes of sheet and forked lightning, and large hail stones. ....After a short lull, I saw a ball of fire of a pale yellow colour

rise behind the houses, on the other side of the fields, apparently from the Regent's Canal. The ball at first rose slowly, apparently about as fast as a cricket ball thrown into the air, rapidly incresing its rate of motion until it reached an elevation of about 30°, when it started off so rapidly as to form a continuous line of light, proceeding at first due east and then to the west, rising all the time; and after describing several zigzags, disappeared into a large black cloud to the west, from which flashes of forked lightning had come. There were two large black clouds near each other, and the ball when it formed the zigzags moved first towards one and then towards the other. In about three minutes another ball ascended, and in about five minutes afterwards a third, both behaving as the first and disappearing in the same cloud...." (R3, R38)

X4. March 21, 1877. Vence, France. "Toward midnight there was observed, about eleven miles north-east of Vence, a large black thundery cloud, in a state of extreme agitation, and continually raising and lowering its position. At the upper part of this cloud three or four balls of fire issued every two minutes, as if from the invisible centre of the cloud, diverging in all directions, and after running a course of from six to eight degrees, broke silently with effulgent brightness. Their apparent diameter, as seen at a distance of eleven miles, was about a degree. They were mostly of a reddish colour, a few, however, being of a yellowish tinge, but all of them assumed a white colour in the act of bursting. Their course, which was horizontal and parallel to the plane of the cloud, was relatively slow, not exceeding two degrees per second, and they bore a strong resemblance to immense soap bubbles, both as regards apparent lightness and general appearance." (R4)

X5. May 1878. Lower Cumber, England. "A singular phenomenon was witnessed here on Wednesday night last, about eleven o'clock. A large fir tree, growing at the gate of the church avenue, appeared all dotted over with twinkling little stars, of a whitish-blue colour, whose rays shed a faint light for some distance around, and filled the surrounding atmosphere with an oppressive and disagreeable odour. These atoms of light in a short time united into a globe of fire at the top of the tree, of a brilliant green, and immediately rose in the air, wafted slowly by a slight breeze---leaving a trail of luminous matter behind it---towards the church tower, against which it struck, smashing the ball into atoms. A few very large drops of rain at this juncture fell, accompanied by a brilliant flash of lightning, and followed by a terrific peal of thunder, when the glittering sparks evaporated." (R5) Apparently St. Elmo's Fire coalesced into ball lightning.

A photograph of alleged ball lightning hovering above a garden. (J.D. Barry, R101)

X6. August 10, 1888. No place given. "Capt. Grace, of the schooner Rebecca Smith, on August 10, 1888, during squally weather with thunder and lightning and heavy rain, observed a bolt of lightning in the shape of a ball fall in a perpendicular (zigzag) line from the zenith and strike the surface of the water less than a length from the vessel's beam. There was apparently no disturbance of the surface when the lightning struck (although this might have been missed in the glare of the lightning), but for a space of at least five minutes after the lightning struck, a thin blue smoke, similar in appearance to powder smoke, was seen to rise from the surface to a height of at least ten feet. The smoking surface was generally circular in form, about twelve or fourteen feet in diameter, and had the spot in which the ball struck for a center. The occurrence took place in broad daylight." (R1)

X7. April 11, 1894. Dunstable, England. "Whilst watching the incessant forked lightning in the east at 2.30 p.m., I suddenly saw a broad spout of fire drop almost vertically from the clouds to the earth. The band of fire was not at all like lightning, as it was ten or twenty times as broad, and formed a continuously, slightly curved line, without the slightest trace of zig-zag. It was like a large ball of ribbon being quickly unrolled, one end being retained in the clouds. The fall was less rapid than lightning, and was accompanied by a dazzling light. It was immediately preceded and followed by the crash of thunder, but the thunder was at the time continuous. The fall appeared to be close by, and I soon after learned that a 'fireball' had descended on the Dunstable side of Luton, near Dallow Farm, about four miles from here. On visiting the spot, and questioning two or three eye-witnesses of the fall, I was told that the 'thunderbolt' was seen as a large 'ball of fire,' that the fall was accompanied by a loud rushing sound and a dazzling intense light." Great damage was done to a barn. (R6)

X8. July 20, 1897. Suffolk, England. "During the thunderstorm of July 20, with which the drought broke up, an elderly man, Thomas Smith, residing in this parish about half a mile from the railway station, was watching the lightning from his cottage door, between 5 and 6 p.m., when he noticed a white ball, 'about the size of an egg,' dancing about in the air 'like rooks when at play.' He watched it through the intervals between two or three lightning flashes, therefore during several seconds. After some interval (perhaps a few minutes), he still standing at the door, his wife just coming down the stairs to him, something seemed to pass between them which felt hot to their faces. Simultaneously Miss Downes, schoolmistress, sitting on the landing above the stairs, felt something hot pass her hair behind, and then in a small bedroom, with open door adjoining, a loud detonation took place; whitewash from the ceiling covered bed and floor, the wall paper was torn, the plaster fissured, and the house filled with a 'sulphurous' smell." (R7)

X9. August 21, 1900. Telemarken, Norway. A storm was approaching. "I had been watching the particularly vivid lightning for some time, when suddenly I saw a streak of 'yellow,' apparently about one inch broad, dart from the sky just above the top of the hill opposite and, gradually falling, make straight for where I was sitting. I was too spellbound to move, and the length of time of the whole occurrence was too short to call the attention of those who were sitting with me. I remember having the sensation that it must hit my forehead, when just as it got in front of the hotel window it changed to a ball of dazzling yellow fire (about the size of a cricket-ball) and then burst with a frightful crash, emitting volumes of violet-coloured flame, which spread in all directions. This must have happened in one or two seconds, but for several minutes afterwards I was completely dazed." (R8)

X10. July 1921. Grindelwald, Switzerland."A dark cloud was noticed approaching from the east, but neither rain, hail, nor snow fell before the occurrence of the fireballs, and only distant lightning had been observed. Suddenly from the air inlet of the large stove, in which a small wood fire was burning, came, practically simultaneously, a large number of very bright round balls of various colours, the largest perhaps nearly as large as my head. Almost at the same moment, a dreadful deafening explosion occurred, and the balls had all vanished. The room was full of a grey smoke---perhaps disturbed dust---and a strong peculiar odour was observed.....The fire had not been disturbed, and none of the fuel was ejected. The guests who were nearest the stove momentarily experienced a slight electric shock, but no one was injured." (R9) These spheres resemble aerial bubbles (GLD7).

X11. July 27, 1952. No place given. "During an electrical storm on the afternoon of July 27, 1952, several witnesses observed accurately the sudden appearance of a ball lightning in a closed room on the ground floor of my house. A few seconds after a lightning stroke in the neighborhood, we observed outside the window a brightly gleaming sphere the size of a fist which moved downward in short serpentine lines. Then this luminous ball penetrated through the closed window pane and entered our room. At a depth of about 1 m it performed a sud-

den turn of 90° parallel to the wall and continued floating another meter further into the room. Thereupon it burst, and the luminous sphere disappeared with a brief deafening explosion. This ball lightning was purplish with a reddish cast which persisted during the entire duration of the phenomenon. It lasted about 3 sec. No damage whatever was caused either on the inside or outside of the room. After the bursting of the luminous ball, we could perceive the typical odor which occurs in the case of electrical discharge." (R10)

X12. August 12, 1956. Tambosk, Russia. "A commercial airliner (LI-12) was struck by ball lightning on 12 August 1956 while flying in the lower Tambosk region of the USSR. Before being struck, the aircraft had been flying at 3.3 km altitude through a slowly moving cold front which contained dense thunderclouds. During a penetration of one thundercloud, where the air temperature was about -3°C, the crew saw a rapidly approaching dark red almost orange fireball 25 to 30 cm in diameter to the front and left of the aircraft. At a distance of not more than 30 to 40 cm in front of the nose, the ball swerved and collided with a blade of the left propeller, exploded in a blinding white flash, and left a flaming tail along the left side of the fuselage. The sound of the explosion was loud enough to be heard over the noise of the engine. No substantial damage could be found. One of the left propeller blades had a small fused area 4 cm along the blade and less than 1 cm in depth. Around the damaged region was a small area of soot, which was easily wiped off." (R11)

X13. 1958 or 1959. Cheektowaga, New York. During a typical summer thunderstorm. "At one point a single lightning stroke was observed coming from a cloud directly over the open field. Some distance above the ground, the stroke divided into two simultaneous branches, each of which moved toward one of adjacent telephone poles. At a distance of some meters above the pole tops the entire lightning stroke disappeared, and in its place two (one over each telephone pole) large luminous spheres appeared. The color was yellowish, much like the flames of a brightly burning wood fire. The diameter at least two or three pole diameters, possibly as much as five or six such diameters (0.4 to as much as 1.2m). The luminous spheres slowly descended toward the pole tops. When the spheres came very near or in direct contact with the pole tops, they exploded with a loud sharp bang. During the extremely brief 'explosion' phase, the spheres appeared to contract (much against my expectation for an event described as 'explosion') and turned brilliant bluish white, as if to indicate much higher internal temperatures. Following the explosion, dark smoke was seen to rise from the pole tops, but it did not persist to indicate a fire." (R12)

X14. May 21, 1973. Newbury, England. "On 21 May 1973 at 2150 GMT I was standing at the front door of my bungalow looking at the northern sky, which was mainly clear of cloud. Suddenly there appeared a luminous object, blue in colour, about the size of a tennis ball, slowly descending towards the earth. At first I thought it was a meteor, but it lacked certain characteristics of meteors; there was no rushing movement, nor was there a trail of luminous sparks often associated with such phenomena. As I watched it, it suddenly vanished completely, leaving no trace. There was at the time, thunderstorm activity in parts of south-east England, but none in the vicinity of Newbury." (R13)

X15. August 6, 1868. Ireland. "Another instance of a remarkable kind is recorded by Mr. M. Fitzgerald as having occurred in the Glendown Mountains in Ireland. He noticed a globe of fire in the air floating leisurely along, it decended from a ridge into the valley and reached a stream about 800 yards from the spot where the observer stood. It then struck the land and reappeared in about a minute, again disappearing and reappearing several times, until it flew across the stream and finally lodged in the opposite bank, leaving a hole where it buried itself. On examination of the track of this meteor, an aperture about 20 feet square was found in the peat where it had first touched the land, with the peat turned up on the lea as if it had been cut with a huge knife; it next made a trench about 20 perches in length and 4 feet deep, afterwards ploughing up the surface to about a foot. Next it

tore away the bank of the stream about 5 perches in length and 5 feet deep, and then hurling the immense mass into the bed of the stream.....From its first appearance till it buried itself could not have been less than twenty minutes, during which it travelled lesiurely as if floating with an undulatory motion through air and land over a mile. It appeared at first as a bright red ball of fire about 2 feet in diameter, but became rapidly smaller, particularly after each dip in the soil, so that it looked not more than 3 inches in diameter when it finally vanished." (R14, R36)

X16. No date given. Omaha, Nebraska. During a thunderstorm. "A sharp crackling noise caused me to look toward a window screen to my left. Then I saw a round,iridescent (mostly blue) object, baseball size, coming toward me. It curved over my head and went through the isinglass (mica) door of the kitchen range, striking the back of the oven and spattering into brilliant streamers. There was no sound and no effect on me except a tingle as it passed over my hair. Later examination showed a tiny hole with scorched edges in the screen and isinglass, and scorch-like marks on the back of the oven." (R15)

X17. No date given. West Yorkshire, England. During a thunderstorm. After one lightning discharge there appeared a ball of light, 'electric' blue in the centre with an ill-defined yellow white fringe, the whole being about 18 in. in diameter. It first appeared from beneath the tree branches on my side of the road, perhaps 20 yards away, and approached slowly with a staggering undulating motion, but keeping approximately to the same height under the trees. As it approached me, it crossed the road gradually and then, when almost opposite me, turned back across the road and slightly backwards, passed through the lodge gates where I lost sight of it. I estimate it moved at a moderate walking pace for 30 yards before I lost view of it and in this time, no changes in size or brightness were noted." (R16)

X18. No dates or places given. Six examples of ignition of inflammable fluids by ball lightning, two of which are presented here. "Distillate was being loaded into the open top of an 8,000 gallon transport truck. 'A ball of light travelled along the fill pipe and down the droptube. It entered the truck compartment and the truck blew up.'" "An observer on a ship several miles from an empty VLCC (very large crude carrier) tanker. 'A ball of light travelled along the deck of the ship and disappeared. Then the ship blew up.'" (R18)

X19. 1556. Gloucestershire, England. Eight people killed by a fiery, sulfurous globe that rolled in through a door. (R19)

X20. 1557. France. An oscillating flame moves about a bedroom. (R11)

X21. July 2, 1665. Norfolk, England. Great gray ball descended during a storm. Did great damage and killed one, lamed others. (R20)

X22. September 1713. Italy. A bluish-white flame rose from a floor, expanded, then disappeared suddenly. (R21, R22)

X23. November 4, 1749. No place given. A large ball of blue fire rolled along water surface, hitting ship and exploding. (R1, R22, R23) Same as GLB7-X5.

X24. July 23, 1763. Hertford, England. Fireball hits church, explodes. (R19)

X25. February 14, 1809. Portsmouth, England. Three lightning balls kill and injure sailors. (R24)

X26. 1841. Milan, Italy. People chase a fireball down the street. (R2, R25)

X27. 1850. North Atlantic. Fireball shatters ship's mast, but no explosion or noise. (R26)

X28. July 5, 1852. Paris, France. Same description as X2, but different date. (R27)

X29. February 13, 1853. Mount Desert, Maine. Many fireballs and purple lightning seen during snowstorm. (R28, R29)

X30. May 23, 1855. Chesapeake Bay. Numerous balls of fire roll quietly around a wharf. Some just faded away; others disappeared with a slight sound. (R1) This may have been St. Elmo's Fire. (WRC)

X31. 1861. North Atlantic Ocean. Three luminous bodies issue from the sea during a squall. In view 10 minutes. (R30)

X32. August 1866. Putney, England. (R31)

X33. 1866. Shreveport, Louisiana. Ball lightning splinters a tree. (R32)

X34. June 30, 1867. Hudson Bay, Canada.

Fireball falls on ship from a cloud, shatters a mast, causes some temporary paralysis. (R33, R34)

X35. July 12, 1868. Guildford, England. Fireball 3 inches in diameter excavates a trench 10 feet long. (R35)

X36. August 14, 1872. Poughkeepsie, New York. Many balls of lightning enter buildings and explode. (R37)

X37. 1876. Palestine, Texas. Woman killed by ball lightning. (R39)

X38. October 12, 1877. Wandsworth Common, England. Several fireballs roll along before the wind. (R40)

X39. July 23, 1878. Southampton, England. Delicate, rose-pink, pear-shaped ball lightning, 6-8 inches long, fell upon a yacht and detonated. (R41)

X40. 1870s. Pyrenees, France. Fireball 6 inches in diameter travelled several miles. (R42)

X41. July 17, 1880. Kent, England. A fireball fell from the clouds and exploded. (R43)

X42. August 19, 1880. Paris France. Fireballs rose from the ground and vanished. (R44) This example is similar to the luminous spheres in GLD7. (WRC)

X43. September 1880. Hendon, England. Ball lightning falls into a pond killing over 100 fish. (R45)

X44. July 20, 1881. England. A fireball 0.5-meter in diameter destroys a house. (R46)

X45. August 23, 1881. Leamington, England. Ball lightning explodes creating much smoke. (R47)

X46. 1881. Scotland. Chain of unconnected balls of lightning observed over a ship. Each was about a foot in length. More fireballs seen running around the ship. (R48)

X47. Summer 1882. England. Mottled whitish ball of fire bounced off the ground and disappeared. (R49)

X48. July 28, 1883. Hartford, Connecticut. Fireball big as a man's head paralyzes man. (R22, R23, R50)

X49. July 1883. Buckinghamshire, England. Ball lightning hit a house. (R51)

X50. September 20, 1883. Banbury, England. Yellow globe the size of a cricket ball. (R52)

X51. October 9, 1883. No place given. Fireball injured three seamen. Exploded into flying sparks. (R53)

X52. July 26, 1884. Cologne, France. A scarlet fireball was visible for several minutes. (R54)

X53. January 28, 1885. No place given. A fireball on a vessel. May have been St. Elmo's Fire. (R1)

X54. August 19, 1886. New Harmony, Indiana. Ball lightning rolled down steps and across a carpet (without hurting it), and out a door. Considerable damage done inside and outside the house. (R55)

X55. August 25, 1886. During a hurricane (no location given), numerous balls of fire shot up from the northern horizon to an altitude of about 20°. (R1)

X56. March 14, 1887. No place given. Sea was phosphorescent, numerous fireballs flying in the air. (R1)

X57. March 22, 1887. No place given. Heavy gale, fireballs flying through the air, St. Elmo's Fire everywhere, sea phosphorescent. (R1)

X58. May 30, 1887. English Channel. Yellowish-white globe the size of the moon. (R56)

X59. November 12, 1887. Off Cape Race. A large ball of fire rose from the sea, moved against the wind. Lasted 5 minutes. (R1, R57, R58)

X60. November 20, 1888. No place given. Two blue balls of fire pass over a ship followed by sounds like artillery. (R1) May have been a pair of meteors. (WRC)

X61. April 6, 1889. No place given. Fireball ran down rigging and burst above the deck. (R1)

X62. July 20, 1889. No place given. Ball lightning falls on ship, glides around the rigging and deck, explodes. (R1)

X63. August 1889. France. Three fireballs fell into a courtyard. (R59)

X64. August 1889. No place given. Luminous ball passed through a house, bounded along the ground, disappeared without an explosion. (R60, R61)

X65. January 2, 1890. Spain. Ball lightning the size of an orange. (R62, R63)

X66. March 1890, Louisville, Kentucky. A tornado was accompanied by numerous fireballs rolling in the streets. (R64)

X67. Day of the Pentecost, 1890. East Prussia. As a man drove his carriage along a road lined by wire fences, two balls of fire appeared, one on each fence. They followed the carriage along until the end of the fence was reached, where they collapsed with a noise like rumpling paper. (R27) This may have been an unusual manifestion of St. Elmo's Fire. See GLD6-X2.

X68. August 28, 1891. Martinique. A great hurricane during which many examples of ball lightning were seen. Some lasted several minutes. (R65)

X69. March 6, 1892. North Atlantic Ocean. Luminous ball bursts on steamer, spreading lightning in all directions. (R66)

X70. July 3, 1892. Liverpool, England. Ball lightning falls into a lake, creating a column of water 60 feet high. (R67)

X71. August 7, 1892. Germany. Large, tapered globe of fire explodes in church devastating it, and leaving a sulfurous odor. (R68)

X72. July 26, 1893. Epping, England. Ball lightning bursts inside a house. Prior to the appearance of the lightning, a dark space fringed with crimson flame appeared in the kitchen. (R69)

X73. December 12, 1893. Devon, England. Ball lightning descends, shedding sparks. (R70)

X74. June 21, 1895. Karachi, Pakistan. Ball lightning explodes, leaving a sulfurous smell. (R71)

X75. August 24, 1895. Donegal, Ireland. Boy injured by ball lightning. (R72)

X76. December 18, 1895. Devon, England. A fireball travels against the wind, kills a man, and tears up the ground for upwards of 100 yards. (R73)

X77. 1895. No place given. Fireballs 2-3 feet in diameter roll about the streets. (R74)

X78. August 1896. Dublin, Ohio. Ball lightning hits a carriage with a hissing roar. Smell of sulfur afterwards. (R75)

X79. August 1898. No place given. About 20 globes of fire roll, one after the other, down the side of a valley. (R76)

X80. 1898. Springfield, Massachusetts. A ball of lightning floats down like a balloon, hits ground, bounces once, then disappears at the same time ordinary lightning hits a house. (R75)

X81. August 4, 1899. Salt Lake City, Utah. Ruby red fireball, one foot in diameter, enters a house by one window, leaves by another. (R77)

X82. June 9, 1901. France. Ball of fire drops from a cloud like a stone. (R78)

X83. July 25, 1901. Dalston, England. Ball lightning, 6 inches in diameter, falls and explodes. (R79)

X84. 1903. England. Ball lightning falls onto a bicycle's handlebars. Rider smells sulfur. Ball falls to ground and explodes. (R80)

X85. 1904. Deux-Sevres, France. Child touches ball lightning with foot. It explodes, killing 11 cattle but not hurting the child. (R81)

X86. April 1905. Surrey, England. Ball lightning explodes over a church. (R82)

X87. Summer 1905. Harrow, England. (R83)

X88. August 1, 1907. Alpena, Michigan. A fireball drops to the floor, moves around the room in circles, smashes holes in walls. (R84)

X89. September 7, 1907. West Australia. Lurid red ball, 4 inches in diameter, with a halo of yellow flame 18 inches in diameter. (R85)

X90. July 1909. England. Globe of light, 4-5 inches in diameter, bursts inside a house with slight report. (R86)

X91. Summer 1909. Buzzards Bay, Massachusetts. Luminous ball descends. Many luminous bodies seen on roof of house. (R87, R88)

X92. Summer 1911. Newport, England. Bright green fluorescent ball floats in a door and then out again. Explosion followed. (R89, R90)

X93. December 15, 1911. France. Ball lightning falls off a wire and explodes. (R91)

X94. July 13, 1912. Sussex, England. White ball, size of a full moon, travels slowly across the sky. In view for 55 seconds. (R92)

X95. January 25, 1915. Rome, Italy. Reddish globe, 40-45 centimeters in diameter, falls on church and explodes. (R93)

X96. August 1, 1915. Norwich, England. Bright, greenish-yellow spots of light seen moving against a cloud. (R94)

X97. April 1919. Kent, England. (R95)

X98. January 13, 1920. Sydney, Australia. Ball of light tinged with violet descends slowly in an oscillating fashion. (R96) This "falling leaf" motion has been reported in many UFO sightings.

X99. Spring 1923. Chevy Chase, Maryland. Ball lightning the size of a toy balloon hits a tree and explodes. (R75)

X100. April 1924. Evanston, Illinois. (R97)

X101. June 8, 1924. Virginia. Fist-sized ball lightning explodes with sparks and smoke. (R75)

X102. September 1, 1924. Gold Coast. Large red globe, 4 inches in diameter, came through open shutter and bursts in a room. No storm at time. (R98)

X103. April 29, 1925. Saxony. Barrel-like object falls from a cloud and broke into

small strokes of lightning. Much damage done. St. Elmo's Fire seen at the same time. (R10, R27)

X104. August 11, 1925. Yarmouth, England. Brilliant red lightning ball, 1 foot in diameter, moves 100 yards along a road surface with a hissing noise. Explodes. (R99)

X105. 1925 or 1926. Pennsylvania. After a severe thunderstorm, a camper sees a golden-yellow ball of fire the size of a basketball enter an open window and exit via the opposite window. (R27)

X106. September 23, 1926. Bangor, Ireland. Ball lightning moves around a room, leaving a trail of broken bric-a-brac and the smell of sulfur. Leaves home and explodes. (R100)

X107. 1926. Norwich, England. (R101)

X108. March 23, 1927. Cattlewater, England. Greenish-blue fireball three times the size of an English football explodes. Others seen in area. (R102)

X109. August 25, 1928. Surrey, England. Ball of fire, 3 feet in diameter, explodes. Dull day but no storm. (R103)

X110. 1928 or 1929. Near Nelson, British Columbia. Two examples of ball lightning seen simultaneously. One falls on a lake wharf, shattering a pile. The second emerges from a cottage fireplace. This second ball vanished when the first one exploded outside. (R104)

X111. July 1929. North Atlantic Ocean. (R105)

X112. Summer 1929. East Hampton, England. Yellow flame, 5 inches in diameter, spins like a top. No explosion, but room full of smoke. (R106)

X113. December 12, 1929. Somerset, England. Ball lightning seen from a window; room filled with blue flame; ball explodes with much smoke. (R107)

X114. July 9, 1930. Chatham, New Jersey. (R108)

X115. August 30, 1930. Lincoln, Nebraska. Many balls of lightning photographed during storm. (R109)

X116. April 1, 1931. Atlantic City, New Jersey. Ball lightning enters a train and explodes. (R97)

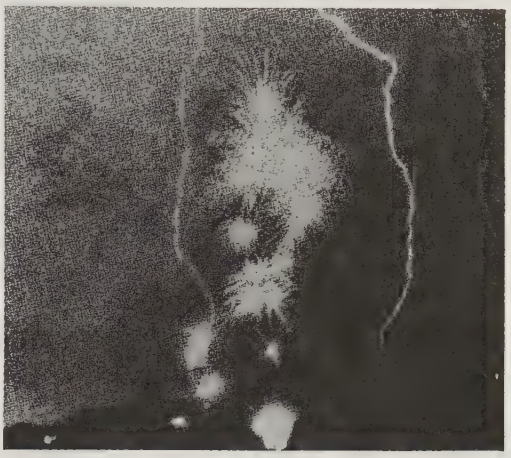
X117. July 18, 1931. Dermott, Arkansas. Pungent odor and a swishing sound precede the explosion of head-sized ball lightning. (R75)

X118. July 9, 1932. Rock Rapids, Iowa. Fiery stream pours from a dust-laden tornado cloud; stream breaks up into separate balls of fire. (R109)

X119. August 31, 1932. Italy. (R110)

X120. March 7, 1933. Stoke Poges, England. (R111)

X121. January 11, 1934. Co. Antrim, Ireland. Three orange-red fireballs the size of cricket balls. (R112)



A still-camera photograph made during a thunderstorm revealing several images that might be ball lightning. (J.D. Barry, R109)

X122. March 5, 1934. Glasgow, Scotland. (R113)

X123. Summer 1934. Loch Tummel, Great Britain. (R114, R115)

X124. 1936. Lincoln, Nebraska. Several red fireballs roll and bounce along street. (R116)

X125. Summer 1938. Europe. Ball lightning comes in the open window of a flying boat at 8,500 feet altitude. Explodes. (R114)

X126. December 6, 1938. Co. Down, Ireland. (R117)

X127. April 26, 1939. Roche-fort-sur-Mer, France. Two balls of lightning, 15-20 centimeters in diameter, exploded doing considerable damage. (R11)

X128. October 1941. In aircraft over the English Channel. Bluish-green fireballs the size of apples hit and explode, leaving a smell of sulfur in the plane. (R118)

X129. 1943. Norwich, England. Orange fireball. 5-6 centimeters in diameter, drifts

through a window and disappears with a loud pop. (R101)

X130. May 8, 1945. Maidenhead, England. Orange globe, the size of the sun, moves across the sky followed by a horizontal column of white vapor. (R119) Possibly a meteor although titled 'globe lightning.' (WRC)

X131. 1945. Oxford, England. (R120)

X132. July 9, 1947. Kirkcudbrightshire, Scotland. Fireball runs along electrical wire, blasts big oak to pieces. (R121)

X133. August 17, 1947. Cornwall, England. Misty-coloured fireballs come through a stand of trees. Where they struck the trees, zigzag lightning flashed out. (R121)

X134. 1952. Moody Air Force Base, Georgia. An aircraft collides with a big orange fireball. A sharp jolt was felt, but a fused radio compass was the only damage. (R11)

X135. August 12, 1953. Co. Durham, Ireland. Two blobs of light jump from one cloud to another. (R122)

X136. February 16, 1957. North Atlantic Ocean. Blue fireball falls from a cloud and shoots across vessel's bow at sealevel. (R123)

X137. August 2, 1960. Atlantic Ocean. (R124)

X138. September 1963. Austria. Whitish-yellow fireball, a little larger than a tennis ball, comes in a door and explodes. (R125)

X139. April 11, 1965. Toledo, Ohio. A tornado funnel emits orange fireballs from its point. (R126, R127)

X140. April 17, 1966. At sea, off Victoria, South Australia. (R128)

X141. March 9, 1970. Australian waters. Three occurrences of ball lightning in clouds. (R129)

X142. August 12, 1970. Sidmouth, England. Red fireball in sky explodes, sending jagged flashes of lightning toward the ground. (R130)

X143. August 1971. Minneapolis, Minnesota. (R131)

X144. 1972. England. A lightning strike generates a fireball 18 inches in diameter, with a red core and yellow halo. It moves several carlengths down the road and vanishes. (R101)

X145. April 3, 1974. Huntsville, Alabama. Tornado spews forth 10-15 red fireballs at a time. (R132)

X146. February 10, 1975. North Atlantic Ocean. Intense bluish-white fireball explodes after 5-7 seconds. (R133)

X147. April 12, 1978. Kent, England. (R134)

X148. December 1979. Surrey, England. Ball lightning appears with a bang, fades away, leaving a strong chemical smell. (R135)

X149. May 1, 1980. Arabian Sea. Orange fireball travels horizontally over the water. Much static electricity. (R136)

X150. October 8, 1980. Oxford, England. Big ball of white light explodes. (R137)

X151. July 9, 1981. Essex, England. (R138)

X152. No date given. Iowa. Yellowish-white fireball the size of a washtub bounces along a road with a rushing noise. It demolishes a shed and kills a horse. (R15)

X153. No date given. Ohio. Pig sniffs at ball lightning; it explodes. (R97)

X154. No date given. Georgia. A sharp click is heard, and ball lightning is seen floating along a hall. Odor of ozone detected. (R97)

X155. No date given. Fontella, Virginia. Globe, 6-8 inches in diameter passes through three locust trees. (R139)

X156. No date given. United States. Ball lightning enters through a window, sails around a room, scorching objects, exits through the same window. (R140)

X157. No date given. Leavenworth, Kansas. A fireball the size of a child's head hops across the floor like a soap bubble. (R141)

X158. No date given. British Columbia, Canada. Pilot and companion in a jet fighter at 48,000 feet see and photograph a luminous object, about the same size as the fighter, in a thundercloud. (R27)

X159. No date given. East Prussia. Reddish rotating ball, about 16 inches in diameter, passes by several people, runs along an electric bell wire and explodes. (R27)

X160. No date given. England. Ball lightning descends slowly and explodes. (R83)

X161. No date given. Denmark. Long erratic trail of purported ball lightning photographed. Trail ended when it went down a chimney and exploded. (R142)

X162. No date or place given. Ball lightning falls into a garden and vanishes quietly. (R143)

X163. No date given. Eastbourne, England. Balls of fire drop out of clouds. (R144)

X164. No date given. Norway. (R15)

X165. No Date given. Lake Geneva. Fireball, like the sun at noon, about 100 feet off the ground, drifts like a balloon for a half mile, settles on a railway pole, and vanishes noiselessly. (R120)

X166. No date given. India. A yellow ball,

6-7 inches in diameter bursts inside a house, leaving an orange-colored gas behind. (R145)

X167. No date given. New Zealand. Ball lightning floats through a shed; does not disturb cows. (R75)

X168. No date, no place given. Great ball of fire appears inside a house as it is struck by normal lightning. (R23)

X169. No date or place given. Glowing yellow bubble appears on a tile floor, explodes, leaving smell of burnt powder. (R10)

X170. October 1860. No place given. White or pale yellow globe of light, same angular diameter as the moon, fell to earth about a quarter mile distant. (R146)

X171. May 25, 1897. Szliacs, Europe. Ball lightning descends during thunderstorm, enters a building through an open window and leaves through a closed window, leaving a fist-sized hole. (R147)

X172. November 13, 1902. Queensland, Australia. Hot dry winds and duststorms. Fireballs hovered in the air, exploding and throwing out sparks. (R148)

X173. July 1865. St. Ives, England. Luminous bluish ball, hissing loudly, passes slowly overhead. (R149)

X174. Summer 1906. Folkestone, England. Ball of blue fire, 4 inches in diameter, rolls up a flight of stairs and disappears. (R150)

X175. April 30, 1925. London, England. Brilliant blue lightning, including blue, molten-looking, globular and elongated ball lightning. (R151)

X176. No date or place given. Bluish-white fireball with a fuzzy outline enters a room through openings in a wooden screen and exits through a pane of glass, melting a neat circular hole, 28 cm in diameter. The ball seemed to possess internal motion. (R152)

X177. June 1929. Morecambe, England. On a completely dry day, the doors of a slaughterhouse fly open, a ball of orange flame enters, then leaves via another door. (R101)

X178. August 2, 1927. Canton River, China. A 'thunderbolt' falls near a ship and explodes with a terrific report. The compasses were permanently affected. (R154)

X179. September 29, 1923. Mediterranean Sea. Ball lightning explodes 200 yards from ship with a brilliant flash and a strong concussion. A column of smoke or a geyser of water was formed. (R155)

X180. November 6, 1944. Kamaran Island, Red Sea. A fireball with the shape of a 'rugger' ball and twice as large explodes with a roar. (R156)

X181. July 24, 1876. Paris, France. Several reports of ball lightning from various sections of the city. (R158)

X182. October 1, 1899. Deeping St. James, England. Ball lightning comes down a chimney and burns a woman's head, leaves through an open door, and then explodes. (R159, R160)

X183. August 3, 1982. Cambridge, England. Several people at the Cavendish Laboratory observed unusual luminous phenomena during a severe thunderstorm.

"An observer on the ground floor of the Mott Building, whose back was to the window, saw his room momentarily lit as if by a very bright object moving past rapidly towards the west, between the Bragg and Mott buildings. Another observer on the first floor saw the space between the buildings filled with a luminous haze at least to the first level, and on looking to the west noticed a blue-white light that he thought at first was a warning light on a distant tower. He apparently noticed no motion, but his companion in the same room must have seen it an instant earlier for she had the impression that it was moving past and away, and possibly expanding as it went, being about the size of a grapefruit when first seen. Three people who saw it after that, as it moved over the ground to the west, agreed that it looked about the size of the moon, was blue-white in colour, and was visible for some 4-5 seconds before suddenly vanishing. To this reasonably well attested observation must be added that while an assistant in the duplicating room, on the ground floor, was closing a small window she was startled by a noise that made her think that the window had been knocked in; a bright sparkling object, resembling the lights thrown out by expensive rockets, entered by her head, rebounded from the machine and left as it came." (R161)

Taken together the foregoing observations are rather confusing. All we really have are perplexing, diverse luminous phenomena, possibly ball lightning, as

reported by several scientists at a noted English science laboratory. Something unusual happened, but it is hard to say exactly what!

X184. June 8, 1974. Wallsend-upon-Tyne. The following very remarkable and carefully documented appearance of what might be ball lightning was provided by an experienced meteor observer. It is certainly as strange as many a UFO report.

"At 01.36 U.T. I awoke to find the room bathed in a dim light. I was lying on my left-hand side at the time. I wiped the sleep from my eyes and rolled onto my back and at the bottom of my bed, about 60 cm from the window (also on my left) and some 1.60 m off the floor, floated a most magnificent orange sphere. I automatically started counting the seconds but, at the same time, broke out into a cold sweat. After all, the last thing one expects to find when one wakes up is a miniature sun! The ball was slowly floating from the window towards the centre of the room and it wasn't until it was about a metre from the window that I realized what the object was. I got out of bed, looking at my watch as I did so, and moved parallel with the ball. At approximately 2.5 m from the window the ball stopped. From the time of first seeing the ball to the time it stopped moving some 20 sec. had elapsed. The ball was still about 1.60 m off the floor and it just seemed to hang in space. The time was 01h 36m 47s according to my watch, although because of circumstances, I didn't really trust the mechanism. I was about a metre from the ball and I noticed that it was revolving, say, once every 10 sec. It was limb-darkened, the centre emitting a light on a level of about 25-30 W. By this time I had stopped counting. I could not feel any heat and nor could I hear any noise; only the rain on the window. I reached out to touch the ball and it was only when my hand was about 10 cm from the apparent limb did I feel any heat; even then it was not very great. In the end I decided not to touch it! Instead I dropped my hands to see if that would have any effect on it. Needless to say, it didn't. Quite frankly I had no idea what to do. It was only after several sec. of watching it did I try to estimate its diameter; about 15 cm. For no apparent reason I was under the impression that it was watching me as closely as I was watching it! After what seemed like hours, the ball finally decided to float upwards toward the ceiling, at about the same velocity as it had crossed the room, and it then moved straight through the ceiling in a manner typical to that of many a Hollywood ghost. I looked at my watch again: the time was 01h 37m 15s. This was just before the ball had reached the ceiling so that, by the time the ball had completely vanished, I suppose the time was 01h 37m 18s." Total duration of the observation: 51 seconds. The exiting ball left no marks upon the ceiling. (R162)

X185. November 1868. Edinburgh, Scotland. Many spectators observe a ball of fire explode over the city. (R164)

X186. October 2, 1888. Geneva, Switzerland. Ball lightning appears suddenly in a house and bursts simultaneously with an electrical discharge outside the house, as seen through a window. (R165) This synchronism suggests an electromagnetic-induction effect.

X187. April 18, 1888. Westminster, England. First, an explosive crash of thunder.

"Immediately after the sound had ceased, he saw what he describes as a fiery ball, about an inch in diameter, resembling a mass of white-hot iron enter the window with a fizzing noise---like a fuse burning or a rocket rushing through the air---and leaving behind it a fiery trail; it struck against the terminal board with a thud, as though the ball were of some plastic material, and then bounded back again out of the window. A slight odour of sulfurous nature was noticed. No mark was left on the board, but about thirty indicators were found to be damaged in the exchange." (R166)

This 1-inch ball could just as easily have been classified in GLB6 with other miniature manifestations of ball lightning.

X188. No date given. Great Britain. A ball of fire 18 inches in diameter

fused much wiring when it "went to earth." (R167)

X189. April 19, 1889. Hirschberg, Germany.

During a thunderstorm, "...a woman and her son were looking out two different windows of their house, when they noticed a yellowish ball of fire, about the size of a skittle-ball moving slowly along the telegraph wires with a noise something like that of a flag rustling in the wind. After falling on to the grass-covered square, the fireball again rose and disappeared rapidly over the roofs of the opposite houses in a S.S.W. direction. A similar phenomenon was observed by a woman who was looking out of a window facing east. A fire-ball passed in front of the window from south to north, at a distance of some 20 metres; it then rose towards the roof of a house provided with a lightning conductor and it disappeared, leaving no trace of its track. The ball was about the size of a child's head, of a yellowish colour, and no noise was heard. This ball is said to have been followed by a row of fireballs about the size of billiard balls." (R168)

The interesting feature here is, of course, the large ball followed by the train of smaller ones.

X190. No date or place given. A fireball dropped from the clouds into a cornfield and rolled along the surface. After about a second it exploded. A brilliant red light seemed to surround the observer. (R169)

X191. April 22, 1889. Ealing, England. A brilliant round fireball damaged houses and then exploded. (R170)

X192. April 29, 1906. Niagra Falls, Ontario, Canada.

"I was standing, looking out of the window during the storm. There was a very sharp flash, and about one minute afterwards I saw the ball lying on the ground, burning like the fuse of a large fire-cracker. It burnt like that for about one-half minute. Then it exploded in the shape of a column of fire six inches in diameter and three feet in height, with a cloud of smoke coming from the top. The color was of a reddish yellow. I went to the spot and found what appeared to be some melted substance that looked in color like tar. About ten minutes later, I put my hand on the ground where the ball was, and it was still so hot that it burnt my hand. It smelled like sulphur, and when I touched it, it turned my fingers yellow. I felt no shock. There were several of the neighbors' electric lights blown out, and also the fuses of the transformers on the poles on the streets." (R171)

For accounts of falling, burning material bearing some resemblance to the above phenomenon, see GWF in Tornados, Dark Days....

X193. September 1925. Gatineau Point, Ontario, Canada.

"When the storm came up, Mr. Watters and Mr. Power took refuge in an old log barn some two hundred yards from the homestead. The front door of the barn was open, but the rear was closed. Mr. Watters sat on a log, just inside the open door of the barn, watching the storm, while Power sat on the opposite side of the door. Suddenly a big ball of fire appeared in the sky, and descending, hit the end of the log on which Mr. Watters was sitting. The log was splintered to kindling wood. The ball of fire seemed to circle about the inside of the barn, and then it knocked out some dozen boards at the far end of the barn from which it entered, and disappeared. Although Power was not in actual contact with the lightning bolt, the force of the electricity threw him out into the field, perhaps fifteen feet from when he was sitting." Watters, on the other hand, was rendered unconscious for 8 hours and was partially paralyzed even longer." (R172)

X194. Theory. "The theory proposes that ball lightning is a nonequilibrium, multiply ionized, low-temperature plasma, held together by electrostatic forces and prevented from rapid recombination by

the imprisonment of resonance radiation. It is proposed that such a plasma state is formed by ion bombardment from the restrike current following the interruption of a high-current lightning discharge by the m = 0 pinch instability." (R173)

X195. April 24, 1979. Hatfield, England.

"At the time there was a thunderstorm overhead and a very loud bang was heard together with a temporary failure of the electricity supply. This was followed by another terrific bang near the back door which gave the impression of the door being struck with a sledge-hammer. The back door was opened and nothing was seen, but after closing the door and returning to the kitchen, a hazy ball of fire, coloured orange-red and the size of a tennis ball, was observed. The ball was about 3 feet from the ground and hovered there for about three seconds before disappearing. There was no form of explosion when it vanished and the observer felt nothing even though the fiery ball was only about 2 or 3 inches from her held-out hand. Two of the three witnesses said that they saw a bright flash appear to pass through the window before the ball was seen, but nothing was either scorched or damaged. (R174)

X196. No date given. Entebbe Peninsula, Uganda. After a nearby lightning bolt,

"A second or less later, several balls of brilliant blue light, about 4-6 cm diameter, entered the room through a window on the south side and 'floated' across the room to leave by a window on the east side. My wife and I were already awake (it would have been difficult not to be) and independently exclaimed aloud on what we had just seen." The windows had metal screening. The same phenomenon occurred during another rainy season. (R175)

X197. Summer 1958. Southington, Connecticut.

"In the late summer of 1958, I stood looking out of the second-floor window of my room westward to the low mountain range separating the Southington-Milldale-Marion valley from Waterbury. The mountain drops down just east of Waterbury and is made of basalt and well-covered with tall trees. It is perhaps 1,000 feet high and 3 miles from our house. In the late afternoon about 5 o'clock, the sky was darkening for a coming storm over that western great hill range. The air was heavy and ominous, but the blue sky was clear, almost glistening clear. Thunder could be heard far away, and I watched the dark blue overcast advance. All of a sudden, there was a contained flash in the clouds above the mountain range or, better, a focus of sudden brightness, and a brilliant reddish ball dropped straight onto the mountain. I was 3 miles from the range, and so I can only guess that the brilliant ball lightning was about the size of a basketball. At the time I considered it to be the size of a fist but it had to be larger. It outshone in daylight the car headlights I usually saw at night. It dropped from the clouds 300 or 400 feet to the tops of the trees in about 4 seconds and then bounced as if repelled by the contact and made a shallow arc to drop again 300 to 400 feet farther down the great hillside onto the tree tops. Again it was repelled and bounded in an arc another hundred feet down and hit the treetops and vanished. The bouncing and falling was to me unhurried, but it wasn't slow because of the actual distance it had to go. From appearance to disappearance, it took approximately 10 or more seconds but traveled almost 1,000 feet." (R176)

X198. November 4, 1749. Somewhere at sea. While most of today's scientists disdain observations exhumed from the older literature, there is no reason to suppose that our ancestors were not careful observers and accurate reporters. They may even have been better percipients than ourselves because they were not stifled by today's paradigms that tell us what we are supposed to see! With such thoughts in mind, here follows a famous and wonderful old sighting, couched in the terminology of its time, but still providing interesting detail. The source is a 150-year-old text on the wonders of nature.

"Analogous to the discharges described as globular lightning, are the fire-balls,

so often noticed, about which there has been no little scepticism; but the evidence cannot reasonably be doubted, that displays of electrical light have repeatedly occurred, conveying the impression of balls of fire to the observer. An instance is given by Mr. Chalmers while on the Montague, of seventy-four guns, bearing the flag of Admiral Chambers. In the account read to the Royal Society, he states, that "on November 4, 1749, while taking an observation on the quarter deck, one of the quarter masters requested him to look windward, upon which he observed a large ball of blue fire rolling along on the surface of the water, as large as a millstone, at about three miles' distance. Before they could raise the main tack, the ball had reached within forty yards of the main chains, when it rose perpendicularly with a fearful explosion, and shattered the maintopmast to pieces." (R177)

X199. July, about 1883. Leicestershire, England. A family was traveling along a country road between Great Bowden and Market Harborough in a horse-drawn cab. They were enveloped by a terrific thunderstorm.

"Suddenly there was an uncanny hush and the party saw a fireball (up to one foot in diameter) rolling towards the cab on the road, and, as it passed under the cab, there was an explosion and the cab was tipped partly into the ditch at the side of the road, the driver being thrown over the hedge. Fortunately on investigation it was found that he was only shaken by the experience and he managed to get the cab to Market Harborough by leading the horse, which had been blinded by the explosion, although it recovered after afew days.

"Examination of the cab, which fortunately had a double bottom, revealed that the outer layer had been completely splintered to pieces, and the party could have been killed with only a single bottom in the cab." (R178)

X200. September 10, 1989. Ashford, Kent, England. R. Cahill was making a video recording of lightning flashes. During the process he did not notice ball lightning, but later examination of the video tape revealed images he interpreted as ball lightning. However, further study of the event (by a skeptic of ball lightning) resulted in a very different interpretation. "Analysis and comparisons show that the object was most probably an image of the stop plane of the recorder illuminated by a street lamp. Detailed analysis demonstrates how the video camera can have caught the lamp when it was out-of-focus. It also shows how the recorder can have produced the image. The incident is a cautionary tale." (R199) Even video cameras can lie!

X201. Here is a ball lightning report worth cataloging because of the unusual physical effects.

"In May or June of 1988 or 1989 around 2 P.M. CEST, Mr. Alois Fuehrer, a farmer of 38 years from Jungschlag, a small village south of Ottenschlag, northern Lower Austria, 850 meters above sea level, returned early from fieldwork because a heavy thunderstorm moved in from the northwest. Fuehrer stood in the open on a wooden plank at the rear of the diesel tractor driven by his father. The vehicle had passed the last Ottenschlag houses southbound, when he noticed a falling object. It was round, 20 centimeters across, and 'seemed to come down like a toy balloon,' vertical, soundless, without rotation. It was brilliant white, a steady light, and had 'something like a smoke trail.' Only 20 to 30 meters to the right of the tractor and of the road, after 4 to 6 seconds, the object hit the surface of a green summer barley field, flashed up and 'exploded with a loud, very high pitched bang.' Mr. Fuehrer said 'this was no thunder,' and noticed no heat or pressure wave,' However, what he felt caused panic--- a tingling, and his hairs stood on end on his head, neck, even on his hands. He urged his father: 'Get out of here, the next one will kill us!', who also felt the electrostatic effect in the driver's cab. The diesel tractor continued to function normally.

"Arriving home, the Fuehrers still wondered what had happened and they went back to have a look on the same evening. They found a circular patch about 6 meters across in the impact area where green barley plants had been reduced to ashes and smoke, 'as with a

cutting torch.' The burn effect was strongest in the center. The soil had not been moved." (R180)

X202. May 1983. Chiswick, England. Ball lightning is sometimes surrounded by a corona as seen in the following experience of A. Ruddin.

"A thunderstorm of average violence had been in progress for some time. She cannot recall whether it was raining. Something caught her eye as it flashed past the window. She looked up and saw a shimmering mist through which she could at intervals see the house opposite quite clearly. She realized that something had gone past, then she looked out another window through which she saw a round, opaque, orange ball surrounded by a yellow corona, about 12 to 18 inches in diameter, hovering in mid-air about 10 feet away from her outside the window. She compared its size, which remained constant, to that of a Frisbee, and said that her hand held at arm's length would just have obscured the ball. The brightness of the ball was comparable to that of a 40-watt bulb and remained constant. The ball was brighter near the outer surface. She does not remember a flash of lightning before the ball appeared. After 5-10 seconds, the ball zoomed off extremely rapidly to the right, passing behind the wall between the two sets of windows, and after a few moments she heard an enormous explosion like a bomb which shook the house. The ball appeared to travel with the mist behind it and to be surrounded by vapour." (R181)

The nature of the "mist" and "vapor" accompanying the ball is puzzling. Apparently, they were different from the corona.

X203. June 8, 1996. Salisbury, England. Attracted by a sizzling sound during a thunderstorm, I. Ryder saw a "white glowing ball in a blue flame" hovering in the air about 1 meter above the grass. Curiously, the blue flame that surrounded the radiant core exhibited structure something like the petals of a cornflower. (R182)

X204. August 31, 1992. Dublin, Ireland. A large, orange-red ball was seen gliding through the sky. It was estimated to be about 2 meters across. It exploded violently, blowing a hole in a wall 2-feet thick at a Dublin clinic. Interestingly, those occupants in the affected room who were holding metal objects received slight electrical shocks and had the objects torn from their hands! (R183)

X205. 1942. Kos, Greece. While battling German troops in Greece during World War II, British sailors set up a small radio station below ground. Following a severe thunderstorm, a large, bluish bubble "fell" down the opening to the station. Silently, like magic, it drifted to a biscuit tin upon which one of the radio operators was sitting. There it exploded loudly, injuring the man and raising much dust. (R184)

X206. July 4, 1989. Senning, Austria. An experienced weatherman was taking time-exposure photographs of lightning strikes, when he appears to have encountered a manifestation of ball lightning. He testified, "Out of the blue, something formed like in a spiral, rotating movement. It was a white ball of light with fuzzy outlines, big as the full moon, very bright, almost blinding, a quiet, steady light. The ball formed 2 or 3 metres in the air, 200 to 300 metres right [south] of the ground stroke, stayed there and very slowly moved downward like a toy balloon. Then it went out like a candle flame in carbon dioxide." The photographer's time exposure did not catch the cloud-to-ground flash, but the ball lightning did appear in the lower-left corner of the frame. (R185)

X207. Summer 1978. Vorarlberg, Austria. Here is still another photographed manifestation of what appears to have been ball lightning. "[W.] Berger was just taking another time exposure, so the camera shutter stood open and the wire-release was pressed down, when he heard a peculiar sound, suddenly, 'like a Christmas sparkler or a wire-brush moved over an edge (intermittently)'. Then, just ahead, 'a fireball fell down' and Berger---somewhat shocked---let go the wire release before the object actually disappeared. When asked to re-imagine the course of events with his

eyes closed, the witness gave a time estimate of three seconds total duration with two seconds visual observation time (repeated stop-watch readings). The 'fiery' object seemed to drop' in free fall.' The resulting photograph was computer-enhanced and revealed strange

Photograph of possible ball lightning taken by W. Berger in Austria. (X207)

sparks and flares accompanying the core of the ball. Publicity following following the photographed event brought to light 17 additional ball lightning anecdotes associated with the incident. (R186)

X208. August 30, 1992. Llwyngwril, Wales. Ball lightning accompanied a lightning strike that knocked out electrical power and did considerable damage to a bungalow and shed. The ball was bluish in the center and yellowish on the edges. It seemed to rotate twice in the two seconds it survived before disappearing. (R187)

X209. August 19, 1983. Cumbran, South Wales, United Kingdom. S.M. Ainley reported blinding sheet lightning and frequent strong lightning strikes.

"The thunder was like an artillery shell exploding. I went back inside to fetch my camera, and, when I got back outside, a sudden bold streak of lightning seemed to veer towards a small bungalow about 1,000 yards away. It struck a C.B. [Citizen's Band] aerial fixed to the roof and a small object seemed to spring out from the point of contact. As it was so faraway, I can only estimate that it was about the size and shape of a football, maybe a bit smaller. It was extremely bright and seemed to make the whole building glow orange. It seemed to roll down the roof, and on contact with the ground there was terrific bang and darkness fell on the area. I went up to the bungalow the following morning, but there was no sign of damage, except a slightly bent aerial." (R188)

This may not be an example of ball lightning but rather an electric-discharge phenomenon akin to St. Elmo's fire. See GLD6-X5 for a similar occurrence.

X210. June 1983. Devizes, Wiltshire, England. From a letter by M, Penny.

"While working on an extension to a house in Devizes, the sky being very black, my glance happened to fall on a child's swing in the corner of the garden (only 15 feet away). At this moment, with no previous thunder, centered on the swing was a blinding blue, spherical flash some 8 to 9 feet in diameter. At the center of this was a 3-feet, white-hot glow that appeared to hang in the air for a couple of seconds. This flash was accompanied at the same moment, not with the normal rumbling crack of thunder but with a single very loud explosion. Being only 15 feet away gave me a great shock, but the only physical effect was that immediately my hair felt like it was standing on end, just as it would with static electricity. When I got over the shock, I walked to the corner of the garden where it had occurred, and was very surprised to find no signs of burning of scorching whatsoever." (R189)

X211. May 20, 1983. Staffordshire, England. Lightning in the guise of a large red ball blew the roofs off two bungalows. In one house, plaster was ripped off all the walls, windows were blown out, and electric plugs were torn away from the walls. (R190)

X212. May 18, 1983. Ipswich, England. A golden/pale-yellow, misty ball-of-light, about the size of cupped hands. floated slowly across a lawn at a height of about 2 meters, It lasted less than 1 minute and disappeared with a very loud bang. (R191)

X213. Summer 1948. Lubeck, Germany.

"The afternoon was hot and humid, with heavy unbroken cloud, the cloudbase was around 150 m. I was on the second floor of a three-storey barrack block. My attention was drawn to an intense white light which appeared under the cloud at a distance of about a kilometre. The light resembled the sun in colour and size, and although at first it gave the impression of the sun breaking through cloud, it was immediately clear that the object was moving. It descended from the cloud with an undulating motion, like a child's balloon drifting downwind after release from a high building. It came towards the building and was lost from sight behind the end of the block. After a space of five or ten seconds, I heard a violent explosion which rocked the building and rattled doors and windows. I considered it was equal to the detonation of a 300 lb (136 kg) bomb at a distance of two or three hundred metres. (I had a similar experience in 1943---on that occasion from a Junkers 881." Upon investigating the site of the explosion, the observer found a blackened patch 2-meters in diameter on the wall of a building. Witnesses said that the ball had drifted along finally attaching itself to a radio antenna and exploding. The entire episode lasted 1 to 2 minutes. Estimated size of the ball: ½ meter. (R192)

Of particular interest here is the undulating descent of the ball, which is reminiscent of some UFOs.

X214. Autumn 1940. Berwyn Mountains, Wales, United Kingdom. The percipient in this unusual ball lightning sighting was schoolmaster at Sandyhurst College.

"While out walking he was caught in a violent thunderstorm on the side of a hill with a scooped valley below. Ahead of him perhaps 300 feet distant, a bolt of lightning struck a tree with a sharp explosion of noise. Almost immediately a sphere six inches in diameter appeared from the direction of the strike and began to bounce across the ground towards him like a rubber ball. Climbing the hill under its own energy, the object rolled in a parabolic path and hit the ground every ten or twenty feet, climbing up to about three feet in height with each 'rebound'. Every time it hit the ground there was no sound, but a puff of greyish smoke or vapor was emitted. The object got to within about 50 feet of Mr. H. before it suddenly vanished. This allowed him to have a good look at it at close proximity. He says that it was completely round and was a smokey-grey colour." (R194)

X215. Summer 1991. Southern Bavaria, Germany. R. Urbanek, a teacher from Wasserburg, recalls her encounter with ball lightning.

"I was with a friend in the area of Traunstein. My friend drove a mini-bus ...150-200 meters...ahead of my car. Golf and several other cars were following behind me. It (had been) raining with heavy lightning and thunder. I did not drive at normal speed in such weathe ...Then came a straight stretch of road with a bicycle path to the right, and an open wide field...Suddenly I saw a bright green, phosphorescent...ball about the size of a medical training ball, that dropped to the ground behind the minibus...It fell to the road and rolled towards me. I knew immediately it was ball lightning, and from school physics I knew a car acts as a Faraday cage. So I kept my feet to the floor mat and grabbed the wheel with both arms. 3 to 5 seconds passed until the ball reached my car. It came in a straight line, with a slight deviation to the right (as seen from my position). When the ball caught my car at the right front side, it gave the vehicle a strong shock or jerk, as if I had driven against an obstacle. All that was on the right side of me lit up bright green---the hood, the windscreen, the instrument panel, and even the padding. In the rear-view mirror I could observe that the ball went off the road behind my car. It rolled about 50 meters on the bicycle path, then went into the field and was gone after about 100

meters."

This event was observed by people in the cars behind Urbanek. Later examination of the car found no physical damage, no magnetic anomalies, and no indications of contact with lightning. (R194)

X216. June 17, 1996. Tewkesbury, England. On this day, two remarkable observations were made a few seconds apart. Even so, one cannot be certain that the first caused the second.

For the first observation, there were two witnesses. Both saw lightning strike a low-flying USAF jet. Mrs. E. Shobli wrote the following account:

"Two forks of lightning came from the clouds in front of the plane, converged on it and gripped it. The tail end of the plane became illuminated---vapours came from its end and formed into a bright, dense mass. I thought I was witnessing damage to the plane. The light continued to separate from the plane, downwards like a flare. It appeared as yellow, lit-up gases. These seemed to take shape, becoming brighter and denser, and then move downwards in the same direction as the plane (south). About two seconds after disappearing behind the roof there was an ear-splitting explosion. To my relief the plane reappeared unscathed." (R195)

At the time of the lightning strikes, the jet was passing over a factory, where a fork-lift driver saw a dazzling blue-white ball bounce along the factory roof and enter the building. Many workers inside were treated to an amazing pyrotechnic display as the ball made its way through the building.

'It entered the factory through an up-and-over door and was seen as a 'pulsating light' or a 'fiery sphere the size of a tennis ball'. Once inside the building it moved very rapidly for two seconds, following the course of the overhead girders without touching them and lighting up each girder 'blue, white and orange' as it raced along. It produced what one witness described as 'unbelievable sparks'. Intensely bright, the object illuminated the whole printing works and was seen by about 40 people. After thus racing around the interior of the building for two seconds, the 'fireball' hit a window which glowed orange, and the ball disappeared with a bang so loud that the report was even heard by a deaf worker." (R195)

X217. August 12, 1992. Conwy, Wales, United Kingdom. We have here a carefully observed case of ball lightning with rather spectacular side effects. A Mrs. P. Stafford was looking through her front window:

"...when she saw what she first thought was a 'ball of white fire', larger than a football, about 20 to 30 feet from her, travelling horizontally at a constant height up her drive. There was very heavy rainfall, perhaps with some hail, but no lightning or thunder. The ball was seen against the background of other houses and her view of it was not interrupted. It was round, opaque and predominantly white with some yellow, and surrounded by a blue, irridescent halo. She said it was reminiscent of a meteor or comet and the light from it was like that from a fluorescent tube. It was bright enough to be clearly visible in daylight and appeared to be spinning or rotating. It hit the oak tree, perhaps 12 or 13 feet away, in Mrs. Wignall's front garden, with a terrific crack and explosion.

"The ball was in sight for about 10 to 15 seconds, and its appearance did not change until it struck the tree, whereupon it became smaller. It hit the trunk about half way up and split the bark and trunk, showering splinters of wood over a distance of about 50 yards. As it did so, it rolled down the tree and dispersed in flashes---she said that there seemed to be 'waves of lightning' passing from it into the ground and radial sparks streaming out of it in all directions. Her husband, however, thought he saw the ball, now smaller in size, cross the lawn." (R196)

X218. November 24, 1975. Tendele Hutted Camp, Drakensberg Mountains, South Africa. The following observations were made during violent electrical storms.

"Around 10pm, WN observed a luminous vertical column in an easterly direction which appeared suddenly at a location

low on the hillside on the far bank of the Tugela River at a distance of about 1km. This stationary light column seemed to have the dimensions of a pencil stub (approx. 50mm x approx. 7mm) held vertically at arm's length. The column, which had a bluish glow like a fluorescent tube, was visible for about 5 to 10 seconds.

.....

"At 11.15pm, when the intensity of the storm had abated and the sky was lit intermittently with flashes of sheet lightning, the writer saw a luminous spherical object, seemingly of golf to tennis ball size, moving rapidly with an apparently vertical undulating motion from left (northeast) to right (southwest) on a horizontal course in the general direction of Mont-Aux-Sources (3282 m) where the Tugela River has its origin. This sighting lasted 2 to 3 seconds. About 3 minutes later, another similar object crossed the field of view, following the same course as the first object and showing about 2 or 3 undulations in its passage. At midnight, a third object was seen having the same characteristics as the first two objects. However it did not arise from the extreme left of the field of view but appeared to originate from a point marked by a small tree close to and in the middle of the window. These objects had a bright yellowish-blue luminescence, and no noise was heard which could be associated with their passage." (R197)

X219. October 21, 1989. Dalmuir, Scotland, United Kingdom. Text of a letter from a Mrs. Barr.

"The day started off as a nice clear autumn day with blue skies. About 11 a.m. the sky became grey and very heavy. It was not cold. By lunchtime there was a steady drizzle of rain which became quite heavy at times.

"I was in a butcher's shop in Dalmuir (west of Glasgow) at 2 p.m. with my husband and about a dozen or so other customers. The rain had stopped. I looked through the windows to see if it had started again when I saw a silver-coloured ball shoot across from the east, not far overhead but down low. It seemed to be inside a broad ribbon of silver light. The ball looked as if it was still, not rotating on itself. It all happened very quickly. As it shot across the road outside, there was a 'swoosh' sound, something like a firework rocket shooting up, and it landed with a deafening explosion (like a bomb) which shook the ground and the butcher's shop." Torrential rain followed. There was no mark on the road where the ball hit. (R198)

The most interesting aspect of this anecdote is the ribbon of silver light.

X220. July 22, 1988. Ryazan, Russia.

"Dr. Aleksandr Mitrofanov of the Institute of Physical Problems of the Academy of Sciences of the U.S.S.R. and two friends were camping on the left bank of the River Oka near Ryazan (at a point where the river makes a sharp bend to the east) on the 23rd July 1974. It had been a clear day, very hot in the afternoon. Together with Muscovites from another encampment they sat up talking and drinking tea [!] until late in the evening (in fact until early the next morning). At 2:10 a.m. they all saw a light which at first they thought was a torch. It appeared to be 70 metres away in the undergrowth along the bank. As they all stood up the 'ball lightning' (which is what Mitrofanov thought it was) seemed to 'float up' from behind the bushes and move straight towards them, increasing in size. But it did not reach them; it slowly 'swam' horizontally before disappearing after 4 minutes. When it seemed to be at its nearest, a ring detached itself, like the ripple of water when a stone is thrown into water. The ring vanished as it expanded, but was followed by a second ring, less bright than the first. Before it vanished the ball took on a pear shape. Just after it vanished the sky in that direction, for about 10° of azimuth, became red dish and lighter than the rest of the sky to the north. This illumination lasted no longer than half a minute. The 'ball' had made no sound and there were no traces or smell remaining. Mitrofanov did not mention hearing thunder or seeing lightning." (R199)

S. Campbell reviewed this account and opined that rather than observing ball lightning the Russias probably saw instead the planet Venus on the horizon. (R209)

Sketch of the luminous phenomenon reported by A. Mitrofanov, who surmised that it was ball lightning. The ring was most unusual. Although the apparition seemed to be positioned in front of some trees, one skeptic suggested that it was only the mirage of a celestial object. (X220)

X221. August 2, 1921. Hohenschaftlern, Bavaria, Germany.

"The witness who reported the event was nine years of age at the time of the observation, and was indoors with her uncle on the first floor of a building during a severe morning thunderstorm with heavy rainfall. There was a lull in the storm and the ball lightning appeared on the left side of the window sill about 4-5 m from the observers. The window had been left open because there was a balcony above it which prevented the rain from entering the room.

"The ball fell to the floor where it jumped up and down once or twice. It then started to roll slowly towards the observers across the floor, at about the speed of a dropped ball of wool. Its diameter was about 20 cm, it was translucent, and the rapidly changing colours showed spots of light green, crimson, light blue and pale yellow. It was bright enough to be clearly visible in daylight, and it was uniformly bright over its entire surface. It had protrusions 'like the Andromeda nebula.'

"When it came near the table, where my uncle and I were sitting, I tried to get up to have a closer look. My uncle (fortunately) held me back. It then rolled towards the tiled stove on the right side of the room, crept up the iron parts of the stove leaving (in its path) a deep groove about the width and depth of a thumb, then it exploded in the (airvent) higher up, the sound was like that of a blown up paper bag when (burst) leaving a smell of ozone. The path of the ball was about 5-6 m in length, and it left no marks on the wooden floor." (R200)

X222. March 21, 1983. Kingsley, England.

"A large white luminous ball, probably over a metre in diameter, blasted its way into a factory workshop by shearing an irregular hole through a steel-mesh-reinforced window. There was no evidence of any fusion of the glass. The ball, accompanied by a deafening roar, passed very quickly in a straight line through the processing shop and left by blasting a 2 by 3 metre hole in a wall of 6 mm corrugated asbestos, fragments of which were later found 20 to 30 metres away outside the factory." (R201)

X223. June 14. 1988. Ankara, Turkey.

"May and June are usually very showery and thundery in central Anatolia and this year is no exception. However, the previous few days had been unusually stormy here in Ankara, and on the 14th the second thunderstorm of the day was in progress with curtains of rain and flickers of lightning, a few kilometres away to the north-west. The storm was moving towards us and the squally wind had already begun. I was again watching the weather from my office, which is on the fifth floor, when I was suddenly distracted by the appearance of a very bright, circular flash of blue-purple light (perhaps one metre or less in diameter), which persisted for about two seconds and then silently 'popped out,' leaving behind a puff of smoke, which then drifted away. The flash of circular light occurred about 500 m away from me: it was about 30 m above the ground, close to, and partly behind, a tall factory chimney. There was definitely no cloud-to-earth lightning over

that area at that time, but the edge of the cumulonimbus cloud, giving the storm a few kilometres away, was directly overhead." (R202)

X224. June 12, 1991. Braintree, Massachusetts. From a newspaper account.

"One of Earth's rarest and most mysterious weather phenomena occurred in front of Olga Perrow's Braintree home yesterday afternoon.

"Ball lightning, an orange-reddish glow of luminosity that Perrow said 'looked like a bowling ball,' greeted Perrow and her two grandchildren as they drove into the driveway at 665 Commercial St. during the height of yesterday's thunderstorm.

"'I was stunned,' Perrow said. 'It was so smooth-looking. It was like a big ball of fire.'

"Perrow said the ball moved alongside the car up to the front wheel and 'exploded' when the car went into the garage.

"'It sounded like a bomb,' she said. 'We expected to see a hole in the ground, but there was none.'

"Chase Trowbridge, Perrow's grandson, said the ball was hovering about five or six inches off the ground. 'It moved very slowly; we were watching it for about 10 seconds,' he said. 'It was weird.'" (R203)

X225. June 18, 1991. Houston, Texas. The following report is from H.D. Mayor, a scientist at Baylor College of Medicine:

"During an incredible electrical storm in the evening while sitting at a table in the breakfast room, I saw a ball of lightning enter the utility room [an extension of the breakfast room] apparently through the back door. It hovered as a revolving sphere of bright yellow, orange and red light about 10 inches in diameter, in the air about three feet above the floor. It stayed in the same place. After about two or three seconds the globe disappeared with a loud pop rather like a discharge from a champagne bottle. The discharge was followed by a distinct odor of ozone. My Siamese cat also appeared to see the ball; at least he ran toward it." (R204)

X226. November 18, 1983. North Atlantic Ocean. Aboard the ACT 7, enroute Rotterdam to Melbourne. As reported by two of the ship's officers.

"At 2000 GMT, with calm seas and clear skies, lightning was observed to the south-east. At first only white-blue sheet lightning was visible, accompanied by one or two isolated cumulonimbus clouds in the distance. However, at 2040 GMT with moderate cumulus cloud cover, intense reddish-white balls of lightning appeared like explosions above the clouds.

"By 2200 cloud cover had dramatically increased and banks of cloud were seen to approach from the south-east. As the skies darkened, more sheet lightning was observed and the blinding balls of lightning would flash from SE to SSW in a chain reaction. The flashes were extremely intense and seemed to emanate from the middle of each cloud, completely illuminating the sky and sea for seconds at a time." (R205)

The aerial display reported above is dramatically different from the usual lone, slow-moving luminous sphere seen in ground-level observations of ball lightning. Perhaps a different mechanism is involved.

X227. November 12, 1976. Transvaal Highveld, South Africa. Observations from a research station. Lightning discharges were being recorded on video tape. In one multiple-stroke flash, a ball-shaped image appeared on three of the frames showing the discharge. The sphere appeared to be detached from the main lightning channel. Knowing the distance of the flash, it was estimated that the luminous sphere was about 5 meters in diameter. (R206)

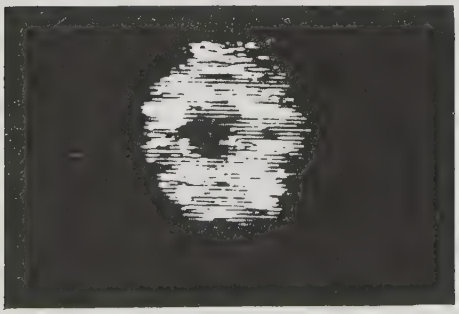
X228. March 10, 1997. Morecambe Bay, United Kingdom. Aboard the Britannia Endeavour, a standby vessel located 400 meters from a gas-field accommodation platform. A strong squall was nearing the platform.

"At 1545 the observers saw a large ball of lightning discharged towards the drilling platform, which is located at the

east end of the central complex. The sky lit up dramatically, the resulting illumination triggered off all the ultraviolet detectors on the platform, and all personnel went to their muster stations. The Captain of the Britannia Endeavour reported a possible lightning strike on the drilling platform as the ball appeared to go through the legs of the platform. The platform was inspected and no damage was found."

The response to a request for additional information on the event revealed that the luminous phenomenon was circular in shape and had emerged from a low cloud base. Its size was about that of the lid of a dust bin. The ball's velocity was estimated to have been about 100 miles per hour---very fast for ordinary ball lightning. (R207)

X229. September 10, 1989. Ashford,Kent, England. R. Cahill was making an amateur video of lightning strikes from the bedroom of his home, when he captured the image of a luminous sphere that appeared to be ball lightning. The ball appeared immediately after a lightning flash and a crash of thunder. The dull red ball entered the camera's field of view at the left, moved diagonally across the screen, and exited at the top right. The transit time was about 1.5 seconds. A study of the video images and their comparison with a street light seemed to confirm the belief that it was ball lightning. R.C. Jennison et al summarized the characteristics of the presumed ball lightning as follows:



A dull-red, luminous, toroidal object caught on a video camera in 1989 by R. Cahill. (X229)

"A study of its properties in slow motion, and still-frame advance, revealed that it is toroidal in shape with a relatively small inner radius of apparently no luminosity. During the movement the axis of the torus precesses through about 90 degrees. The structure appears coherent, and it is optically thick with slight limb-darkening and is markedly mottled in depth. By controlling image brightness and contrast, it has been possible to conclude that the image exhibits eight-fold symmetry in longitude with discernable nodes and antinodes which maintain their relative positions throughout the transit.

"Controlled experiments at the same time of day using the same camera settings have been carried out and from them it has been possible to estimate that the object was of the order of 20 cm in diameter travelling at about 1 ms^{-1}.

"These experiments together with careful study of the original recording make it very difficult to attribute the properties of the ball at any artifact or other light source. The conclusion is that the object is probably ball lightning, perhaps at an early stage in its existence." (R208)

The meticulous analysis and strong conclusions voiced by Jennison et al (R208) have been questioned by S. Campbell, who is a foremost critic of ball lightning (and UFO) claims. Campbell visited the site and examined the video camera that caught the flight of the supposed ball lightning. He believes that the luminous object was actually the image of the camera's stop-plane as illuminated by distant car lights in an out-of-focus situation. Campbell actually replicated rather convincingly the supposed ball-lightning image employing this rationale. Comparison photographs are presented in The Skeptic. (R209)

In R209 Campbell also debunks several other prominent ball-lightning claims. He asserts that all ball-lightning data are anecdotal and that no defensible instrumental evidence exists for the reality of the phenomenon!

The conclusions of Jennison et al (R208) and Campbell (R209) could hardly be further apart.

X230. General observations. In the years since the first edition of this volume was

published (in 1982), we have identified two general treatments of ball lightning that must be recorded. (There are undoubtedly more such in the unexamined, voluminous literature.) Those who wish general discussions of this phenomenon that go beyond that available in the Description at the beginning of this section are advised to acquire R210 and R211 for amplification.

In R210, M.A. Uman, an authority on lightning in general, terms ball lightning "wild and wonderful" in his short overview, in which he relates how the apparent properties of ball lightning constrain theory.

In R211, D.J. Turner reviews the observed characteristics of ball lightning in some depth, as set forth in the extensive literature that has accumulated. Turner has his own ball-lightning theory (see X232) and, quite naturally, tells why his hypothesis seems promising.

X231. Surveys of ball-lightning observations. In the 20+ years that have transpired since our first edition, two useful, but somewhat limited, surveys of the phenomenon have been acquired. (There are surely others.)

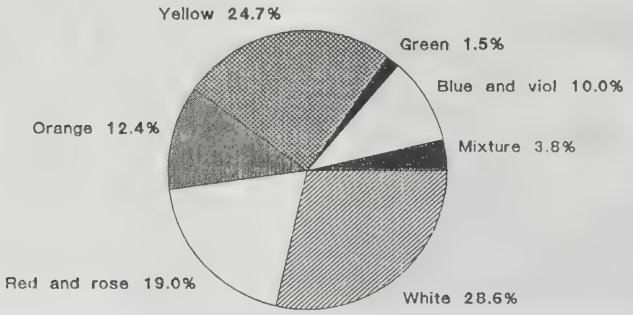
The first survey was conducted by M. Stenhoff, an English physicist. After studying about 200 ball-lightning reports, he arrived at a negative opinion concerning the reality of the phenomenon.

"A study of about 200 first-hand accounts of observations of alleged ball lightning indicates that about 80% may be readily explained by other means and that the residual reports may mostly be called into question because of the time elapsed between event and report. The validity of earlier statistical studies is thus called into question. The low signal-to-noise ratio may be responsible for the absence of a single, convincing theory of ball lightning." (R212)

Stenhoff's reservations about ball lightning are not unlike those most scientists hold regarding UFOs and other "fringe" phenomena. The reality of both UFOs and ball lightning are both supported by thousands of anecdotes, but these are not sufficient to convince most mainstream scientists. Nevertheless, some of the observations of ball lightning, as presented in the foregoing pages, are quite convincing. Even so, ball lightning remains a questionable phenomenon in the eyes of many scientists. Of course, UFOs are subjected to even greater doubts.

The skeptics of anomalous phenomena employ a standard tactic to discredit them. First, many anomalous observations can be explained, and this the skeptics do with relish. Second, the residual observations that do not yield to easy explanation are dismissed as unreliable. We see this tactic used to question the reality of ball lightning again and again. To be honest, however, anomalists do recognize that some anomalous phenomena are not real.

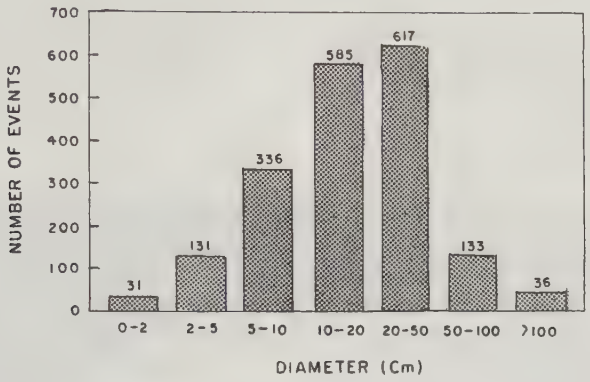
In contrast to Stenhoff's approach (above), V.L. Bychkov and colleagues are perhaps a bit too anxious to accept the reality of the 2,000+ reports



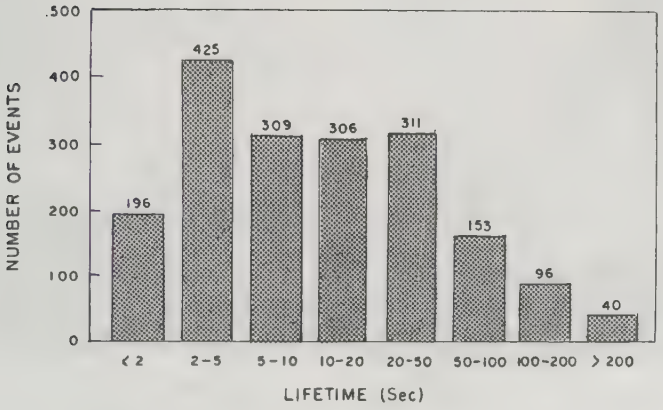
Color-distribution of ball lightning, as derived from 1812 observations collected in a Russian-Austrian data bank. (X231)

employed in their survey. They draw upon events accumulated in a Russian-Austrian data bank, but reveal little about the soundness of these observations and the capabilities of the percipients. Despite this caveat, Bychkov et al have generated several interesting graphs and pie-charts that portray some general properties of ball lightning. Three of these illustrations are reproduced here. But, not knowing the pedigrees of the observations, we should not draw sweeping conclusions from them. (R213)

Both of the above-mentioned surveys demonstrate convincingly that the phenomena subsumed under the heading of "ball lightning" are diverse indeed. It is no wonder that no consensus has been reached about what ball lightning is, and even whether it is "real" or not.



Size-distribution of ball lightning, as derived from 1869 observations collected in a Russian-Austrian data bank. (X231)

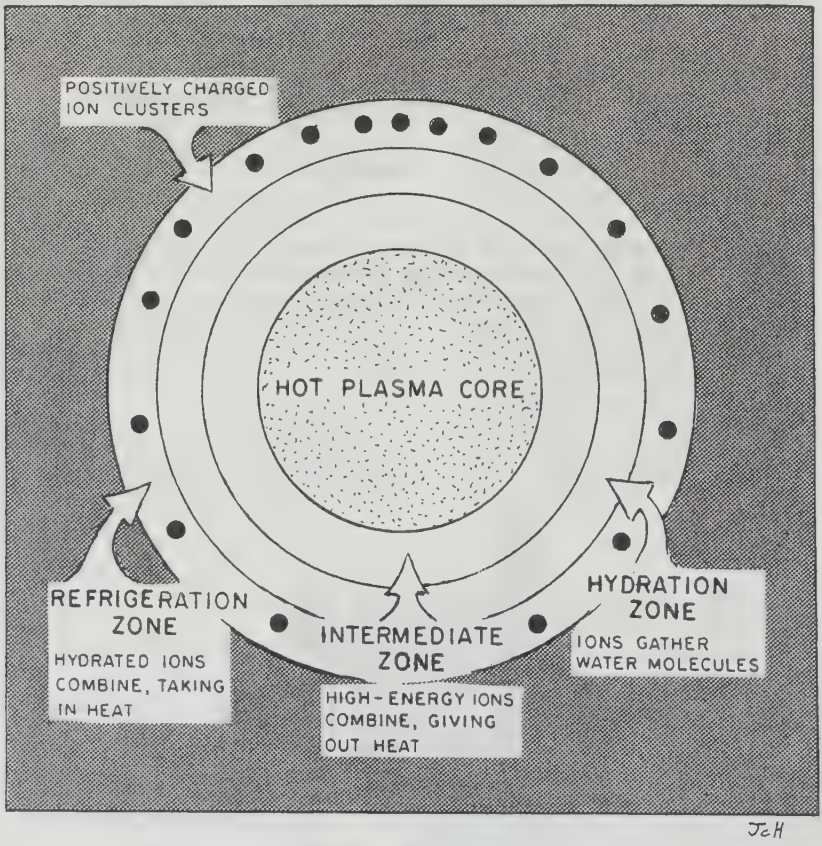


Lifetime-distribution of ball lightning, as derived from 1836 observations collected in a Russian-Austrian data bank. (X231)

X232. Theories. Dozens of ball-lightning theories can be extracted from the science literature. Because the main purpose of the present volume is the exposition of potentially anomalous phenomena rather than their explanation, we give theories of ball lightning short shrift. We simply list those theories mentioned in the literature collected since the first edition was published.

- Linked magnetic loops. (R214)
- Electromagnetic knots. (R215)
- Kapitza waves (electromagnetic standing waves. (R216)
- Vacuum bubbles delimited by a thin layers of charged particles. (R217)
- Electrostatic discharges. (R218)
- Rydberg's matter (a condensed state of excited electrons). (R219)
- Micrometeors. (R220)
- Polymer-formation phenomena. (R221)
- Self-organized, complex, space-charge configurations. (R222)
- Onion-like structures consisting of hot plasma cores, hydration zones, and refrigeration zones. (R223, R224)
- Nanoparticle oxidation produced when normal lightning strikes soil. (RR225-R227)

Obviously, this is merely a partial list of hypotheses that scientists and laymen have proposed over the past two centuries.



A theory advanced by D.J. Turner holds that ball lightning possesses an onion-like structure. (X232)

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GLB2 Ball Lightning with Projections or Spikes

Description. Ball lightning adorned with spikes or protuberances.

Background. "Ordinary" ball lightning is often pear-shaped suggesting the presence of internal forces distorting the normal spheroid. The appearance of spikes, knobs, and projections may be another expression of internal forces.

Data Evaluation. Only a few reports of a testimonial nature have been found. Rating: 3.

Anomaly Evaluation. Projections and other complex shapes, if they are stable, would seem more difficult to explain than a simple spherical shape. Rating: 2.

Possible Explanation. All observations of ball lightning with projections and spikes have been fleeting, suggesting that deviations from a spheroid are transitory and may, in fact, be a prelude to detonation.

Similar and Related Phenomena. Ball lightning with rays (GLB3), dumbbell-shaped ball lightning (GLB5), fragmenting ball lightning (GLB9), ball lightning with long tails (GLB16)

Examples of Ball Lightning with Projections or Spikes

X1. August 22, 1904. South Devon, England. "During a sharp thunderstorm experienced here on the 22nd inst., between 11.30 a.m. and noon, after a sharp peal of thunder, globular or ball lightning was observed at 11.40 a.m. in the S.E. The ball was estimated to be about $1/2^{o}$ in diameter and of a molten glowing yellow colour. It was situated about 5^{o} above the surface of the sea, and remained visible for nearly five seconds. There was a narrow pear-shaped appendage attached to the top of the ball extending to about 1 $1/2^{o}$ above it." (R1, R5)

X2. May 14, 1919. Dublin, Ireland. "On the night of May 14 a thunderstorm took place over Dublin. A shower of rain fell after 9 p.m., but between about 9.25 and 9.40 there was practically no rain, only a few drops falling. At about 9.50 I went outside, and when I had gone about two steps from the door I suddenly saw a luminous ball apparently lying in the middle of the street. It remained stationary for a very brief interval---perhaps a second---and then vanished, a loud peal of thunder occurring at the same time. The ball appeared to be about 18 in. in diameter, and was of a blue colour, with two protuberances of a yellow colour projecting from the upper quadrants..... The thunder was heard just at the disappearance of the ball, but the sound seemed to come from overhead rather than from the place where the ball was." (R2)

X3. December 31, 1924. Cardiganshire, U.K. A brilliant fireball with luminous projections. (R3)

X4. May 17, 1981. Norfolk, England. Ball lightning appeared inside a house. It was about the size of a tennis ball with four sharp points. (R4)

X5. December 3, 1979. Fleetwood England. A carefully observed case of spiked ball lightning---a very rare configuration for this phenomenon.

"On the evening in question there was an intermittent thunderstorm with rain in heavy showers. My son Michael had just come in from the college and had gone into the room and was standing watching the T.V. The time would be a little before 6.00 p.m. I said something to the effect that his meal would be ready and he'd better wash his hands, so he turned the television off, although it remained plugged in... At this point a spherical object about six inches (15 cm) in diameter floated down the (sealed) chimney and into the room. It appeared to be rather like a soap bubble but was dull purple in colour covered or rather made up of a furry/spiky emission all over. The coating seemed to be about one inch (2.5 cm) thick with spikes of two inches here and there but changing all the time. It was quite dim and appeared to be semi-transparent, in so much as I could see through to the inside of the opposite side, which appeared quite smooth---all the spikes pointing outwards from the surface. It appeared to me to be insubstantial and made no sound. It drifted between the two of us towards the television screen at about 30 inches (75 cm) from the floor, covering the six feet (2 m) in about four seconds. When about eight inches from the screen it disappeared (imploded?) with a fairly loud crack/pop sound leaving behind a smell as of an electrical discharge." (R6)

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GLB3 Ball Lightning with Diverging Rays

Description. Luminous spheres with long, radial, fan-shaped rays shooting from their surfaces. These rays appear most often during detonation or disintegration of the balls, but occasionally they are long-lived features.

Background. The appearance of long radial streamers may be indicative of ball lightning's internal structure and/or its disintegration scenario.

Data Evaluation. Observations of rayed ball lightning are rare, but enough examples have accumulated to give us confidence that the rays are real features of some ball lightning occurrences. Rating: 2.

Anomaly Evaluation. Essentially nothing is known about the diverging rays. Are they intense beams of electromagnetic radiation or streams of incandescent material. Rating: 2.

Possible Explanation. The structure providing ball lightning with its external appearance, presumably some sort of electromagnetic bottle, may begin its dissolution by developing holes or weaknesses in the "bottle," allowing energy and material to escape. The rays may thus be precursors of detonation.

Similar and Related Phenomena. Protuberances and spikes on ball lightning (GLB2) may reflect the same sort of internal instability as the rays. Fragmenting ball lightning (GLB9) may also be closely related.

Examples of Ball Lightning with Diverging Rays

X1. Circa 1860. Lambeth Walk, England. Experience of a Mr. Munro during a very heavy thunderstorm. "While looking out from his position of shelter, he saw a ball of fire, about 2 inches in diameter, thrown into the air from some invisible source, with streamers of fire or light diverging from it, the ball eventually bursting with a loud report." (R1)

X2. Circa 1915. London, England. During a powerful thunderstorm. "Looking down toward Eccleston Bridge, he saw a ball of fire, resembling a brilliant full moon, its apparent diameter about 6 ins. at first, descending at about 45^{o}. It approached rapidly and struck and dislodged 15 or 20 ft. of a heavy moulded cornice on a house at the eastern corner of the cross roads, which fell with a crash into the area below. He was uncertain whether there was also the sound of an explosion. At the same moment fanlike rays of what he believed to be lightning darted from the ball, and he experienced a painless but very heavy momentary pressure, followed apparently by a sudden depletion, which left him breathless...." (R2)

X3. August 10, 1937. Fitzwilliam, New Hampshire. "I was seated on a second story porch enclosed with glass watching the storm. A radio aerial extends from a distant tree to a point on the side of the house some distance from the porch. Coincident with a crash of thunder, the fire-ball appeared. I can not say that it followed the wire or came from the sky. It just came out of space and seemed to move directly toward the window and then fell as though to enter the cellar of the house. It was a round, bronze, glistening ball with gleaming rays shooting from the top and sides; by its beauty and brilliance reminding one of an ornament at the top of a Christmas tree." (R3)

X4. No date given. Mt. Bohul, Russia. Report by a geodesic party. "An extremely bright violet ball, surrounded with rays which were, the party says, about two yards long, struck the top of the peak. A second and a third followed, and the whole summit of the peak was soon covered with an electric light which lasted no less than four hours." (R4)

X5. August 23, 1878. London, England. Ball lightning bursts with a splendid mass of whitish-blue rays. (R5)

X6. April 15, 1916. Puy de Dome Observatory, France. Several fireballs explode, throwing out tongues of fire in all directions. (R6)

X7. No date given. Nioheim, Prussia. Ball lightning the size of a cannon ball explodes in a bundle of rays. (R7)

X8. June 1849. Paris, France. The old report now recorded is difficult to categorize, but it seems much like a bizarre form of ball lightning.

"In June, 1849, in the evening of one of the days when cholera was raging most formidably in Paris, the heat was suffocating, the sky appeared calm, but summer lightning was visible on all sides. Madame Espert saw from her window something like a large red globe, exactly resembling the moon when it is seen through mist. It was descending slowly toward a tree. She at first thought it was a balloon, but its colour undeceived her; and while she was trying to make out what it was she saw the lower part of it take fire, while it was still some yards above the tree. The flames were like those of paper burning slowly, with sparks and jets of fire. When the opening became twice or thrice the size of one's hand, a sudden and terrific explosion took place. The infernal machine was torn to pieces, and a dozen flashes of zigzag lightning escaped from it in all directions. The debris of the globe burned with a brilliant white light and revolved like a Catherine wheel. The whole affair lasted for at least a minute. A hole was burned in the wall of a house, three men were knocked down in the street, and a governess was wounded in a neighboring school, besides a good deal of other damage." (R8)

X9. October 20, 1962. Madras, India.

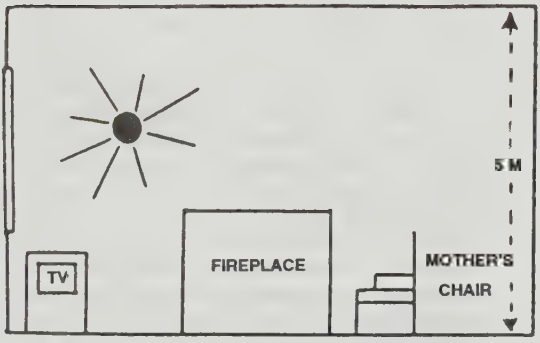
"...following two or three violent thunderbolts at about 12:30 P.M., a reddish (fire-like) ball moving across the street about five feet above the ground. The movement was from north to south. The resident of a house about 80-100 yards from the [printing] press was surprised to see a dazzling fire-ball (size estimated as that of a football) suddenly appearing 3 ft above the ground in the open corridor inside his house. The lightning ball had obviously passed into his house from the street. There were streaks of intense and blinding light about 4 to 6 ft. all around the ball. It revolved for about a minute and flashed upwards in [an easterly] direction. This lightning had caused much damage in the adjoining house." (R9)

Note that this account comes from an obscure English-language journal. Ball-lightning reports can be found in great numbers in the world's science literature. We record here just a small fraction of them.

X10. May 31, 1982. Wakefield, England. Of particular interest here is the apparent simultaneous appearance two separate manifestations of ball lightning of different types.

"We live to the south of Wakefield on the ground floor of a large Victorian house with high ceilings, attics and cellars. Our kitchen and living room face roughly S.S.W. In the late afternoon, a very heavy thunderstorm erupted with torrential rain, and thunderclaps and forked lightning occurring not quite, but almost, simultaneously. Towards the end of the storm, about 5.30 P.M., I was in the kitchen and my mother in the living room, both facing the windows. There was a very loud peal of thunder and a loud crack, rather like the little explosion of a Christmas cracker greatly magnified. I was at the sink, close to the window, on the ledge of which stands an electric Corvette water heater, plugged in but not switched on. Beside me, about four feet from the ground and two feet to the left of me, at the moment of the crack, there appeared for a second or so, electric blue flashes, six to eighteen inches in length coming from a white centre. I felt nothing, but was startled. There was no damage to the water heater or anything else. Just as I exclaimed at the blue flashes, I heard my mother cry out and ran to her in the living room. She was sitting in a chair about ten feet from the window,

under which stands the television set, plugged in but not switched on. About eight feet from the floor and four feet in front of the double-glazed window (i.e. between the television and the fireplace, but not quite over or opposite either), appeared an orange fireball, rather smaller than a football, with straight lines of orange light, varying from about one to two feet in length coming from it in all directions. This ball seemed to hover for up to five seconds before disappearing. I did not see it myself. My mother quickly recovered from the shock and there was no damage in the room." (R10)



An orange fireball with orange rays materialized in the living room of a home in Wakefield, England, in 1982. (X10)

X11. 1980. Shotton steelworks, England. Testimony from a worker regarding an unusual physical effect of what may have been ball lightning.

"A high wind was followed by a bright light which lit up the whole area. When we looked down on the yard from our vantage point we could see that a great ball of lightning had struck. As it bounced from spot to spot, we had to duck to get out of its way, but as soon as it has passed we ran out and saw it strike the side of a scrap shed. When the sun came up, it picked out the shape of a dartboard on the scrap shed. The pattern was clear, with all the segments in place, and it was about 37 feet across." (R11)

X12. January 8, 1992. Minneapolis-St. Paul Airport. The following material is "reprinted" from CompuServe's Aviation Special Interest Group (AVSIG), with the permission of J. Baum. For the uninitiated, we are dealing with a computer bulletin board here!

Sb: #235852-Ball Lightning
Fm: Jeff Baum (PHX) 73740, 1302
To: Emory Kimbrough [TCL] 72777, 1553 (X)

"On 8 January 1992 we were in MSP [Minneapolis/St. Paul] ready for push-back at sunrise. Weather was sleet squalls, temperature of +2 degrees C (35 degrees F), ceiling of indefinite 100 obscured, visibility of about 1 and ½ miles variable. We deiced and taxied for the active 11L [runway], airborne in 8 minutes after deicing had ended. The First Officer was flying that leg. Climbing through about 900 feet ABL, this incandescent sphere approximately 10 cm (6 inches) in diameter surrounded by a, what I called, plasma cloud of bluish white approx. 1 to 1 and ¼ meter (3 to 4 feet) in diameter with bright white 'rays' similar to a fireworks explosion formed just forward and to the left of the radome. We contacted this within ¼ second on our left side, just aft of the attach seam of the radome (namely about in line with my left foot). With this contact there was a sharp bang. The cabin crew reported the loud bang but didn't see any haze or light inside the cabin. One did report seeing a bright light on the left side of the aircraft's exterior." (R12)

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GLB4 Rod-Shaped Ball Lightning

Description. Luminous masses of cylindrical shape but otherwise possessing most of the characteristics of ordinary ball lightning (GLB1). Sizes from 5 x 15 inches to 3 x 8 feet have been reported. Bright flames sometimes issue from the surfaces of the cylinders. In general, the phenomenon seems somewhat more bizarre and energetic than ordinary ball lightning, as the examples below will confirm. Rod-shaped ball lightning has been seen to change into spherical ball lightning.

Background. Ordinary ball lightning is often pear-shaped, but cylinders with length-to-diameter ratios of two or greater seem to represent a distinctly different variety with, perhaps, a different mode of formation and another type of internal structure.

Data Evaluation. Rod-shaped ball lightning is much more rare than the spherical variety. The few extant cases do, however, display good internal consistency. Rating: 2.

Anomaly Evaluation. It is more difficult to imagine an electromagnetic containment scheme for cylinders with high length-to-diameter ratios than for simple spheroids. Rating: 2.

Possible Explanation. Rod-shaped ball lightning may be an intermediate state between ordinary ball lightning and dumbbell-shaped ball lightning, although this possibility certainly does not explain any variety of ball lightning. Interchangeable forms just heighten the enigma.

Similar and Related Phenomena. Ordinary ball lightning (GLB1), dumbbell-shaped ball lightning (GLB5), bead lightning (GLL).

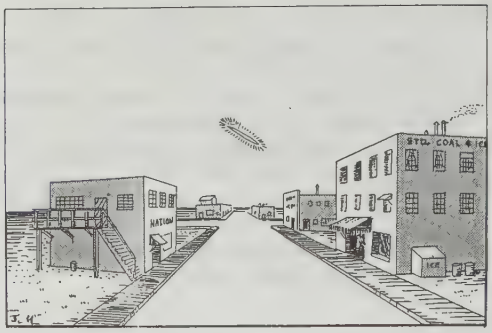
Examples of Rod-Shaped Ball Lightning

X1. August 5, 1889. England. "On Monday, the 5th instant, at midday, this district was visited by a violent storm of rain, which lasted half an hour, and was accompanied by thunder and lightning. When the storm had passed over and the sky was getting bright, a rod-like object was seen to descend from the sky. It is described as being of a pale yellow colour, like a hot iron, and apparently about 15 inches long by 5 inches across. ..... The object descended 'moderately slowly,' 'not too fast to be followed by the eye' and quite vertically. On reaching a point about 40 feet from the ground, and in

close proximity with a chimney-stack belonging to a house in Twickenham Park, the object seemed to 'flash out horizontally as if it burst,' showing an intensely white light in the centre and a rosy red towards the outer parts. At the same instant a violent explosion was heard, and soon afterwards a strong smell was perceived, which is described by the observers as 'resembling that of burning sulphur,' for which the smell of ozone and nitric oxide might easily be taken." (R1)

X2. May 28, 1901. Liverpool, England. "On afternoon of May 28 last, whilst I was in the kitchen of my house in the country during a most violent thunderstorm, my housekeeper sitting on one side of a window, the top sash of which was open and I on the other, simultaneously with a very heavy peal of thunder a red-hot bolt the size of a small rocket flew in through the open window, followed by a stream of sparks. When in the middle of the kitchen the bolt exploded with a bright flash and sharp crack as of a pistol. Stranger still, this was followed in about 15 seconds by two more similar bolts, one of which came through the back door and one through the front door, both of which were open. There was no smell or after-effect noticeable. I may say the house is not in a conspicuous situation, the adjoining one being much loftier." (R2) The terms 'bolt' and 'rocket' seem to indicate a cylindrically shaped mass.

X3. Circa 1907. Burlington, Vermont. "I was standing on the corner of Church and College streets, just in front of the Howard Bank and facing east, engaged in conversation with Ex-Governor Woodbury and Mr. A. A. Buell, when, without the slightest indication or warning, we were startled by what sounded like a most unusual and terrific explosion, evidently very near by. Raising my eyes and looking eastward along College Street, I observed a torpedo-shaped body some 300 feet away, stationary in appearance and suspended in the air about 50 feet above the tops of the buildings. In size, it was about 6 feet long by 8 inches in diameter, the shell or cover having a dark appearance, with here and there tongues of fire issuing from spots on the surface resembling red-hot unburnished copper. Altho stationary when first noticed this object soon began to move, rather slowly, and disappeared over



Artist's concept of the 6-feet-long, torpedo-shaped, luminous object seen hovering about 50 feet above the roof tops at Burlington, Vermont, in 1907. (X3)

Dolan Brothers' store, southward. As it moved, the covering seemed rupturing in places and thru these intensely red flames issued. My first impression was that it was some explosive shot from the upper portion of the Hall furniture store. When first seen it was surrounded by a halo of dim light, some 20 feet in diameter. There was no odor that I am aware of perceptible after the disappearance of the phenomenon, nor was there any damage done so far as known to me. Altho the sky was entirely clear overhead, there was an angry-looking cumulo-nimbus cloud approaching from the northwest; otherwise there was absolutely nothing to lead us to expect anything so remarkable." (R3)

X4. 1959. Kansas City, Missouri. "In 1959, Mrs. Lillian Mack, of Kansas City, Missouri, was in her home during an afternoon thunderstorm when she heard a sound like 'crushing glass.' An object about two feet long and one inch in diameter came flying like a spent arrow into the room where it hovered while forming the shape of a ball. After half a minute, it dissolved, and 'while dissolving we all heard the sound of breaking glass... but no glass was broken... sparks flew from the falling dust-like stuff and the (object) looked like hot metal.'" (R4)

X5. July 1879. Lambertville, New Jersey. A cylinder of fire, 3 feet by 6-8 feet fell with a whizzing sound. (R5)

X6. August 25, 1880. No place given. A brilliant cylindrical body with conical ends passes between clouds. (R6)

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R2. G.; "Thunderbolt," English Mechanic, 74:15, 1901. (X2)

R3. Alexander, William H.; "A Possible Case of Ball Lightning," Monthly Weather Review, 35:310, 1907. (X3)

R4. Gaddis, Vincent H.; Mysterious Fires and Lights, David McKay Co., New York, 1967, p. 54. (X4)

R5. Van Dyck, F.C., and Hayden, Everett; "Globular Lightning," Science, 11:110, 1888. (X5)

R6. Tomlinson, Charles; "Remarks on the Weathering of Rocks and Certain Electrical Phenomena," Philosophical Magazine, 5:26:475, 1888. (X6)

GLB5 Double and Triple Ball Lightning

Description. Two or three balls of lightning connected by a luminous rod-like structure. The balls may be of different sizes but they move together.

Data Evaluation. Very few cases of double or triple ball lightning have been discovered so far. One example, however, was well-described by trained observers (X2 below). Rating: 3.

Anomaly Evaluation. Double and triple ball lightning cannot be less mysterious than ordinary ball lightning. The puzzling connecting structure only aggravates the problem of explaining these long-lived energetic manifestations. Rating: 2.

Possible Explanations. Double and triple ball lightning may be abbreviated forms of bead lightning (GLL), which itself is not well-understood. Alternately, ball lightning with protuberances might ultimately fission into two spheres, so might rod-shaped ball lightning. These surmises are not, of course, explanations but only thoughts about possible relationships.

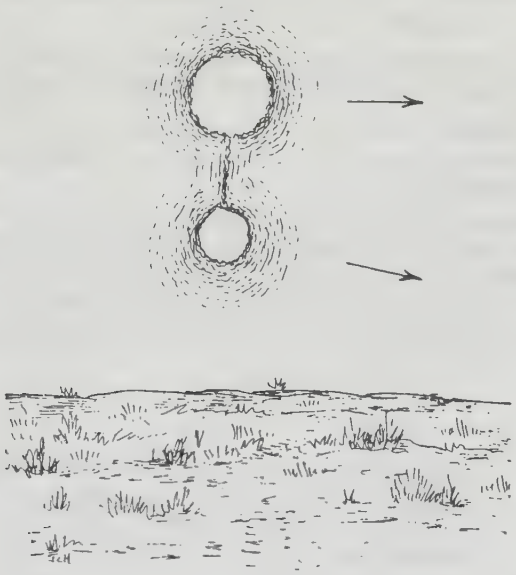
Similar and Related Phenomena. Ball lightning with projections (GLB2), rod-shaped ball lightning (GLB4), and bead lightning (GLL).

Examples of Dumbbell-Shaped Ball Lightning

X1. July 1898. Scranton, Pennsylvania. "In July, 1898, in the city of Scranton, Pa., between the hours of 12 noon and 1 o'clock P.M., as the sun shone brilliantly from a cloudless sky, there appeared in front of the writer, apparently not more than 100 feet away and 50 feet elevated from the earth passing from an easterly to a westerly direction, three balls of candescent light linked together, descending like a bolt of lightning and accompanied with a most terrifying and hissing sound, ending in a report much like the sudden immersion of a large molten mass of iron into a body of water." (R1)

X2. May 12, 1912. Dresden, Germany. "A remarkable example of ball lightning was observed on May 12, 1912, at 6.45 p.m. from the 200-m-high section of Plaven near

Dresden on the adjacent side of the narrow Weisseritz Valley. Although the observation site itself lay beyond the range of the thunderstorm (the nearest of the three thunderclouds was at a horizontal distance of 3 km), suddenly, without there preceding a lightning of some other form, there appeared at a height, which must have been less than 100 m above the ground, a luminous spherical mass at a distance of approximately 1 km from the observation site. The instant that one of us first noticed the luminous phenomenon there was a second, smaller ball about 1.5 m below the first which was connected to the upper ball by a fine strip similar to a string of beads. The color of the balls was reddish yellow (about 600 mμ). Both moved slowly one directly above the other in the direction northeast, whereby the upper ball maintained a constant height above the ground, while the lower one slowly descended as the connecting luminous strip faded.....Both balls had a velocity which could hardly have exceeded 1 m/sec....we concluded that the diameter of the lower ball could not have been greater than 1 m.....No noise was perceived, and the total duration of the event from the moment the phenomenon was noticed to the instant the upper ball faded amounted to two minutes....." (R2, R3)



Dresden, 1912. Two lightning balls connected by a 1.5-meter strip of luminous beads. Lower ball was about 1 meter in diameter. (X2)

X3. July 20, 1931. Toronto, Ontario, Canada.

"While my wife was at the rear of the house closing the windows, two balls of fire came in the open window which faces north. They were about two feet apart and came with a sizzling sound, 'and then some.' Owing to the suddeness with which they appeared and the speed at which they travelled it was impossible to say how large the balls were, but they were larger than walnuts. There was a terrific peal of thunder. I was almost blinded. They seemed to land on the pillow beside me, but I believe they struck the bed light, causing a flash, also a short circuit which blew out a fuse. Particles of metal from the lamp which was struck, fell on the pillowslips and burned several tiny holes in both of them." (R4)

X4. August 31, 1978. Pawnee Cove South, near Mannford, Oklahoma. The interaction between the following two balls of lightning is curious to say the least!

"Two balls of lightning 'chased' each other up a tree in a spiral fashion across the inlet in Pawnee Cove North park. They were about 100 yards away and I judged their apparent diameters to be about 1 foot. Their color was a wan, pale yellow. I watched them for about 15 seconds and boarded my ranger truck for the 5 minute run to PCN [Pawnee Cove North]. Upon my arrival, they had vanished.

"The sky was absolutely clear. I had heard, however, that the aurora borealis had been seen as far south as Albuquerque, New Mexico. Higher than normal solar activity as the cause for both, perhaps?" (R5)

It is hard to imagine how solar activity could affect the appearance of ball lightning. Also puzzling is the fact that the above incident occurred in fair weather.

References

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R2. Meteorologische Zeitschrift, 29:384, 1912. (X2)

R3. "Double Ball Lightning," Literary Digest, 46:177, 1913. (X2)
R4. Anonymous; "An Example of Ball Lightning," Royal Astronomical Society of Canada, Journal, 25:322, 1931. (X3)
R5. Partain, Keith L.; Personal communication, February 28, 1983. (X4)

GLB6 Miniature Ball Lightning

Description. Spherical or nearly spherical luminous structures with diameters less than about 1 inch. Much smaller than ordinary ball lightning, this form has been seen only inside houses during thunderstorms or unsettled weather. The pea-sized lights sometimes disappears simultaneously with lightning and thunder outside, suggesting they may be induced by strong electric fields and possibly akin to St. Elmo's Fire (GLD).· The energy content of miniature ball lightning is evidently very small.

Background. We know so little about the constitution of ordinary ball lightning that we cannot say that miniature varieties are impossible. However, the characteristics of miniature ball lightning seem somewhat different from ordinary ball lightning, indicating a basically different phenomenon, perhaps a mobile form of St. Elmo's Fire.

Data Evaluation. A very rare phenomenon, but the examples available show good consistency. Rating: 3.

Anomaly Evaluation. If miniature ball lightning is true ball lightning, the problem of explaining it is at least as difficult as it is for ordinary ball lightning. If miniature ball lightning is a mobile form of St. Elmo's Fire, as seems reasonable, the anomaly is less pronounced. Rating: 3.

Possible Explanation. A mobile form of St. Elmo's Fire or corona discharge.

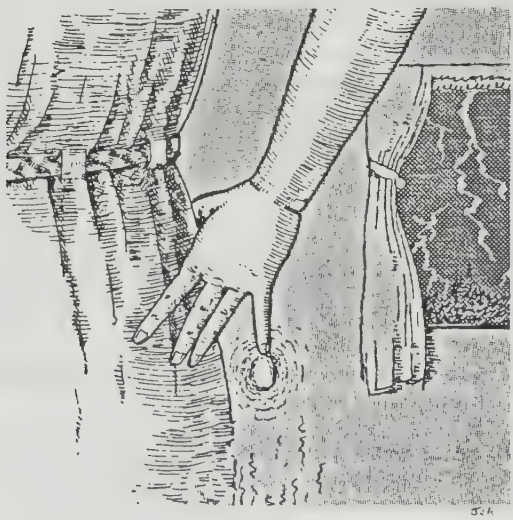
Similar and Related Phenomena. St. Elmo's Fire (GLD).

Examples of Miniature Ball Lightning

X1. August 17, 1921. Eastbourne, England. "The two ladies were sitting at a table about 8 p.m., with the window open. It was raining heavily at the time, and there was no wind. Stormy clouds were about, but it was not unusually hot. Thunder and lightning at the same time were afterwards reported from London---a distance of, say, 50 miles---but there was no thunderstorm at Eastbourne. There had been no rain during the few preceding days. As one of the ladies took up a knife to cut bread the ball of light was seen to flash past the knife (without touching it) on to the table, travelling a distance of about 9 in. at an average height of about 3 in. from the table, but moving toward the latter. When the ball touched the tablecloth it 'went out with a spitting sound,' leaving no mark

or trace of any sort.....As to the appearance of the ball itself, it was 'about the size of a pea, the light encircling it being about the size of a golf ball. The light was white and intensely bright, like electricity. Too dazzling to see through." (R1, R3)

X2. June 19, 1924. Baltimore, Maryland. "Mrs. Ames was standing on a rug during a thunderstorm with her hand at her waist, one finger more or less extended. I was about five feet away and noticed the air between her finger and the floor was quivering so that it looked just like the hot air over a field. I noticed something rise slowly from the floor up towards her finger and then there was for an instant a small oblong fireball about the size of a pecan attached to her finger. It was not very bright and appeared to shine through a haze. There came a flood o lightning outside and the fireball disappeared." (R2)



Pecan-sized ball lightning materializes in a Baltimore house in 1924. (X2)

X3. August 1885. Sotteville, France.

"In the month of August, 1885, a storm burst over Sotteville (Seine-Inferieure); lightning furrowed the sky, the thunder muttered, and the rain fell in torrents. Suddenly, in the Rue Pierre Corneille, several small balls, about the size of a common pea, were seen to fall; these burned on touching the ground, sending out a little violet flame. People counted more than twenty, and one of the spectators, on putting her foot on one of them, produced a fresh flame." (R4)

References

R1. Chattock, A. P.; "Globular Lightning Discharge," Nature, 109:106, 1922. (X1)
R2. Humphreys, W. J.; "Ball Lightning," Americal Philosophical Society, Proceedings, 76:613, 1936. (X2)
R3. "Ball Lightning," Meteorological Magazine, 57:46, 1922. (X1)
R4. Flammarion, Camille; Les Phenomenes de la Foudre, 1890, p. 86. (X3)

GLB7 Giant Ball Lightning

Description. A luminous, roughly spherical but sometimes shapeless mass ranging in size from approximately 3 feet to 60 feet. These glowing masses usually descend from thunder clouds, drift a bit, and fade away silently. There is often a strong resemblance to electric discharge phenomena (GLD).

Background. At the large end of the ball lightning size spectrum, as well as at the small end, the phenomena seem to take on the characteristics of such phenomena as electrified clouds and St. Elmo's Fire (GLD). Classical ball lightning is much more energetic and destructive than either giant or miniature ball lightning. Thus, the explanations may vary with the size of the luminous mass.

Data Evaluation. Good observations and photographs exist. Rating: 1.

Anomaly Evaluation. Although giant ball lightning does not seem to possess the energy density of ordinary ball lightning, no explanation exists for its ability to preserve its shape and motion for the several seconds it persists. Rating: 2.

Possible Explanation. Giant ball lightning may be a large, poorly organized plasmoid held together by a weak magnetic bottle.

Similar and Related Phenomena. St. Elmo's Fire and other electric discharge phenomena. (GLD)

Examples of Giant Ball Lightning

X1. November 1, 1864. Florence, Italy. "A white globe of fire many times larger than the full moon seemed hanging almost motionless in the air; a large portion of the surrounding heavens was lighted up by it, so much so that my head being turned away from it, I mechanically apprehended it was moonlight, though, had I thought at all, I should have known that no moon was at that time in sight; but a bright shimmering of light on a tall bay tree not far from me recalled my attention, and turning I saw this fireball, white for a moment, shades of orange and blue passing over its surface, the latter gaining on the former. After a full minute's time (after I had turned towards it) it disappeared suddenly---vanishing, not appeared to move from where it was; only just before its disappearance a smaller ball was seen immediately below it, of a fiery orange colour, the first one appearing at that moment of the same hue." (R1)

X2. February 8, 1906. Beccles, England. During a thunderstorm. "Then almost immediately, in the north-west, there appeared a huge circle of light, giving the impression of the heavens being opened, most vivid, and in size, as far as one could judge, 2 or 3 times the diameter of a setting sun. It appeared just above the cedar in height, but not near it in distance from me. At the same moment an appalling crash came like the bursting of a big shell immediately overhead. This was, I suppose, the moment at which the east end of our church, 100 yards from this house, was wrecked. The circle of light was visible for some appreciable time..... My wife, in a room above this sitting away from the window, describes the appearance almost exactly as I have done, except that she says the colour was very yellow, like gas, whereas I should say it was white or nearly so. My daughter, aged sixteen, looking out of window from the same upstairs room, speaks of it as a huge ball of light like a great sun, and says that the whole garden seemed to be a blaze of light. These two add that the globe of light seemed to travel over the house." (R2)

X3. July 9, 1975. Albany, New York. "Of particular interest was the observance of apparent ball lightning associated with, but not connected to, a long diagonal stroke which hit a factory a distance of just under a kilometer to the north of the observatory. Over a three-second interval, four distinct

In 1975, ball lightning measuring about 5 feet in diameter was observed near Albany. (X3)

lightning strokes, each following the same path, hit the building, and during this time an unmistakable fireball was seen near the ground an estimated 5 m to the west of the point of impact of the lightning stroke. The ball was very bright, fuzzy in appearance, equal in brightness to the lightning stroke, and orange-yellow in colour. Apparently, the ball was quite large, its size estimated to be approximately 5 m in diameter. It appeared at the moment the first stroke reached the factory and vanished when the final stroke disappeared. The ball maintained a constant brightness for the duration of the entire flash, a full 3 secs; it did not flicker on and off in unison with each individual stroke." (R3)

X4. June 8, 1977. Dyfed, West Wales, U.K. "The ball lightning phenomenon was very large and estimated to be about the size of a bus. It was described as a brilliant, yellow-green, transparent ball with a fuzzy outline which descended from the base of a towering cumulus over Garn Fawr Mountain and appeared to 'float' down the hillside. Intense light was emitted for about three seconds before flickering out. Severe static was heard on the radio. The object slowly rotated around a horizontal axis, and seemed to 'bounce' off projections on the ground. It was noticed that cattle and seabirds in the immediate vicinity became disturbed." (R4)

X5. November 4, 1749. North Atlantic Ocean. Ball of fire, the size of a large millstone, was seen rolling over the water. It exploded when it hit the ship and did considerable damage. (R5)

X6. June 26, 1921. St. John's Wood, England. Large incandescent mass floats in the air below the clouds. It remained stationary for some minutes. (R6)

X7. August 30, 1930. Nebraska. A lavender colored shapeless mass floats slowly downward as a squall line approaches, and globular structures, 28 and 42 feet in diameter, run along power lines. (R7-R9)

X8. July 22, 1951. Dorset, England. A large mass of blinding light hovers over ground and fades out. Not spherical, about 1 yard in all dimensions. (R10)

X9. November 11, 1940. London, Ontario, Canada. Rain had fallen earlier but had ceased. There was a warm wind, unusual

for that time of year, but no thunderstorm. A couple driving home just after midnight had a remarkable experience.

"Suddenly they noticed, for both saw it, coming towards them from the west, at about a quarter of a mile distant, what appeared to be a car on fire. They watched it as it came down the road to meet them and soon found that this fiery-red mass, roundish in shape, the height and width of the car, with a purplish tinge to it, was no car on fire but a large 'fire-ball.'

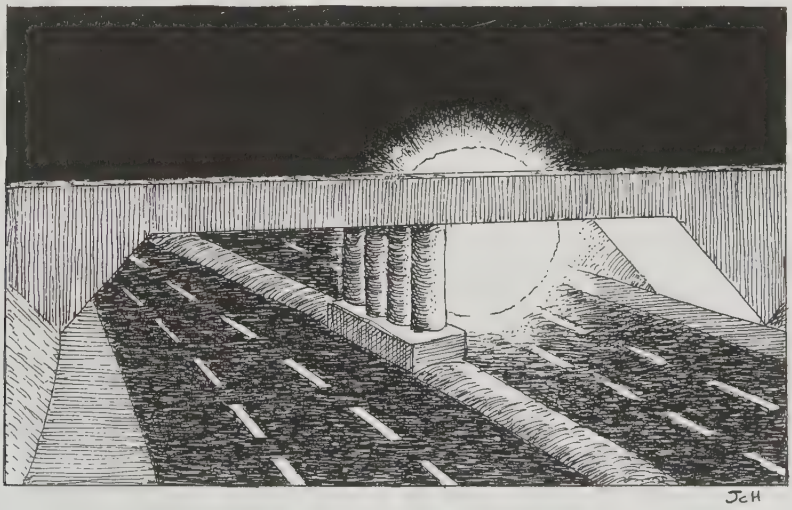
"They drove into their driveway and from this point of vantage they watched this phenomenon as it seemed to lightly drift or bounce along the surface of the road. When this ball of fire arrived at about a hundred yards from them it suddenly shot up into the air to a height of approximately fifty feet, arms or streamers shot out from the centre of it, sideways. Down it came to the road and then once more it rose suddenly to the same height. Finally it descended and as it hit the surface of the road it broke up and disappeared like a flash.

"Mr. Weaver walked to the place later where this 'fire-ball' seemed to have hit the road twice and found a little white precipitate somewhat like slaked lime, although, he says, that may easily have been there previously." (R11)

X10. July 6, 1983. Buckinghamshire, England. Giant ball lightning was seen by several people who were travelling along the M1 Motorway. The ball (see sketch) was blue in color and certainly large enough to be cataloged here. Note in the sketch that the bridge partially obscures the ball, demonstrating thereby that it was probably not an afterimage or illusion. (R12)

X11. November 24, 1987. Tulsa, Oklahoma.

"Circa 3:20 P.M. CST. Location: 2800 Southwest Blvd. in said city. Parents of Keith L. Partain saw a lightning strike near an oil refinery storage tank. Immediately after the strike they saw a bluish sphere with red and yellow highlights, not more than 9 feet in diameter, some 100 yards away, near the tank. The sphere lasted in that form some five seconds before fragmenting in a loud detonation. During the act of detonation the sphere became an irregular spheroid before fragmentation. Mr. Partain reported that he could feel the heat from the detonation. Both individuals, seated in a truck, were quite astounded by the apparition. The weather was quite stormy



Apparent giant ball lightning as seen along British Highway M1 in 1983. Using the bridge as a reference, this ball was about 25 feet in diameter. (X10)

and violent in its gales, rain and lightning." (R14)

X12. June 28, 1989, near Silbury Hill, Wiltshire, England. The following account is of particular interest because of its association with the formation of one of the controversial crop circles. The crop circle in this case is of very simple design and could well have a natural origin. It should be added that G.T. Meaden, the editor of the U.K.'s Journal of Meteorology favors a plasma vortex origin for the simplest of the crop circles. Very energetic plasma vortexes might be self-luminous, as are some tornados as cataloged in GLD10.

"Soon after midnight the occupier of the roadside cottage by the path which leads to West Kennett Long Barrow noticed a large ball of light 400 metres distant in a wheatfield to the west. At the time of the observation he was walking from house to garage, and had a clear view to the illuminated part of the field through a gap in a hedge which borders his garden. He described the ball as orange in colour, adding that it was brighter around the periphery, and he guessed the diameter as 30-40 feet (say, 10-13 metres). When first seen, the ball was already low over the field and still descending. The witness watched the base of the ball 'go flat' as it made contact with the crop and/or the ground. The ball then gave 'a little bounce' and after a further 'seven or eight seconds' disappeared in situ." A large crop circle was found the next morning in the spot where the luminous phenomenon was seen descending. (R14)

X13. June 8, 1977. Fishguard, Dyfed, Wales, United Kingdom. The observer was an officer at the coastguard station.

"The ball lightning phenomenon was very large and estimated to be about the size of a bus. It was described as a brilliant, yellow green, transparent ball with a fuzzy outline which descended from the base of a towering cumulus over Garn Fawr Mountains and appeared to 'float' down the hillside. Intense light was emitted for about three seconds before flickering out. Severe static was heard on the radio. The object slowly rotated around a horizontal axis, and seemed to 'bounce' off projections on the ground. It was noticed that cattle and seabirds in the immediate vicinity became disturbed." (R15)

X14. July 26, 1995. Ruislip, Middlesex, England. A couple in a car that was stopped at a crossing saw an enormous fireball hanging in midair across the road. It was estimated that a large dinner plate held at arm's length would have covered it. The ball was orange-yellow in color and extremely bright. There were a few small tubular shapes on its circumference, and it seemed possess some internal movement. It ultimately exploded violently. A thunderstorm was underway at the time, but no rain was falling. Electrical equipment in some nearby buildings was damaged. (R16)

References

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R10. Davis, M.; "A Near Flash," Weather, 6:384, 1951. (X8)
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R13. Partain, Keith; Personal communication, November 24, 1987. (X11)
R14. Meaden, G.T.; "Nocturnal Eye Witness Observation of Circles in the Making," Journal of Meteorology, U.K., 15:3, 1990. (X12)
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R16. James, Adrian; "Ball Lightning at Ruislip, Middlesex, 26 July 1995," Journal of Meteorology, U.K., 21: 256, 1996. (X14)

GLB8 Transparent Ball Lightning

Description. Transparent luminous masses that otherwise resemble ordinary ball lightning. Ball lightning is usually so bright that one cannot see through it, but if the ball's energy density is very low it might well be transparent.

Background. Although this phenomenon is classified with other types of ball lightning, it may in fact be more closely related to nocturnal lights (GLN), as exemplified by ghost lights and will o' the wisps. The line of demarcation between ball lightning and nocturnal lights is not at all clearcut. Ball lightning generally seems to be more violent and closely associated with storms.

Data Evaluation. The data are scant and soft. Rating: 3.

Anomaly Evaluation. Rating: 2.

Possible Explanations. A very low energy density form of ball lightning or a variety of will o' the wisp, neither of which has a good explanation.

Similar and Related Phenomena. All of the nocturnal lights (GLN).

Examples of Transparent Ball Lightning

X1. September 1910. Mazoc, South Rhodesia. "...at about 9 p.m., he observed a ball of fire, the colour of an electric light, about one foot six inches by ten inches in size, and similar in shape to a rugby football. The ball was luminous and transparent, but it cast no light beyond its own body. When first seen it was stationary over a road on Mr. Biggs' farm, and it remained in one position for about five minutes, during which time, Mr. Biggs approached within three yards. The light then moved away in a zig-zag fashion at a rate of about six miles an hour, and finally entered a belt of trees, where it disappeared, leaving no trace whatever of its flight. No noise was heard, no trace of damage could be found, and no smell could be detected." (R1)

X2. June 1, 1984. Nottingham, England. This possible example of transparent ball lightning is also notable for its sound effects and association with water.

"I was in my kitchen. The window and door were both closed. I was standing with my back to the window when I

heard a 'boiling noise' and a noise which sounded like glass splintering---a crash sound. I was very scared and turned around to face the window and saw a large glass-looking ball, approximately 10 inches diameter (25 cm), slightly oblong (oblate), with a white filament in the middle. This was floating in a bowl of water which was in the sink. I ran into the bathroom, and seconds later I heard an explosion and splintering glass. When it was quiet---I think a few seconds elapsed---I returned to the kitchen. The ball had gone and there was no damage." (R2)

X3. December 3, 1979. Fleetwood, England. This example of transparent ball lightning also sported prominent spikes, so it was cataloged in GLB2-X5. (R3)

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GLB9 Fragmenting Ball Lightning

Description. Ball lightning that bursts into many smaller balls or incandescent pieces that fly off in all directions. The formation of multiple, smaller, long-lived balls is rare. The "pieces" of ball lightning may carry dangerous amounts of energy or be harmless.

Data Evaluation. Fragmenting ball lightning has been observed frequently. Rating: 1.

Anomaly Evaluation. It is not clear how ball lightning's structure, whatever it may be, can split into smaller, luminous, apparently self-sustaining (temporarily stable), pieces. Do the fragments have the same structure as the parent ball lightning? How is the original ball's energy subdivided? Rating: 2.

Possible Explanations. The structure of ball lightning may be multicelled and fissionable when stimulated. Another possibility is that fragmenting ball lightning may generate electric fields intense enough to create corona discharge and St. Elmo's Fire, appearing as multiple spheres.

Similar and Related Phenomena. St. Elmo's Fire (GLD) has also been observed to split and even recombine. Ordinary lightning (GLL) frequently splits into many bolts and, more rarely, bead lightning. Luminous air bubbles. (GLD)

Examples of Fragmenting Ball Lightning

X1. November 16, 1857. Charleston, South Carolina. From the testimony of a Mr. Scriven. ",...he saw a red, fiery ball of the size and shape of an orange, slowly descending through a distance apparently of 20 or 30 feet, to the ground. Its fall was scarcely more rapid than that of a soap bubble, giving him time to call his sister, a little girl, to see it

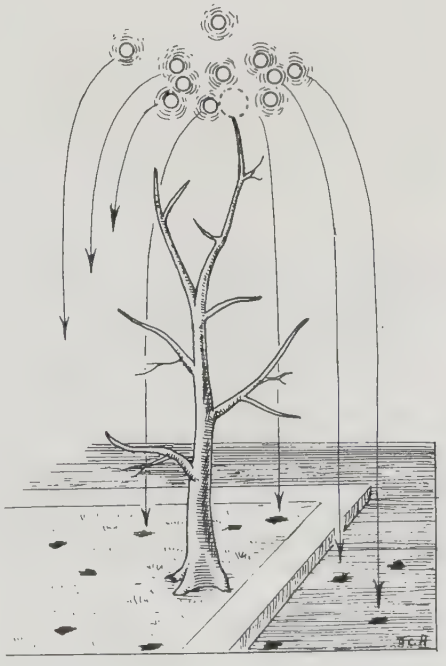
strike a high wooden fence, distant about fifty or sixty feet from the portico, and which separated the door-yard from a church enclosure adjoining. It seemed to adhere for an instant to the board against which it struck, and then separated into three parts and disappeared." (R1)

X2. July 17, 1890. Surbiton, England. During a severe thunderstorm. "The room I was standing in was situated about 30 ft. from the ground, when all at once at the time mentioned it seemed to me as if a huge ball of reddish yellow fire was suspended in mid air, about the level of the window. (The colour was that of an electric arc as seen in a dense fog). It did not last a moment, then it rapidly changed colour, and turned to an intense whiteness, move vivid than any other light I have ever seen, and burst with a terrific explosion, increasing in size many times over, and dozens of small splashes darted out of it on all sides; its brilliancy dazed me for several moments after." (R2)

X3. April 13, 1904. Essex, England. "A thunderstorm occurred during the early morning hours, at about 3 a.m. there was a blinding flash, lighting up the whole neighborhood for miles around, followed immediately by a crashing explosion. One person stated that he saw what appeared to be a cylinder, and another person, a ball of fire, descend and then explode, 'casting darts' in all directions. On careful examination in daylight it was found that in an oatfield which had recently been dredged there were three distinct sets of holes ranging from 9 in. down to about 1 in. in diameter. The holes, which were perfectly circular, diminished in size as they went downwards, and remained so on to the perfected rounded ends at the bottom. Upon digging sectionally into the soil, which is stiff yellow clay, it was found that the holes were 'as clean cut as though bored with an auger.'" (R3) Note that ordinary fulgerites have branching structures.

X4. October 8, 1919. Salina, Kansas. "At about 6.30 p.m., October 8, 1919, a brilliant display of ball lightning occurred at Salina (sic), Kans., on one of the most frequented street intersections of the town. Eyewitnesses described it as 'a ball of fire as large as a washtub floating low in the air.' It struck the northwest corner of the Campbell Building, corner Santa Fe and Iron Avenue, about midway to the top of the building, which is 35 feet high, tore out some brick, demolished a second-story window, and then exploded with a bang that resembled the noise made by the discharge of a large pistol, filling the air with balls of fire as large as baseballs, which floated away in all directions. Some of these balls followed trolley and electric-light wires in a snaky sort of manner and some simply floated off through the air independently of any objects near by." (R4)

X5. 1960s. Neustadt, Germany. During a thunderstorm. "Suddenly, at a height of about 16 m above the ground and at a short range of about 24 m, I saw a spherical plasma ball coloured bright yellow-white. This object appeared to have a diameter of 50 to 100 cm. It moved vertically downwards with a speed of about 4 m s^{-1}, and its path ended in the top branches of a tree, at a height of approximately 9 m. On touching the tree the ball instantly disintegrated into eight to twel-



Neustadt, Germany. Ball lightning hits a tree and fragments into many smaller balls. (X5)

ve smaller spheres. These were the same colour as the large one and each had a diameter of 12 to 15 cm. They fell to the ground, guided by the outer contour of the tree, and moved vertically during the last few metres in the absence of branches. On reaching the ground (an asphalt roadway and a neighboring footpath) the spheres instantly disappeared. There was no noise apart from that of the rain and no lightning associated with the primary plasma-like sphere. Three to five minutes afterwards, the same phenomenon occurred again in precisely the same way as before, indicating that the conditions needed to produce and guide the primary sphere were still maintained or reestablished during the time that had elapsed. Immediately after the rain had stopped, I went out into the street to look for further evidence. There were circular patches of melted asphalt on the wet asphalt cover of the roadway which showed the interference colours of thin layers. Their diameters were each 12 to 15 cm and they obviously marked the impact areas of the smaller spheres. This event was described similarly by all of the witnesses." (R5)

X6. July 28, 1973. Rabaul, Papua-New Guinea. Clouds to the south illuminated by lightning. "From the top of the tallest cloud of the group (it appeared to emanate from the top) a 'ball' of lightning very swiftly traversed the sky, leaving behind it what could only be described as a meteoric tail. The angle of elevation from me to the 'ball' I estimated as approximately 30^{o}, at point of commencement (this was a rough guess and could have been less). Still leaving its meteor-like tail the 'ball' travelled towards me, climbing to an estimated angle of 50^{o} or so, then literally exploded into four or five 'fingers' like a roman candle firework, each separate finger of the same constitution as a meteor's tail. These fingers climbed to an estimated angle of 60^{o}, then appeared suddenly to retract into themselves down the paths that they had followed, forming into a ball again and returning as such into the cloud of origin. (R6, R7)

X7. July 16, 1750. Surrey, England. A large fireball divides into many parts. (R8)

X8. August 1881. No place given. A bright elongated fireball emerges from a cloud; before reentering the cloud a portion of it breaks off and falls to earth. (R9)

X9. August 1881. Connersville, Indiana. Lightning bolt fragments into many balls that roll around the ground. (R10)

X10. February 24, 1884. Amiens, France. A brilliant mass divides into many glowing but harmless globules. (R11)

X11. June 10, 1891. Woodstock, England. Fireball bursts into glowing fragments. (R12)

X12. August 9, 1893. Kingstown, England. A fireball darts about the surface of the water, leaving smaller balls behind. (R13)

X13. Circa 1895. Culday, Ireland. A great shining mass approaches a boy and bursts into several fragments, mangling his hand. (R14)

X14. Circa 1907. Minnesota. A fireball strikes a tree and scatters in all directions. (R15)

X15. Circa 1920. Marietta, Ohio. Ball lightning, 9 inches in diameter, explodes and hurls brilliant particles in all directions. (R16)

X16. September 10, 1924. Finley, North Dakota. A dull, greenish-yellow ball of light appears and splits into many smaller parts. (R17)

X17. June 10, 1948. London, England. A reddish-white fireball, twice the size of a football, explodes, throwing pieces in all directions. (R18)

X18. No date given. Lanarkshire, England. Ball of fire settles on the ridge of a thatched roof and gradually disintegrates into pieces that stream down the thatch. (R19)

X19. November 1825. Newton, Ohio. "At the same time, and at the same place the meteor was seen to fall, two ladies were walking in the road in the same direction in which the meteor was moving, found themselves suddenly enveloped in a mass of light. A ball of fire or light, several feet in diameter, seeming to come from above and behind fell upon them and the ground, breaking, as it struck, into a thousand smaller balls, rolling upon the earth and breaking again into still smaller balls, till it disappeared. Looking up, they saw the other portion of the meteor just as it disappeared in the distance before them. The phenomenon was attended with no noise or heat, and their clothing exhibited no traces of having been in contact with any foreign substance." (R20)

X20. April 21, 1964. Stockton-on-Tees, England.

"I was travelling in my car along Bowesfield Lane, when the sky suddenly became black, and as there was a cloudburst of rain I slowed up. I was amazed to see a shimmering, perfectly spherical ball slowly appear out of the black cloud ahead. I stopped the car, and watched the ball slowly fall, but instead of falling to the ground in front of me it suddenly changed direction and floated across towards my righthand side at a height of about 100 feet, but still at the same quite slow speed. When it had travelled about 3/4 mile it suddenly dropped and disappeared from my sight causing a tremendous explosion.

"My late mother lived in Hartburn Avenue and as it appeared that the ball had fallen in that vicinity, I turned the car and went along to find out what had happened. I found that the sphere had landed on the roof ridge of her house and the explosion had blown more than half the roof off. A witness had seen the sphere hit the roof, and it had then split into three separate spheres which had dropped to the ground and then run across Hartburn Avenue, each ball hitting three separate houses on the other side of the road where they had exploded causing damage." (R21)

X21. August 24, 1895. No place given. A remarkably similar case of a fragmenting sphere was presented by C. Flammarion, the noted French astronomer.

"On August 24, 1895, about ten in the morning, in the midst of a storm of wind and rain, several persons saw descending to the ground a whitish-coloured globe of about an inch and a half in diameter, which, on touching thew ground, split into two smaller globes. These rose at once to the height of the chimneys on the houses close by and disappeared. One went down a chimney, crossed a room in which were a man and a child, without harming them, and went through the floor, perforating a brick with a clean round hole of about the size of a franc. Under this room there was a sheep-fold. The shepherd's son, seated at the doorway, suddenly saw a bright light shining over the flock of sheep, while the lambs were jumping about in alarm. When he went up to them, he was startled to discover that five sheep had been killed. They bore no trace of burning, or of wound of any kind, but about their lips was a sort of foam, slightly pink in colour. In the adjoining house, the second fireball had also gone down a chimney, and had exploded in the kitchen, causing great damage." (R22)

The tiny sizes of these balls would also qualify them for category GLB6.

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GLB10 The Materialization of Ball Lightning in Enclosures

Description. The formation of luminous spheres, usually smaller than average ball lightning, inside closed houses, aircraft, and electrically shielded volumes. Ball lightning may penetrate glass windows without breaking them. It may emerge from electrical apparatus, including telephones and aircraft instruments. Materialization may be coincident with lightning strikes outside the closed volume. Otherwise, this phenomenon has all the attributes of ordinary ball lightning.

Background. Ball lightning, supposedly an electrical phenomenon, should not materialize inside electrically shielded volumes, such as modern aircraft. This puzzling anomaly may be very significant in the explanation of ball lightning of all types---assuming several types actually exist!

Data Evaluation. Many excellent observations of ball lightning materialization exist; some by experienced scientists. Rating: 1.

Anomaly Evaluation. As mentioned above, the materialization of ball lightning in closed volumes really deepens the enigma of ball lightning. Rating: 2.

Possible Explanation. Electrostatic induction may help explain the appearance of ball lightning inside closed houses. Intense electrostatic fields generated by storms outside may penetrate the walls of the house and cause ionization of the air inside. This does not, however, explain how a long-lived spheroid is formed or how so much energy is concentrated in a small volume. Of course, the materialization of ball lightning in metal aircraft by induction would seem impossible because the electrostatic lines of force should not penetrate the metal skin.

Similar and Related Phenomena. St. Elmo's Fire and corona discharge (GLD). Miniature ball lightning (GLB6)

Examples of Ball Lightning in Enclosures

X1. June 22, 1915. Drifton, Pennsylvania, During a severe storm during which many examples of ball lightning were seen. "I was on the ground floor of my home, which is near the center of the area affected. I saw a flash in the hallway resembling the discharge between the points of a high power induction coil, and heard a sharp crackling sound above the noise of the thunder or else immediately preceding it. On both second and third floors of the house 'lightning balls' were seen passing down the hallways, as well as one in the kitchen in the rear of the house. For a few moments afterward there was a distinct smell of ozone in the air. No damage whatever was done except that the lightning arrester of the telephone was blown out. Exactly similar effects were noticed at houses a quarter of a mile to the north and a quarter of a mile to the south of my home, and at many places in the town of Freeland, about a mile to the east.... The telephone operator at the Freeland exchange said that 'balls of fire' issued from most of the plugs on the switchboard. Persons who were out of doors at the time describe 'balls of fire' dropping from the sky and exploding on hitting the ground." (R1)

X2. Summer 1938. Wiltshire, England. In the Meteorological Office, Boscombe Down. "Immediately after the lightning flash, a brilliant white sphere, with a diameter of about 20 cm and diffuse edges, was observed hovering near the aneomometer supports. The diameter, symmetry and absence of structure agree with Johnson's description. No heat radiation was noted..... The object followed an irregular course; it travelled from one anemometer leg to the other, and then from the anemometer to a radio receiver transmitter which was being operated at the time. The distance from the anemometer to the radio set would be about 2 m, and the height above the floor about 1.5 m. The object disappeared as it reached the radio set, perhaps 3-5 s after its appearance." (R2)

X3. August 7, 1951. In an aircraft over Southern England, as a research instrument was being pulled in. "..... an extremely loud bang was heard, and the cockpit was illuminated by an intense light which seemed to last about 1 sec. Observers in different parts of the aircraft saw different effects as follows:--- (i) From the co-pilot's seat, the flash appeared to be between himself and the pilot, near the instrument panel and the aircraft controls, and appeared as a white floating ball of fire. Its disappearance and the bang were simultaneous. (ii) A second observer immediately behind this position also saw the flash in the same place, and also reported that the observer holding the impactor was surrounded by a bluish glow." (R3)

X4. July 27, 1952. Hamburg, Germany. "A few seconds after a lightning stroke in the neighborhood, we observed outside the window a brightly gleaming sphere the size of a fist which moved downward in short serpentine lines. Then this luminous ball penetrated through the closed window pane (without damage to the glass) and entered our room. At a depth of about 1 meter it performed a sudden turn of 90° parallel to the wall and continued floating another meter further into the room. Thereupon it burst, and the luminous sphere disappeared with a brief deafening explosion. This ball lightning was purplish with a reddish cast which persisted during the entire duration of the phenomenon. It lasted approximately three seconds. No damage whatever was caused either on the inside or outside of the room. After the bursting of the luminous ball, we could perceive the typical odor which occurs in the case of electrical discharge." (R4) See also GLB1-X11.

X5. 1960. On an Air Force tanker en route to Nevada. "As I was concentrating on the instruments on the panel (no outside visual references were visible) a ball of yellow-white color approximately 18" in diameter emerged through the windshield center panels and passed at a rate about that of a fast run between my left seat and the co-pilot's right seat, down the cabin passageway past the Navigator and Engineer. I had been struck by lightning two times through the years in previous flights and recall waiting for the explosion of the ball of light! I was unable to turn around and watch the progress of the ball as it proceeded to the rear of the

Aircraft, as I was expecting the explosion with a full load of JP-4 fuel aboard and concentrated on flying the aircraft. After approximately 3 seconds of amazingly quiet reaction by the 4 crew members in the flight compartment, the Boom operator sitting in the rear of the aircraft called on the interphone in an excited voice describing a ball of fire that came rolling through the aft cargo compartment abeam the wings, then danced out over the right wing and rolling off into the night and clouds! No noise accompanied the arrival or departure of the phenomenon." (R5)

X6. March 19, 1963. In an aircraft over the U.S. East Coast. "The aircraft encountered an electrical storm during which it was enveloped in a sudden bright and loud electrical discharge (0005 h EST, March 19, 1963). Some seconds after this a glowing sphere a little more than 20 cm in diameter emerged from the pilot's cabin and passed down the aisle of the aircraft approximately 50 cm from me, maintaining the same height and course for the whole distance over which it could be observed. The observation was remarkable for the following reasons: (i) The appearance of the phenomenon in an almost totally screened environment; (ii) the relative velocity of the ball to that of the containing aircraft was 1.5 ± 0.5 m s^{-1}, typical of most ground observations; (iii) the object seemed perfectly symmetrical in all three dimensions and had no polar or toroidal structure; (iv) it was slightly limb-darkened having an almost solid appearance and indicating that it was optically thick; (v) the object did not seem to radiate heat; (vi) the optical output could be assessed as approximately 5 to 10 W and its colour was blue-white; (vii) the diameter was 22 ± 2 cm, assessed by eye relative to the surroundings; (viii) the height above the floor was approximately 75 cm; (ix) the course was straight down the whole central aisle of the aircraft; (x) the object seemed to be in perfect equilibrium; (xi) the symmetry of the object was such that it was not possible to assess whether or not it was spinning." (R6)

X7. November 6, 1963. Nottingham, England. "..... at approximately 11.5 p.m., my father saw in his bedroom, in the centre of the room, a small, egg-shaped ball of brilliant light. Within the space of a few seconds, this small ball of light spread itself to form a sheet of darkish green light as wide as the room itself (approximately 12 feet). This curtain of light then moved towards my father and turned greyish colour. The whole sight then vanished as suddenly as it appeared, with a very loud bang, similar to the report from a rifle." (R7)

X8. August 25, 1965. Dunnellon, Florida. Sky overcast, slight drizzle, roofed patio with fiberglass screens. "Mrs. Greenlee had just swatted a fly when a ball of lightning the size of a basketball appeared immediately in front of her. The ball was later described as being of a color and brightness comparable to the flash seen in arc welding, with a fuzzy appearance around the edges. Mrs. Riggs did not see the ball itself, but saw the flyswatter 'edged in fire' dropping on the floor. The movement of the ball to the floor was accompanied by a report 'like a shotgun blast.' The entire incident was over in seconds." (R8)

Artist's concept of ball lightning materializing inside a screened porch in Florida in 1965. (X8)

X9. August 8, 1975. Warley, England. During a vigorous thunderstorm; witness in her kitchen. "..... a sphere of light appeared over the cooker. The ball was ~10 cm across and surrounded by a flame-coloured

halo; its colour was bright blue to purple. The ball moved straight towards the witness at an estimated height of 95 cm from the ground. Burning heat was felt, and there was a singeing smell. A sound something like a rattle was heard. The ball was in sight for only a second or so because its lifetime was cut short: 'The ball seemed to hit me below the belt, as it were, and I automatically brushed it from me and it just disappeared. Where I brushed it away there appeared a redness and swelling on my left hand. It seemed as if my gold wedding ring was burning into my finger.' Where the ball struck her, the clothing of the witness was damaged." (R9 R10)

X10. 1753. St. Petersburg, Russia. A pale blue, fist-sized ball of lightning emerges from the apparatus of the scientist, G. W. Richman, floats into his face, and kills him. (R4)

X11. July 16, 1905. Paducah, Kentucky. A large fireball appears in a closed house. (R11)

X12. June 19, 1924. Baltimore, Maryland. Miniature ball lightning materialized in a closed room. See GLB6-X2. (R12)

X13. December 1929. Liverpool, England. Orange fireball explodes in a closed house. leaving the odor of ozone. (R13)

X14. June 9, 1930. Auckland, New Zealand. Explosion and bright yellow flash in a closed kitchen. Attributed to ball lightning. (R14)

X15. 1956. Katsina, Nigeria. A fireball the size of a tennis ball appears inside a house with thick mud walls and a tiny remote window. (R15)

X16. No date, no place given. Ball lightning appears suddenly on the floor of the passenger cabin of an aircraft, runs down the aisle, and disappears with a bang. (R16)

X17. 1914. No place given. During a severe thunderstorm, a fireball emerged from electrical machinery. Diameter: 15-18 inches. It floated into an office, hit the ceiling, and splashed in all directions like water. Odor of ozone detected. (R17)

X18. April 20, 1915. Columbia, Missouri. Thunderstorm in progress. "Mr. Seaton had barely taken his position at the window (2.20 P.M.) when there was a sharp report, closely comparable with the report of a sporting rifle. There was an immediate answering click at the telephone. I instantly looked up, and saw a palish red, slightly corrugated ball, apparently 1 1/2 to 2 inches in diameter, or about the size of the outer rim of the mouthpiece of the telephone, moving across the space, about 6 feet, between the telephone and the window by which Mr. Seaton was standing. The fireball seemed to float as a liquid bubble does, though it seemed solid. It kept a fairly straight line for the window; it rolled over the windowsill, and disappeared, not into the outer air, but flickered out like a bubble. There was no explosion or sound of any kind following the click of the phone; there was no odor nor did it leave any marks on the windowsill. Mr. Seaton received no shock or injury of any kind. The telephone was not in the least damaged nor did it bear any marks to show that the ball actually came out of the mouthpiece....I should say that the ball took about two or three seconds to cross the space between the telephone and window. There was no more thunder after that one sharp report." (R18)

X19. July 24, 1994. Oxfordshire, England. It was a hot, humid day that produced strong thunderstorms. Some 14 kilometers west of Oxford, Mr. and Mrs. Langer were in their sitting room when the following sequence ensued:

"'The storm was almost overhead and I knew the next one would be a cracker, but almost five minutes went by in perfect silence. The window is very big, almost one wall in glass, and was wide open. My husband and I sat in recliner chairs side by side with our backs to the window. Suddenly a shaft of brilliant light came over our heads into the middle of the room and seemed to form itself into a white ball as big as a car tyre. It bounced gently upwards and about five feet from the ground it exploded with a terrible noise.'

"No rain was falling at the time of observation. The ball was in view for two or three seconds and emitted no noticeable heat or odour. It was opaque in appearance and its colour changed from reddish gold to white before it blew up, at which point it was about one metre away from the room's occupants.

No traces were left by the ball other than 'some slight brown marks on the carpet,' which were all but removed by cleaning." (R19)

X20. July 3, 1982. Berkshire, England. In the following instance, we have the nondestructive materialization of ball lightning inside a house but a forceful exit. A thunderstorm was in progress.

"Mr. Bell had just settled into his armchair to watch television when the oak tree was struck some 50 yards away, so he was understandably still shaken that same evening as he recollected seeing the ball lightning in front of him. In common with most other interior observations of the phenomenon, he could not say exactly how or from where the bright sphere materialized into vision... only that it seemed to float in front of him immediately after the lightning flash.

"'A glowing, slivery-gold colour, about 5 to 6 inches across and rotating slowly, it flew around the room, and went out through the open doors, right through the house into the bathroom, where there was the biggest bang of all. At the same time as this bang, the TV set exploded as I was watching it.'

"Mrs. Bell happened to be in the kitchen and noticed the ball's passage on its way to the bathroom. She had been about to open the refrigerator when it 'started to buzz.' She stood up and turned around to see 'this glowing thing go through,' to be followed immediately by the loud bang from the bathroom.

"When they investigated, they found the bottom-right corner 12½ inches x 8½ inches bathroom window pane broken as if a cricket ball had been hurled through from within, because only one small piece of glass lay inside on the window sill while the remainder fell to ground outside." (R20)

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GLB11 Black Ball Lightning

Description. Ball lightning that appears black or smoky, presumably because it is surrounded by an opaque layer. Black ball lightning usually explodes like ordinary ball lightning, producing the normal bright flash and frequently luminous fragments.

Background. Black lightning flashes, as detected visually and photographically, can generally be blamed on physiological effects and film overexposure, respectively (GLL). Black ball lightning, however, is more smoky than black and confirms its reality by exploding.

Data Evaluation. Observations of black ball lightning or smoke balls are rare. Rating: 3.

Anomaly Evaluation. The origin of the smoke or opaque gas of black ball lightning poses a serious problem if ball lightning is wholly an electrical phenomenon; that is, there is no combustion of matter. Rating: 2.

Possible Explanations. The smoke might be normal atmospheric gases made opaque (light-absorbing by electrical excitation. Possibly during it formation ball lightning accidently entrained some solid material that was subsequently vaporized.

Similar and Related Phenomena. Black lightning (GLL) and black auroras (GLA). Some fiery, smoky apparitions appearing in classification GLD may be related to or identical to black ball lightning.

Examples of Black Ball Lightning

X1. March 19, 1887. North Atlantic Ocean. "During a severe storm saw a meteor in the shape of two balls, one of them very black and the other illuminated. The illuminated ball was oblong, and appeared as if ready to drop on deck amidships. In a moment it became dark as night above, but below, on board and surrounding the vessel, everything appeared like a sea of fire. The ball fell into the water very close alongside the vessel with a roar, and caused the sea to make tremendous breakers which swept over the vessel. A suffocating atmosphere prevailed and perspiration ran down every person's face on board and caused every one to gasp for fresh air." (R1, R2) The sizes of the balls are not mentioned and this item might well be classified in GLD.

X2. May 13, 1906. Morchard Bishop, England. Watching a thunderstorm. "I leaned forward to have a wider range through the open window, when I saw a large, dark egg-shaped ball swiftly falling straight down from the sky in the open space between two elm trees on the lawn and a fir tree. When the ball came to about the height of the latter, it suddenly collapsed and sparks of fire flew about in all directions like a magnificent firework.... When the ball split, a solid lump of rather light looking fire (like the colour of a blaze) issued forth, at first more from the bottom than the sides, and this emitted thousands of red-hot (bright deep red) sparks which flew in all directions, taking a circular shape." (R3)

X3. August 28, 1929. Peoria, Illinois. After a flash of lightning among some nearby trees. "About six feet from the trunk of one of these hedge trees we observed a ball of smoke about two feet above the ground. The ball appeared to be about eighteen inches in diameter and perfectly spherical. The color of this smoke, if it was smoke, was a yellowish brown quite similar to the smoke given off by burning straw. The ball began immediately to diffuse into the surrounding air just as the smoke from an exploding shell." (R4)

X4. December 1596. Wells, England. A dark object the size of a football enters a church and explodes. (R5)

X5. December 9, 1897. Castelgandolfo. Italy. After close lightning, black globe 25-30 cm in diameter appeared in a kitchen. Seemingly formed of dense smoke, it

scattered sparks and escaped through an open window. (R6, R7)

X6. November 4, 1867. Chatham, England. The following observation is difficult to classify. Are the reported objects examples of black ball lightning, a swarm of those so-called "nebulous meteors," or perhaps just windblown debris of some sort?

"On the afternoon of Monday the 4th, between the hours of three and four, I I witnessed a very extraordinary sight in the heavens. I have not heard of any one hereabout having seen it. The facts are as follow:--- At the time above mentioned I was passing by the Mill by the Waterworks Reservoir. On the gallery I noticed the miller uttering exclamations of surprise, and looking earnestly towards the west. On inquiring what took his attention so much, he said, 'Look, sir, I never saw such a sight in my life!' On turning in the direction towards which he was looking, the west, I also was astounded---numberless black discs in groups and scattered were passing rapidly through the air. He said his attention was directed to them by his little girl, who called to him in the Mill, saying, 'Look, father, here are a lot of balloons coming!' They continued for more than twenty minutes, the time I stayed. In passing in front of the sun they appeared like large cannon shot. Several groups passed over my head, disappearing suddenly, and leaving puffs of greyish brown vapour very much like smoke." (R8)

The Editor of the journal, famous in its time, added that several others had also observed the black discs and concurred with Beveridge's description.

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R2. "Rare Electrical Phenomenon at Sea," American Meteorological Journal, 4:98, 1887. (X1)

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R5. "Fireballs---Some Fiery, Some Dark," Journal of Meteorology, (U.K.), 1:312, 1976. (X4)

R6. Mathias, M.E.; "Les Globes Noirs et Blancs sans Lumiere Propre," Comptes Rendus, 182:32, 1926. (X5)

R7. "Black and White Globular Lightning," Nature, 117:211, 1926. (X5)

R8. Beveridge, James E.; "An Extraordinary Phenomenon," Symons's Monthly Meteorological Magazine, 2:130, 1867. (X6)

GLB12 Ball Lightning's Electromagnetic Effects

Description. Ball lightning affecting ships' compasses, automobile ignition systems, etc.

Background. If ball lightning is an electrical phenomenon, electromagnetic effects are to be expected. If, however, ball lightning owes its existence to chemical combustion, anti-matter meteorites, or many of the other suggested origins, electromagnetic effects should not occur.

Data Evaluation. Despite ball lightning's spark-emitting detonations, ozone odors, and close associations with thunderstorms and electrical equipment, good records of its expected electromagnetic effects are very scarce. Rating: 3.

Anomaly Evaluation. Ordinary lightning often causes electromagnetic effects, so perhaps it is the great rarity of electromagnetic effects from ball lightning that is anomalous. Rating: 2.

Possible Explanation. The energy of ball lightning may be temporarily stored inside an electromagnetic bottle which also confines electromagnetic fields.

Similar and Related Phenomena. The electromagnetic effects of ordinary lightning (GLL).

Examples of Ball Lightning's Electromagnetic Effects

X1. February 24, 1890. Lexington, Virginia. Balls of lightning do heavy damage and magnetize pens. (R1)

X2. No date or place given. Ball lightning strikes the sea 100 yards from the SS Sai On permanently affecting the vessel's compasses. (R2) See also GLB1-X178.

X3. October 7, 1811. Devon, England. Four balls of lightning seen in a church. The bell ringers complain that the bells seem "too heavy" to ring. A possible electromagnetic effect of the ball lightning? (R3) A tongue-in-cheek article? (WRC)

References

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R2. Barlow, E. W.; "Thunderstorms at Sea," Marine Observer, 12:49, 1935. (X2)

R3. Blair, A. J. F.; "Magnetic Fields, Ball Lightning and Campanology," Nature, 243:512, 1973. (X3)

GLB13 Ball Lightning with Apparent Internal Structure

Description. Ball lightning with well-defined internal structure; usually a writhing mass of snake-like fibers of light.

Background. Ball lightning is usually so bright that internal structure, if it exists, cannot be discerned. There is no reason to suppose that all ball lightning possesses the structures reported here.

Data Evaluation. Reports of ball lightning with obvious internal structure are very scarce but also very consistent, especially considering the bizarre nature of this phenomenon. Rating: 3.

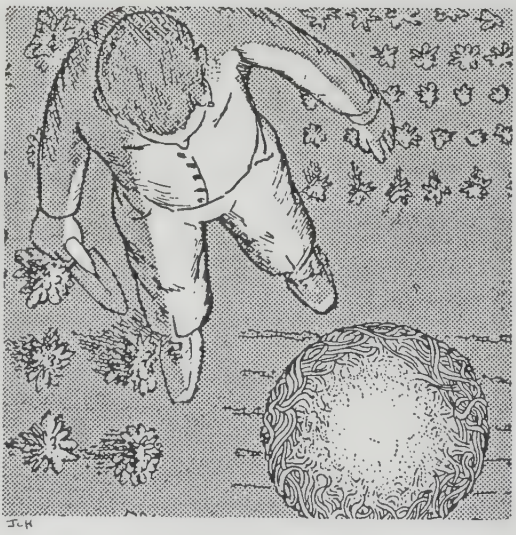
Anomaly Evaluation. No theory of ball lightning even attempts to deal with the snake-like structures reported. Rating: 2.

Possible Explanations. The luminous fibers might be transitory plasma currents or possibly wave-like structures on the surface of a plasma sphere.

Similar and Related Phenomena. Ordinary lightning has occasionally been described as running around ships and houses "like snakes."

Examples of Ball Lightning with Internal Structure

X1. 1887. England. While walking in a heavy thunderstorm under an umbrella. "Without any noise or notice, I saw what appeared to be a ball of live light fall just in front of me and slide along the road, and quietly disappear after going a few yards. The ball was about the size of a cricket ball, and appeared to be made up of a vibrating mass of strips of light, in rapid rolling motion. This, I suppose, was a sample of ball lightning, and at the time I felt very thankful it had fallen just clear of my umbrella rather than on it. What struck me most forcibly was the extraordinary appearance of the apparent fibres of light wriggling like a mass of eels." (R1)



In 1940, ball lightning with a "wormy" suface materialized in an English garden. (X2)

X2. November 10, 1940. Coventry, England. "I was working at the far end of my garden, the weather was normal, no rain, no signs of thunder. Suddenly, I seemed to be in the centre of intense blackness and looking down observed at my feet a ball about 2 ft across. It was of a pale blue-green colour and seemed made of a mass of writhing strings of light, about 1/4 in. in diameter. It remained there for about 3 seconds and then rose, away from me, just missing a poplar tree about 8 ft away. It cleared the houses by about 20 ft and landed at the rear of the Weavers Arms on the Bell Green Road, a distance of about 1/4 mile. There was a loud explosion and much damage was done to the public house." (R2)

X3. 1924. Blackpool, England. A letter from P. Revell to M.W. Rowe. As will be apparent, this luminous manifestation could also be classified as rayed or giant ball lightning (GLB3 and GLB7, respectively). The "chains," however, seem the most anomalous feature.

"'It happened in the afternoon in 1924. There came a large ball of fire---or so it looked---but the thing was that it had chains all the way round. It lasted about five minutes, then all the chains clashed together with a terrific bang; then we had a terrible thunderstorm which lasted quite a long time.'

"In a second letter Mrs. Revell drew the ball lightning as a red globe with 16 rays, composed of links like a chain, issuing from it; the rays were rather longer than the diameter of the ball. She said, 'You asked the size. From the ground it looked about four to five yards across, which would be larger than that in the sky. The chains opened from the top to the bottom with a terrific bang.'" (R3)

X4. 1920. Parkside, Australia. C. Illert and his mother were on their veranda. The sky was overcast. They heard an explosion seemingly several hundred yards away.

"It wasn't long till we heard a hissing noise and, looking up to the western sky, saw an object about 12 inches in diameter slowly moving through the air down toward us---about 12 feet away. It was travelling eastward and came down over Mrs. Harris's wooden fence landing on the cement porch floor about 3 feet behind us. It gracefully bounced along the cement floor in a straight path covering the 30 foot length of the veranda at a walking pace. It bounced three or four times rising to a height of 18 inches on each occasion. Each time the spherical ball touched the cement it was flattened at the point of contact, and deformed, but it quickly resumed its globular shape when it left the ground. It was not transparent but, rather, like a ball of smoke with glowing 'comma-shaped' electrical 'worms' wriggling about---sizzling, hissing and flickering. It flattened by 1/4 into the egg shape on each bounce. On reaching the far western end of our veranda it accelerated rapidly and rose at a steep angle of about 45 degrees clearing the apricot tree, wires, and the house next door. At this stage my mother rushed in the back door of the house where we huddled for about 30 seconds before hearing a resounding crash some 250 yards away off to the east. It had hit Green's house at the far eastern end of Campbell Road. It apparently then bouced all the way to the Salvation Army home and demolished the whole house somewhere near Dawson and Florence Streets at Fullarton." (R4)

The ball rotated slowly and emitted small sparks.

X5. September 1981. Berkhamsted, England. Testimony of M.L. Cook.

"I was resting on my settee listening to music on the Third Programme when there was some interference of a crackling kind. Suddenly, a ball of bright light appeared in front of my radio. It was about the size of a large orange. It was dazzlingly white and gave the appearance of dozens of stick crystals 5.0 mm in length jigging about with a crackling sound. By the time I reached the switch it had disappeared, but a loud burst of thunder broke overhead." (R5)

X6. June 2, 1982. Hornsey, North London, England. The wheel-like structure of the apparition described below is very unusual---even for ball lightning.

"During a very violent storm which broke out over Hornsey, I was standing at my side door when I had, what I can only say, was a very frightening experience. Adjacent to the sideway are several trees, and I saw through these trees which are about 20 to 30 feet high, what appeared to be a brilliant catherine wheel, gold in colour, and spinning toward me. This thing then seemed to explode with a violent bang, louder than my scream. I was terrified. (R6)

X7. Summer 1989. Huntington, Maryland. It was very humid and a strong thunderstorm was in progress. The observer

was sitting in a house with all windows closed.

"The ball 'suddenly appeared' indoors directly in front of the observer at a range of just over 3 metres and quite stationary. Although the observer was sitting almost directly facing it, its formative stages were not noticed. It appeared almost directly underneath a large skylight made of plexiglass (perspex) and it remained, so far as Mrs. Orser could tell, absolutely motionless for the whole minute it was present. Thus she had plenty of time to observe it and hear its crackling noise.It then disappeared without additional noise and, about 45 minutes later, a second ball, somewhat smaller in size, appeared for a few seconds underneath a different skylight. Mrs. Orser obviously could not observe this once so carefully and the detailed descriptions apply to the first ball.

"The ball was unusual both for its long life (particularly for a ball indoors) and its exceptional positional stability. For a ball formed indoors it was also unusually large, being almost a metre and a half in diameter. The second ball was about a metre in diameter. In appearance, the balls were bright bluish white with the bright white more towards the centre (at least for the better observed one) and the blue more toward the edge. As an indication of brightness, Mrs. Orser noted that the ball was not painful to look at---a bit like white paper illuminated by a bright but diffused light source. It was, however, translucent to transparent. The translucent portions were where small electrical discharges seemed to be continually forming. The crackling noise was presumed to be associated with these 'worm-like discharges.'" (R7)

Once again, worm-like structures were observed inside or on the surface of a glowing ball.

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GLB14 Unusual Physiological Effects of Ball Lightning

Description. Headache, nausea, neck pain, memory loss, disorientation, and related physiological symptoms suffered after encounters with ball lightning.

Background. Many of these symptoms occur after a severe electrical shock and are expected if ball lightning is truly electrical in nature. The thrust here, however, is the search for symptoms characteristic of nuclear radiation, which would imply a nuclear origin for ball lightning, as some have suggested. (R4, R5)

Data Evaluation. With the exception of one rather old example (X1), the physiological symptoms reported after exposure to ball lightning can well be attributed to simple electrical shock or eye-strain. Rating: 3.

Anomaly Evaluation. Symptoms of radiation sickness, if demonstrated, would suggest either a nuclear energy source for ball lightning (antimatter meteorites?) or the generation of nuclear reactions by high temperatures or electrically accelerated particles in ball lightning. All of these possibilities would be difficult to explain in conventional physical terms. Rating: 2.

Possible Explanations. Symptoms similar to those of radiation sickness may be induced by electrical shock, perhaps amplified by the traumatic experience of being close to ball lightning.

Similar and Related Phenomena. Nausea and disorientation experienced during earthquakes; the suffocating sensations and nausea felt near the vortex of a tornado (GWT). It is also important to point out that UFO observers frequently complain of headaches, nausea, memory loss, etc.; and some even exhibit burns and more overt effects.

Examples of Unusual Physiological Effects from Ball Lightning

X1. November 24, 1886. Maracaibo, Venezuela. "During the night of the 24th of October last, which was rainy and tempestuous, a family of nine persons, sleeping in a hut a few leagues from Maracaibo, were awakened by a loud humming noise and a vivid, dazzling light, which brilliantly illuminated the interior of the house. The occupants, completely terror stricken, and believing, as they relate, that the end of the world had come, threw themselves on their knees and commenced to pray, but their devotions were almost immediately interrupted by violent vomitings, and extensive swellings commenced to appear in the upper parts of their bodies, this being particularly noticable about the face and lips. It is to be noted that the brilliant light was not accompanied by a sensation of heat, although there was a smoky appearance and a peculiar smell. The next morning the swellings had subsided, leaving upon the face and body large blotches. No special pain was felt until the ninth day, when the skin peeled off, and these blotches were transformed into virulent raw sores. The hair of the head fell off upon the side which happened to be underneath when the phenomenon occurred, the same side of the body being, in all nine cases, the more seriously injured. The remarkable part of the occurrence is that the house was uninjured, all doors and windows being closed at the time. No trace of lightning could afterward be observed in any part of the building, and all the sufferers unite in saying that there was no detonation, but only the loud humming already mentioned. Another curious attendant circumstance is that the trees around the house showed no signs of injury until the ninth day, when they suddenly withered, almost simultaneous with the development of the sores upon the bodies of the occupants of the house." (R1) The symptoms mentioned in this item closely resemble those due to overexposure to nuclear radiation. The date of the phenomenon precedes the discovery of radioactivity, x-rays, etc.

X2. July 2, 1893. Warwickshire, England. Large fiery globe of dazzling brilliancy.

One observer is momentarily blinded and afterwards experiences pains in the head and neck. (R2) The bright light might have caused these symptoms. (WRC)

X3. No date or place given. An observer of ball lightning receives a shock and loses his memory for several hours. (R3) The electric shock alone may have been sufficient to cause memory loss.

X4. September 3, 1900. Mobile, Alabama. A letter from T.T. Roche to the Editor of the Scientific American Supplement. In what follows, it must be remembered that in 1900, the word "meteor" meant virtually any weather phenomenon and did not necessarily imply a cosmic projectile.

"On last monday night (September 3) the weather was so close and hot that I had lain down in the hammock under the big walnut tree in front of the house, Sister M. had taken a seat in the center of the lawn, quite out of the shelter of the tree. I was lying in such a manner that we were directly facing each other, only a few yards apart. Sister was sitting with her arms stretched out and resting on the arms of a large armchair. While we were talking I saw a meteor descending to the earth directly over her head. It was quite brilliant at first, but grew fainter as it came nearer, until just as it seemed to reach her, it was about the brilliancy of a large, a very large 'lightning bug' or firefly. At the moment when I tried to call out to her that a meteor was descending close by, she lept to her feet, screaming that she had been shot in the arm.

"I sprang up and ran to her, and on examining the arm we found a small red spot just above the elbow, which rapidly grew larger, and rose, a blister forming almost at once. It was exceedingly painful and had all the appearances of a fresh burn. The arm swelled, and the place made a quite painful sore. At present (four days later) it looks exactly like an old vaccination, being quite deeply pitted. On examining the dress, we found the sleeve scorched and burned through, in a tiny hole, just over the spot where the wound is." (R6)

X5. June 21, 1978. Haymarket, Virginia. The following account was derived from a communication from P. Townsend. It is doubly significant because of: (1) the ball lightning's interaction with a human; and (2) the fact that another ball-lightning incident had occurred in the same house, same room, the previous year. (See GLB19 for the first encounter.)

A thunderstorm outside. A fireball entered the kitchen. It was about a foot across with jagged yellow and white edges. It hit Mrs. Townsend in the face, with the sensation being like a slap with an open hand. The ball possessed a surface like that of a textured fabric as before. The witness collapsed and when recovering found herself with slurred speech and neck pains. She soon regained full faculties and health. (R7)

X6. August 17, 1978. Caucasian Mountains, Russia. Victor Kavunenko and four other mountaineers were camped for the night at an altitude of 3900 meters. He reported as follows:

"I woke up with the strange feeling that a stranger had made his way into our tent. Thrusting my head out of the sleeping bag, I froze. A bright-yellow blob was floating about one metre from the floor. It disappeared into Korovin's sleeping bag. The man screamed in pain. The ball jumped out and proceeded to circle over the other bags now hiding in one, now in another. When it burned a hole in mine I felt an unbearable pain, as if I were being burned by a welding machine, and blacked out. Regaining consciousness after a while, I saw the same yellow ball which, methodically observing a pattern that was known to it alone, kept diving into the bags, evoking desperate, heart-rending howls from the victims. This indescribable horror repeated itself several times. When I came back to my senses for the fifth or sixth time, the ball was gone. I could not move my arms or legs and my body was burning as if it had turned into a ball of fire itself. In the hospital, where we were flown by helicopter, seven wounds were discovered on my body. They were worse than burns. Pieces of muscle were found to be torn out to the bone. The same happened to Shigin, Kaprov and

Bashkirov. Oleg Korovin had been killed by the ball---possibly because his bag had been on a rubber mattress, insulating it from the ground. The ball lightning did not touch a single metal object, injuring only people." (R8)

Ball lightning has often been called inquisitive, but this is one of the few reports where it deliberately (?) seems to have attacked people. Note that some Russian English-language publications verge on the sensational, and one must always have some salt on hand.

X7. May 14, 1985. Yorkshire, England.

"At Garton-on-the-Wolds, two miles west-north-west of Driffield and 60 metres AMSL, the electricity went off at 6.15 pm. Half an hour later Mr and Mrs Foster, who were in their paddock tending to the horses during the thunderstorm, heard a 'terrific bang.' On arriving back in their house they found that the television aerial had been blown out of its socket and there were scorch marks on the window sill and curtain lining. The television plug's negative and positive pins had been blown out of the socket but the earth pin was still intact. A hole some 8 cm by 10 cm across and 4 cm deep was found in the wall by the side of the socket. Several components of the television were damaged and fuses in the main fuse box were blown. Also, at 6.45 pm, Mr and Mrs Foster's daughters, Rachel and Rosemary, were with a friend in the kitchen at the other side of the house. Rachel was standing with her hand on the cooker when, without warning she felt 'a sort of thump' in her back. The other two girls saw an orange, spherical object---about the size of a table tennis ball---moving very quickly. It had no smell, made no noise and seemed to be rotating. The ball of light did not harm Rachel's clothes but made a red, five-pointed star mark on her left shoulder blade which subsequently cleared the following day. The ball then fell onto the wet floor where it exploded 'with the noise of a shotgun' and 'like a firecracker' into many white stars. There were no burn marks on the floor although there was a smell of burning in the air ---but this may have been the television." (R9)

X8. December 1991. Brixham, Devon, England. In a fisherman's cottage during a thunderstorm.

"Two young men aged about 22/23, Mr. Andrew Clark and Lloyd Bicknell, were inside Mr. Clark's cottage when a storm of lightning and thunder began. Suddenly, an orange fuzzy airborne blob, the size of a football but not perfectly spherical, came through the wall---so it was said---and hovered at a low level. Lloyd Bicknell lept on to a settee, Andrew Clark jumped on to the lightning ball. This burnt the plastic sole of one of his training shows and melted a hole some 50 to 70 mm across. The lightning ball was disrupted and 'a part of it' went sideways and burnt out the transformer of his C.B. radio (to which was attached a radio mast fixed on the roof outside). The total duration of the event had been about five seconds. Andrew's foot was quite badly burnt and he had to go see a doctor for treatment." (R10)

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GLB15 Artificial Ball Lightning

Description. The creation of detached luminous spheroids by high-current electrical apparatus.

Background. Small greenish plasmoids sometimes appear on submarines where high-current DC equipment is employed. These plasmoids may not possess all of the properties of natural ball lightning, particularly the high energy density and destructive power, but they do offer some insight into the nature and origin of the natural phenomenon. The subject of artificial ball lightning has been investigated at much greater depth by J. D. Barry (R4) and others.

Data Evaluation. The artificial production of luminous plasmoids is well-established. Rating: 1.

Anomaly Evaluation. While the production of artificial ball lightning is not too difficult, there is no consensus on just how the plasmoids are formed and maintained. Rating: 2.

Possible Explanations. See those for ordinary ball lightning (GLB1).

Similar and Related Phenomena. Ordinary ball lightning (GLB1) and artificial bead lightning (GLL).

Examples of Artificial Ball Lightning

X1. 1852. Ireland. "One of Sir William Hamilton's sons, who was fond of experimenting, had a telegraph wire running the length of a shrubbery, as far as the lodge; whether from accident or in the natural course of things I don't know, but an accumulation of the electric fluid, I suppose, passed along the wire from the Observatory and down to the lodge, where it left the wire, passed along the ground a distance of some yards, then rising over a hedge, on which some linen was bleaching, picked up a cravat and mounted high in the air with it, carrying it a distance of about half a mile. I saw it myself like a ball of fire with something white hanging to it; but I could not judge very well of its height." (R1)

X2. 1947. Philadelphia, Pennsylvania. Following a description of submarine electrical apparatus and the formation of arcs. "Usually the arc is 'blown-out.' However, when the amount of charge left in the batteries creates a sufficiently intense current through the arc, a green fireball will 'float' off the contacts into the engine room. The lifetimes of these plasmoids are of the order of a second. The green color is attributed to the copper from which the extensions of the silver electrodes are made. No appreciable damage has been reported from these 'engine-room plasmoids.'.....During the 'Guppy Reconversion Program' in 1947 at the Philadelphia Naval Shipyard, tests were performed on the reverse current gear of the U. S. S. Cutlass (Hull SS478), and a fireball was generated in the engine room using 260 volts and 156,000 amperes direct current. This gives a peak power of about 40 megawatts. Switching times on the order of 0.1 to 0.01 second are standard with mechanical switching, so that an energy on the order of 0.4 to 4 megajoules is the estimated energy range in which this plasmoid forms. The estimated diameter appears to vary between 4 to 6 inches or from 10 to 15 cm." (R2, R3)

X3. No date given. Yeshiva University, New York.

"Physicists have also been moderately successful in making fireballs by focussing electromagnetic fields operating at radio frequencies. Julio Powell and David Finkelstein, at Yeshiva University in New York, experimented with a generator producing 30 kilowatts of electrical power at a radio frequency of 75 megahertz. The generator had movable terminals located inside a glass tube containing a vertical chimney. The researchers gradually drew the terminals apart until they obtained a discharge. Eventually, a luminous column appeared which changed into a quasi-spherical object that slowly ascended the chimney. The ball persisted for a second or so after they switched off the power. Sometimes the ball disintegrated explosively. The researchers

found that they could repeat the phenomenon, so they could carry out a detailed spectral analysis of the discharge." (R5)

X4. 1991. Tokyo, Japan. From the abstract of an article in Nature. (R6)

"Here we report the production of plasma fireballs in a natural atmosphere by microwave interference. The fireballs exhibited certain properties that match eyewitness observations of ball lightning, such as motion against the wind and the ability to pass through a wall intact." (R6, R7)

X5. 1994. Brockton, Massachusetts. High-current electrical discharges (about 10,000 amperes) under water with one aluminum and one copper electrode. Fireballs appear on the surface of the water.

"These luminous fireballs sometimes dance right out of the tank onto the floor. They are very hot to the touch, like touching a glowing piece of metal. They exhibit a brilliant white color indicating the slow combustion of aluminum. With iron-to-iron electrodes, yellow fireballs are produced. It appears that the ball is spinning or the inside kernel is spinning. With the stated current and voltage, the fireballs have lasted for 2 to 5 s and are a quarter inch in diameter before shrinking to a smaller size. ...You can sometimes catch these fireballs in a large wooden spoon for closer observation." (R8)

X6. General observation. "Plasmodes" can be created by putting a small, burning candle in a microwave. The plasmodes float around for as long as the microwave in turned on. (R8)

X7. 2000. University of Iasi, Romania. To test their hypothesis that ball lightning is a self-organization phenomenon, M. Sanduloviciu and E. Lozneanu create fireballs with a laboratory device consisting of a plasma source that generates a plasma column in a glass tube. At the far end of the glass tube are electrodes connected to a radio-frequency oscillator. Another electrode creates a spark in this region that results in the formation of a fireball. (R9)

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GLB16 Ball Lightning with Long Tails

Description. Luminous spheres similar to ordinary ball lightning but possessing long tails. The tails may be many times the diameter of the ball in length. Flat, tape-like, crinkled tails have been reported several times.

Background. Ordinary ball lightning is sometimes pear-shaped, and it is inviting to think that tailed ball lightning may just be pear-shapes with the stem end drawn out into a long strip. This may indeed occur but the most significant examples of tailed ball lightning are so bizarre---long, flat, wrinkled tails---that they cannot be stretched-out pear-shapes.

Data Evaluation. Bizarre though some of the examples may be, they possess an underlying consistency that gives one confidence that this phenomenon is real. Rating: 2.

Anomaly Evaluation. None of the proposed explanations for ordinary ball lightning seems to be able to accomodate tailed ball lightning. Rating: 2.

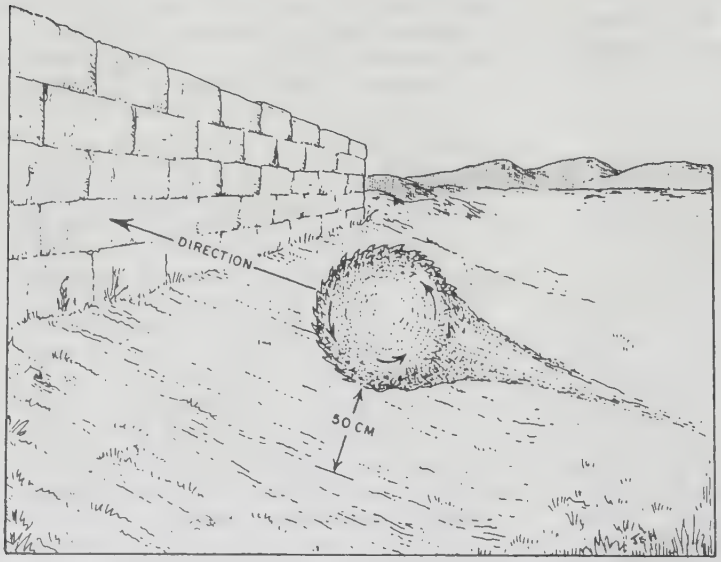
Possible Expanation. None.

Similar and Related Phenomena. The writhing, strip-like structure seen in some cases of ball lightning (GLB13) may be related.

Examples of Ball Lightning with Tails

X1. Circa 1920. Johannesburg, South Africa. "My first experience goes back to 1920 when, as a boy in Johannesburg, I observed a ball of lightning rolling slowly up an incline about 50 cm above and parallel to the sloping ground. This ball of light was about 50 cm in diameter with irregular saw-tooth streaks of light around it, and it had a comet-like tail. The ball continued until it met a dry-stone terrace wall, when it exploded in a flash of flame leaving an acrid smell. The wall was not damaged in any way. It had been possible to see that the ball of light was rolling in an anti-clockwise direction. (R1)

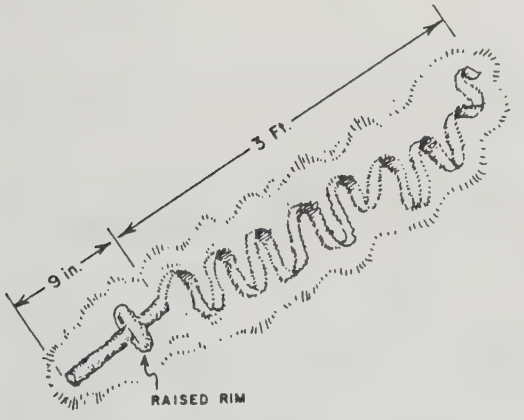
X2. September 22, 1965. Honolulu, Hawaii. In a garden after a light thunderstorm. "Suddenly, around the corner of the mock orange hedge, came the head of the lightning, crum-



Circa 1920, ball lightning with a comet-like tail was seen rolling along the ground near Johannesburg. It exploded against a stone wall. (X1)

pled with lots of black in the folds. As it came closer it was wider until at the end of its twenty-five foot length it was about two feet wide where it was chopped off clean. It was solid---not diaphanous or transparent or ethereal. It was the most brilliant, eye-dazzling electric blue without sparkle or scintillation. It moved fast just above the ground and about half-way between me and the birdbath. The bowl of the birdbath, but not the pedestal was visible. While it gave me the impression of being stiff and flat it might have been tubular. It showed no signs of elasticity, no flexibility; definitely it was not sinuous nor did it undulate. It had no sensation of heat. Had it been white hot, I would have been singed since it came so close to me. It was without a doubt dying lightning, but what made it die and in my garden?" It was like a strip of crumpled paper; dimensions were about 25 feet long and 1 1/2 to 2 inches thick. It made a sizzling sound and disappeared with a clap of thunder. (R2)

X3. August 15, 1975. Argyllshire, Scotland. "I must tell you of the magnificent thing I saw during the last storm of thunder and lightning which was in the autumn. It was what I called a bulb of lightning not a bolt. It was dome-shaped, opaque, like 8 inches in length, slim and came down slowly to within 9 inches of the ground in front of the house. This bulb lingered, and attached to it was a long tail which came down slowly after it. I would say the tail was 1 yard in length, seemed like 1/2 inch in width, like crinkly white silk ribbon, like the old-fashioned ribbon. The tail kept above the bulb which lingered, and then it all snuffed out like a candle, and left no trace." (R3)



In 1975, in Scotland, apparent ball lightning was observed trailing a long, improbable, ribbon-like tail. (X3)

X4. June 22, 1880. Leicester, England. "Fireballs fell repeatedly from a storm cloud. The balls were blunt on the bottom and drawn out into a tail above. (R4)

X5. Circa 1890. Upminster, England. Three lightning balls with tails wriggled across a meadow. (R5)

X6. April 30, 1959. No place given. Three fireballs with tails fall from a cloud. (R6)

X7. March 24, 1977. Capetown, South Africa. "At 2.50 a.m. (24 March) some hours after the passing of the storm, I was awakened by a sharp 's-s-s-spht' and to my amazement saw a small 'ball of fire', about 2 1/2 in-3 in in diameter, with a comet-like tail some 12 in-15 in, travelling north to south (or possibly north-east to south-west) about 2 ft away from the centre of a heavy double wardrobe, with quite heavy brass fittings and about the same distance from the floor and some couple of yards from my bed, the whole thing lasting only seconds..." (R7)

X8. June 1927. Tokyo, Japan. Recollections of M. Yamamuro.

"In June of 1927 I was 13 years old. It was one clear evening (7.30 p.m.). I was standing on a road near the railway bridge of Ebisu Station, Tokyo. I saw a ball of lighting with a long tail floating and moving to the railway bridge. The colour was orange, its surroundings were light yellow, and its tail was light blue. The diameter was 30 cm and the length of the tail was 3-4 m. (R8)

X9. July 30, 1981. Peebleshire, Scotland, United Kingdom. The observer was walking along the River Tweed after fishing. The day was hot but thunderstorms had

not materialized.

"On my right there was wooded higher ground. From behind it, at a height of about 50 yards, a globular object emerged. It seemed to me to have a diameter of not more than two feet. It was descending at an angle of about 20 degrees. It was not only a globe. Attached to it was a conical shape formed by lines of light coming out from the sphere and converging to a point some eight feet behind. The whole had an orange colour. It was a luminous object presenting a very clear and sharp outline of the sphere and the cone. I watched it for at least four seconds before it disintegrated." (R9)

X10. March 21, 1983. Knutton, North Staffordshire, United Kingdom.
At Camillus Road, Knutton. Ball lightning about 40 cm in diameter with a luminous tail 4 m long. One observer saw it descend at an angle of 45° and hit the roadway. (R10)

References

R1. Davis, R.J.; "Personal Experiences with Lightning in South Africa," Journal of Meteorology, (U.K.), 2:290, 1977. (X1)
R2. Price, Saul, and Carlstead, Edward M.; "Observation of a Curious Electrical Phenomenon in Hawaii," Monthly Weather Review, 94:272, 1966. (X2)
R3. Meaden, G.T.; "Remarkable Occurrence of Unusually-Shaped Ball Lightning, 15 August 1975," Journal of Meteorology, (U.K.), 1:310, 1976. (X3)
R4. Mott, F.T.; Curious Electrical Phenomenon," Nature, 22:193, 1880. (X4)
R5. Rowe, W.H.; "Ball-Lightning," English Mechanic, 101:470, 1915. (X5)
R6. Rollinson, A.C.; "Lightning," Marine Observer, 30:58, 1960. (X6)
R7. Seymour, Isabella P.; "Ball Lightning," New Scientist, 77:817, 1978. (X7)
R8. Ohtsuki, Y.H., and Ofuruton, H.; "Observations in Japan of Ball Lightning," Journal of Meteorology, U.K., 15:155, 1990. (X8)
R9. Leszczynski, Zbigniew; Journal of Meteorology, U.K., 7:257, 1982. (X9)
R10. Swinhoe, P.J.; "Unusual Events along the Squally Cold Front of 21 March 1983 in North Staffordshire," Journal of Meteorology, U.K., 8:233, 1983. (X10)

GLB17 Correlation of Ball Lightning Incidence with Solar Activity

Description. The increased incidence of ball lightning with increased solar activity.

Data Evaluation. Only one study has been uncovered so far, and it is based on scanty data from a small area (Holland). Rating: 3.

Anomaly Evaluation. Since thunderstorms are more frequent during periods of high solar activity, and ball lightning is almost always associated with thunderstorms, it would not be particularly surprising to find ball lightning incidence related to solar activity. The question of why, though, is a different one. Rating: 3.

Possible Explanation. Solar activity increases lead to more cosmic-ray bombardment of the terrestrial atmosphere. The increased ionization may lead to more electrical activity. More cosmic rays may cause more nuclear fission of atmospheric xenon, which may help create and sustain ball lightning. (R1)

Similar and Related Phenomena. The correlation of solar activity with thunderstorm frequency (GWS) and the incidence of auroras (GLA).

Examples of the Correlation of Ball Lightning with Solar Activity

X1. General Observation. "Time series analysis of ball lightning in Holland shows that from 1880 to 1956 the annual number of ball lightning increased with the intensity of solar activity as measured by Wolf average annual numbers." (R1)

Reference

R1. Arabadji, W. I.; "On the Problem of Ball Lightning," Journal of Geophysical Research, 81:6455, 1976. (X1)

GLB18 Ball Lightning External to Aircraft (Foo Fighters?)

Description. Fireballs, singly or in formation, that pace aircraft despite high relative air velocities.

Background. Toward the end of World War II, pilots of all combatants, in all theaters, reported many cases of fireballs pacing their aircraft. The Americans called them Foo Fighters. Foo Fighters have seemingly become part of UFO lore and therefore ignored by scientists, but many of the sightings must have had some physical basis.

Data Evaluation. In addition to the large store of Foo Fighter observations in newspapers and the UFO literature, there are several excellent records of fireballs pacing modern aircraft. Rating: 2.

Anomaly Evaluation. In addition to the basic anomaly of ball lightning's nature, the ability of fireballs to maintain their positions relative to aircraft despite high relative air speeds poses a real puzzle to the scientist. Rating: 2.

Possible Explanation. St. Elmo's Fire may account for some observations but not for those instances where the fireball is well clear of the aircraft surface.

Similar and Related Phenomena. St. Elmo's Fire (GLD); UFOs.

Examples of Ball Lightning External to Aircraft

X1. General observation. "There are three kinds of these lights we call 'Foo Fighters,'" said Lieutenant Donald Meiers, of Chicago. 'One is a red ball which appears off our wing tips and flies along with us. No. 2 is a vertical row of three balls of fire, flying in front of us. No. 3 is a group of about fifteen lights which appear in the distance, like a Christmas tree up in the air, and flicker on and off." (R1)

X2. May 15, 1970. An aircraft 150 miles east of St. Louis, Missouri, in a thunderstorm. "At (what seemed) the moment of maximum turbulence and electric discharge, while the aircraft was still descending through the storm, a sequence of events took place that I list below. The whole took not more than 5 s, and I must admit that the order, save for numbers 4 and 6, is not necessarily chronological. 1. The turbulence ceased altogether. 2. The surrounding electrical discharges (glows) ceased altogether. 3. The wing stopped buckling altogether. 4. A white glowing sphere (ball lightning?) appeared on the port wing tip. I do not know if it was actually touching the wing. Its diameter was less than 1 m and more than 10 cm. Its boundary was 'fuzzy' and not distinct. 5. There was a soft 'pop'. 6. The ball lightning (?) vanished." (R2)

X3. No date or place given. "A further important observation was of a 20 cm ball which appeared at a height of about 50 cm over the trailing edge of the mainplane of an aircraft in flight. It moved parallel to the line of the mainplane at a speed of about 1 m s^{-1} before being cast off the end and was not blown off in spite of the considerable air speed." (R3)

X4. April 23, 1964. An aircraft over Bedford, England. A loud bang and a whitish-blue flash of light. A ball of blue light the size of a football appeared on the starboard wing tip. It vanished in two seconds. (R4)

X5. No date or place given. "In the second case, a bright ball appeared on the top surface of the wing outside the aircraft, made rapid movements to and fro for an appreciable length of time and then disappeared. It seemed quite unaffected by the air passing through it at 250 mile/h, which does not accord very well with the theory that the balls may be composed of vaporised metal." (R5)

X6. No date or place given. Describing the types of St. Elmo's Fire. "The 'small ball' formation varies in size from two inches (5 cm) to a foot and a half (46 cm) in diameter and generally 'rolls around' the aircraft apparently unaffected by the movement of the aircraft. On one occasion a small ball (about six inches (15 cm) in diameter) of yellowish-white lightning formed on my left tiptank in an F-94B then rolled casually across the wing, up over the canopy, across the right wing to the tiptank and thence commenced a return, which I didn't note, but I was advised by my observer that it disappeared as spontaneously as it had arisen. I have seen this form several times but rarely for as long a period which I would estimate to be about two minutes in duration. Sometimes the balls are blue, blue-green, or white though it appears to favor the blue-green and yellow-white." (R7)

X7. General observation. Mysterious balls of fire follow Allied planes closely. No explosive or incendiary effects noted. (R8)

X8. General observations. The same sort of fireballs followed aircraft in both the European and Pacific theaters. B-29 pilots said they stayed about 500 yards off, were about 3 feet in diameter, had a phosphorescent glow, and could not usually be shaken off by maneuvering or flying into clouds. This report states that radar did not detect the foo-fighters. (R9)

X9. December 18, 1944. Germany. The famous foo fighters of World War II were bright balls of light, about a foot in diameter, of different colors, that appeared mostly over Germany to both German and Allied pilots. Although the foo fighters could maneuver around and through bomber formations with apparent

ease, they were nuisances rather than physical threats. Most of the foo-fighter reports made by Americans came from the 415th Night Fighter Squadron. Recently a microfilm roll containing the Unit History and War Diary of the 415th was obtained from the U.S. Air Force. We quote below three foo-fighter encounters (X9-X11) found on Frames 1613 and 1614.

"December 18, 1944. In Rastatt area sighted five or six red and green lights in a 'T' shape which followed A/C thru turns and closed to 1000 feet. Lights followed for several miles and then went out. Our pilots have named these mysterious phenomena which they encounter over Germany at night 'Foo-Fighters.'" (R10)

X10. December 23, 1944. Germany.

"More Foo-Fighters were in the air last night...In the vicinity of Hagenau saw 2 lights coming toward the A/C from ground. After reaching the altitude of the A/C they leveled off and flew on tail of Beau (Beaufighter---their aircraft, Ed.) for 2 minutes and then peeled up and turned away. 8th mission ---sighted 2 orange lights. One light sighted at 10,000 feet the other climbed until it disappeared." (R10)

X11. December 28, 1944. Germany.

"1st patrol saw 2 sets of 3 red and white lights. One appeared on the port side, the other on starboard at 1000 to 2000 feet to rear and closing in. Beau peeled off and lights went out. Nothing on GCI scope at the time. Observed lights suspended in air, moving slowly in no general direction and then disappeared. Lights were orange, and appeared singly and in pairs. These lights were observed 4 or 5 times throughout the period. (R10)

There is no evidence as yet that any of the World War-II combatants had anything in their arsenals that could have accounted for the foo fighters. But if the foo fighters are natural phenomena, one would expect at least a few modern reports from the thousands of commercial and military aircraft in the skies every day.

X12. May 3, 1945. Truk, Oceania. The unexplained "foo fighters" seen by Allied pilots over wartime Germany were duplicated to a lesser degree in the Pacific, thereby undermining the contention that they were German weapons. In addition, strange "circles of light" followed American aircraft in the Pacific. Their relationship with foo fighters, if any, is unknown.

The following paragraphs were taken from the "Weekly Intelligence Summary," Headquarters, Eastern Air Command, South East Asia. June 1, 1945.

"A B-24 of the 11th Bomb Group on a snooper mission over Truk during the early morning hours of 3 May 1945, encountered what may prove to be as baffling a phenomena (sic) as the balls of light seen by the B-29s while over the Japanese mainland. (Excerpted From Hq. AAF, POA, Air Intell. Memo No. 4, 8 May 1945.)"

"The B-24 first observed two red circles of light approaching the plane from below while still over the Truk atoll. One light was on the right and the other was seen on the left of the B-24. The light on the left side turned back after one and one half hours. The one on the right remained with the bomber until the B-24 was only 10 miles from Guam. From the time that the B-24 left the atoll, the light never left its position on the right side. It was reported by the crew members as sometimes ahead, sometimes behind, and sometimes longside the B-24 and always about 1200 to 1500 yds distant.

.....

"The light followed the B-24 in dives from 11,000 to 3,000 feet, through sharp course changes and even brief cloud cover always keeping its same relative position and distance. At one time, the pilot turned into the light and he definitely reports no closure occurring. During the night, high cirrus clouds masked the moonlight and no part of the object was observed except the light. At daybreak, the light changed to a steady white glow and a possible wing shape

with a silver glow was noted by some members of the crew." (R11)

X13. General observations. The World War-II "foo fighters" have received little public attention outside of the UFO literature. However, the Associated Press did mention them in a dispatch in early 1945. Both the New York Times (R12) and New York Herald Tribune (R13) ran short articles based on this dispatch. We quote excerpts from the former.

"AMERICAN NIGHT FIGHTER BASE. France, Jan. 1.---The Germans have thrown something new into the night skies over Germany---the weird, mysterious 'foo-fighters,' balls of fire that race alongside the wings of American Beaufighters flying intruder missions over the Reich.

"American pilots have been encountering the eerie "foo-fighter" for more than a month in their night flights. No one apparently knows what this sky weapon is.

"The balls of fire appear suddenly and accompany the planes for miles. They appear to be radio-controlled from the ground and keep up with planes flying 300 miles an hour, official intelligence reports reveal.

"'There are three kinds of these lights we call foo-fighters,' Lieut. Donald Meiers of Chicago said. 'One is red balls of fire which appear off our wing tips and fly along with us; the second is a vertical row of three balls of fire which fly in front of us; and the third is a group of about fifteen lights which appear off in the distance---like a Christmas tree up in the air---and flicker on and off.'

.....

"'A foo-fighter picked me up recently at 700 feet and chased me twenty miles down the Rhine Valley,' Lieutenant Meiers said. 'I turned to starboard and two balls of fire turned with me. I turned to the port side and they turned with me. We were going 260 miles an hour and the balls were keeping right up with us.'" (R12)

References

R1. Creighton, Gordon W.; "Foo Fighters," Flying Saucer Review, 8:11, March/April 1962. Quotation credited to New York Herald Tribune, January 2, 1945. (X1)

R2. Felsher, Murray; "Ball Lightning," Nature, 227:982, 1970. (X2)

R3. Jennison, R.C.; "Can Ball Lightning Exist in a Vacuum?" Nature, 245:95, 1973. (X3)

R4. Vidler, G.T.; "Lightning Strike 23 April 1964," Meteorological Magazine, 93:254, 1964. (X4)

R5. Ingle, W.H.; "Lightning's Effects," New Scientist, 52:185, 1971. (X5)

R6. Aspden, H.; "The Enigma of Ball Lightning," Journal of Meteorology, (U.K.), 6:258, 1981.

R7. Condon, Edward U.; "Coronal Effects," Scientific Study of Unidentified Flying Objects, New York, 1969, p. 735. (X6)

R8. "'Foo-Fire' Reports Leave Scientists Guessing," Science News Letter, 47:24, 1945. (X7)

R9. Chamberlin, Jo; "The Foo Fighter Mystery," American Legion Magazine, 39:9, December 1945. (X8)

R10. Greenwood, Barry; "First Official Foo-Fighter Records Discovered," Just Cause, no. 32, p. 1, June 1992. (X9-X11)

R11. Anonymous; "B-24 Sights "Circles of Light," U.F.O. Historical Review, no. 2, p. 8, September 1988. Cr. B. Greenwood. (X12)

R12. Anonymous; "Balls of Fire Stalk U.S. Fighters in Night Assaults over Germany," New York Times, January 2, 1945. Cr. M. Piechota. (X13)

R13. Blakeslee, Howard W.; "Nazi Fire Balls May Be Kind of Ball Lightning," New York Herald Tribune, January 3, 1945. (X13)

GLB19 Repeating Ball Lightning

Description. The repeated occurrence of ball lightning in the same geographical area. The events, which may number in the hundreds, may be separated in time by seconds or even months.

Data Evaluation. As with most ball-lightning phenomena, our data here are anecdotal. Also, as commonly the case, the examples are to be found in British meteorological journals. Rating: 2.

Anomaly Evaluation. Ordinary lightning strikes some targets frequently, such as New York City's Empire State Building. Prominence and other characteristics of such targets are obviously influential. With ordinary lightning, which may be erratic but is still just an electrical discharge, conditions favorable to repeated strikes are usually easily understood. The conditions leading to the formation of ball lightning are more obscure. So, when ball lightning materializes twice in the same room of the same house, we are at a loss to explain just what characteristics of the locale favor these repeated occurrences. House location, its electrical wiring, its plumbing, its TV antenna; who knows?

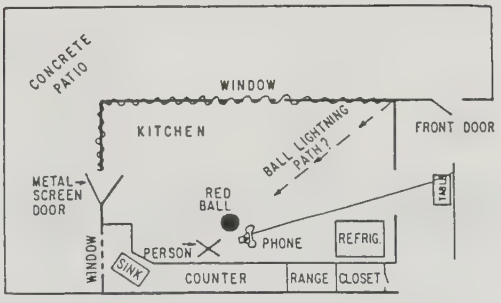
In cases where the same storm is observed to generate hundreds of lightning balls, the repetition is probably not due to local conditions but rather the microstructure of the storm itself, which is somehow providing the favorable conditions for repetition.

In neither case---local geographical conditions or storm conditions---do we understand exactly what factors are conducive to the mulitple production of this fascinating phenomenon. Rating: 2.

Similar and Related Phenomena. Double and triple ball lightning (GLB5).

Examples

X1. Summer 1977, Haymarket, Virginia. Mrs. Townsend was in her kitchen during a severe electrical storm. Immediately following a vivid flash and a tremendous crack outside her house, a red ball came from nowhere and hit her on the chest. She was knocked down but survived. Of more than usual interest here is the fact that ball lightning appeared in the same kitchen a year later, as described in GLB14-X5. Mrs. Townsend was again struck by the ball and again survived. (R1)



Layout of the Virginia kitchen in which a woman was struck by ball lightning in 1977 and again in 1978. (X1)

Several people claim to have been struck by ordinary lightning more than once, but Mrs. Townsend seems to be the only one struck twice by ball lightning!

X2. July 1956. Great Australian Bight. The following account was submitted to D.J. Turner by K.H. Hill, who was aboard a fishing vessel some 25 miles offshore.

"Right after sunset, the electrical storm began, with large balls of lightning coming from the cloud base, dropping

to the sea in 2 to 3 seconds of activity. These rather large balls seemed to be about one metre in diameter, occurring every 3 to 10 seconds, to within 100 metres (but fortunately not on our vessel!) to some miles away. The display allowed us to dispense with our compass sighting as so many times the sky was alight. We could see even thirty miles ahead to Flinders Island and reefs surrounding with ease. The balls of lightning were of a sodium-yellow colour internally with a bright active lilac-blue surface of electrical energy...The display continued for over two hours, so we saw at least 1,000 individual displays. Our eyes were affected to some degree, as the black night that followed seemed the blackest we had known and special care was taken in navigation until dawn arrived, with two on watch." (R2)

We know of no other storms where 1,000± balls of lightning were observed. One must ask how this particular storm was different and, of course, whether real ball lightning was seen. Of course, who knows what defines real ball lightning. The phenomenon is very diverse in its manifestations and may involve several different mechanisms.

References

R1. Bailey, B.H.; "Ball Lightning Strikes Twice," Weather, 39:76, 1984. (X1)

R2. Turner, D.J.; "Reproducibility in the Formation of Lightning Balls," Journal of Meteorology, U.K., 21:397, 1996. (X2)

GLB20 Penetration of Physical Barriers by Ball Lightning

Description. The forceful entry of ball lightning into enclosures by penetration of metal screens, metal sheets (aircraft skins), glass windows, etc. Sometimes the barriers are breached without damage; at other times holes are left.

Data Evaluation. Considerable anecdotal and some circumstantial physical evidence has been published in science journals. Such data are usually susceptible to criticism because the actual act of penetration was not observed directly. Given the surprise and consternation associated with the appearance of ball lightning in enclosures, this lack of detail is not surprising! Rating: 2.

Anomaly Evaluation. Ball lightning, like normal lightning, is usually a very energetic phenomenon. Its easy passage through a thin physical barrier is hardly surprising. More puzzling are ball lightning's retention of its shape during the penetration of barriers and, in particular, its seeming propensity to enter enclosures and wander about them.

Those penetration cases where the barrier is not damaged are probably explicable as induction phenomena, where electrostatic lines of force penetrate the barriers (usually poorly conducting glass in these instances) and there is no transfer of matter. The ball is essentially reconstituted using the atmosphere on

the other side of the barrier. In principle, such barrier penetrations are completely equivalent to the examples of ball lightning's apparent materialization in rooms cataloged in GLB10.

Conceivably, barrier penetration could be a combination both nondestructive induction and destructive entry. No matter which process or combination thereof occurs, explanation seems within reach of the physicists if they only knew how ball lightning is created and sustains itself. Rating: 2.

Similar and Related Phenomena. Ball-lightning materialization in enclosures (GLB10).

Examples

X1. No date, Lake Victoria, Uganda.

"Thunderstorms are frequent in the Entebbe Peninsula, Lake Victoria (Uganda). During one of these storms, which usually come at night time, there was a simultaneous flash of lightning and its associated clattering crash of thunder. A second or less later, several balls of brilliant blue light, about 4-6 cm diameter, entered the room through a window on the south side and 'floated' across the room to leave by a window on the east side. My wife and I were already awake (it would have been difficult not to be) and independently exclaimed aloud on what we had just seen." (R1)

Both windows were open but had metal screens. The same phenomenon occurred again during the same rainy season.

X2. March 21, 1983. Kingsley, North Staffordshire, England.

"A large white luminous ball, probably over a metre in diameter, blasted its way into a factory workshop by shearing an irregular hole through a steel-mesh-reinforced window. There was no evidence of any fusion of the glass. The ball, accompanied by a deafening roar, passed very quickly in a straight line through the processing shop and left by blasting a 2 by 3 metre hole in a wall of 6 mm corrugated asbestos, fragments of which were later found 20 to 30 metres away outside the factory." (R2)

X3. January 1984. Sochi, U.S.S.R. An Ilyushin-18 took off from Sochi, on the Black Sea, in fair weather. Soon after takeoff thunderclouds were noted about 60 miles away.

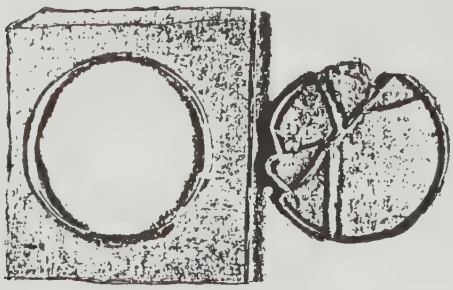
"Suddenly, at the height of 1,200 yards, a fireball about four inches in diameter appeared on the fuselage in front of the crew's cockpit. It disappeared with a deafening noise, but reemerged several seconds later in the passenger's lounge, after piercing in an uncanny way through the air-tight metal wall. The fireball slowly flew about the heads of the stunned passengers. In the tail section of the airliner it divided into two glowing crescents which then joined together again and left the plane almost noiselessly." (R3, R4)

Upon landing back at Sochi, holes were discovered in the fuselage fore and aft.

X4. General observations. In the Autumn 1992 issue of the Journal of Scientific Exploration, A.I. Grigor'ev et al collected 43 eyewitness accounts of ball lightning penetrating closed rooms. Most of the reports came from the former USSR and are new to Western scientists.

The majority of these balls entered through closed glass windows. Sometimes the balls penetrated the windows without damaging the glass at all, but in a few cases neat circular holes were somehow melted or punched through the glass. The accompanying photograph illustrates an incident in which lightning (supposed to be ball lightning) surgically excised a coin-like piece of glass. (R5)

X5. July 27, 1952. Hamburg, Germany. Witness: T.W. Kohn of the Hamburg Meteorological Observatory. A case of window penetration without glass damage.



A hole in a pane of glass presumably made by ball lightning. (X4)

"A few seconds after a close discharge of lightning we saw outside behind a window a bright luminous ball the size of a fist moving downwards along a curved trajectory. This luminous ball passed inside the room through the glass of a closed window, moved one meter into the room, made a 90° turn, moved farther into the room parallel to the wall and then disappeared with a sharp, loud blast. The ball had a violet-and-blue color tinged with red. The observation lasted three seconds. The ball caused no damage either inside or outside the room. After the explosion there remained an odor typical to electric discharges." (R5)

X6. No date given. New South Wales, Australia. D.J. Turner has amassed 5315 descriptions of supposed ball-lightning events. Among these are 42 cases where the balls apparently bored holes in glass window panes, and 26 where they somehow passed through the panes as if the glass were nonexistent.

By what sort of electromagnetic magic can ball lightning whisk through solid glass without damaging it? The few eye-witnesses of these events say that this legerdemain is very rapid, and that the ball's shape and motion are unaffected. Evidently, we have here cases of electromagnetic induction. Electromagnetic fields penetrate the glass and reconstitute the ball from air molecules on the other side --a sort of Star Trek "transporter." Unfortunately, this mechanism is a long way from practical use.

In several cases where holes have been found in the glass after the passage of ball lightning, glass discs of the appropriate size are discovered nearby. (See figure in X4.) Most of the time, though, discs and glassy residue of any kind are lacking. There is usually not even any evidence of glass flow and melting around the edges of the holes.

Turner concludes his lengthy paper with a most unusual case from New South Wales. It seems that a physics teacher arrived early at his school one stormy morning to be confronted by a trembling cleaning woman.

"During the storm that morning she had witnessed a lightning strike on the roof of the school library...After the strike, a fireball danced across the room for several seconds before it disappeared down the side of the building. The lady thought the building might be on fire and went to check.

"As she entered the corridor she found a lens of window glass lying on the carpet. This piece of glass was about 40 meters from where she last saw the fireball. It was not there before the storm.

"She showed me the piece of glass. It was about 30 centimeters long on its longest axis and about 12 cm wide at its widest section. The edges were smooth and the finish was similar to that on metal cut out by oxyacetylene. The lens fitted perfectly into the window, whose glass was 5 millimeters thick." (R6)

Turner's paper mentioned above was followed by a critical article by S. Campbell, a severe skeptic of ball lightning reports. (R7) Campbell was particularly doubtful about the scientific value of the physical evidence (glass damage and pieces thereof) collected from several window-penetration cases.

An exchange of letters between Turner and Campbell ensued in the Journal of Meteorology, U.K.. (R7-R10) In the end, it seems to have been a contest between a skeptic and a scientist with an open mind about the reality of ball lightning. No minds were changed.

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GLB21 Miscellaneous Observations of Bizarre Ball Lightning

Description. Sundry observations of bizarre luminous phenomena that possess some attributes of ball lightning, as loosely defined in the preceeding twenty sections. Certainly, any form of ball lightning is bizarre, but some manifestations are weirder than others and refuse to fit into any of our roughly defined categories. "Ordinary" ball lightning (GLB1), though simple in its morphology, is still difficult to define precisely. Even its physical reality is hard to demonstrate to everyone's satisfaction. "Bizarre" ball lightning is "even more so"!

Data Evaluation. Anecdotal data only, mainly as reported science journals. It must be noted that ball lightning in any of its guises is startling and disconcerting to its observers. The more bizarre (i.e., "less ordinary") an apparition the more careful one should be in data assessment. The common assertion that extreme claims require more proof is operational here. Since the cases cataloged below usually involve single observers and often extraordinary circumstances, we must be a bit leery. Rating: 3.

Anomaly Evaluation. Since "ordinary" ball lightning, assuming its reality, severely challenges science's explanatory powers, "bizarre" ball lightning must be even more anomalous. Rating: 1.

Possible Explanations. Misinterpretation and exaggeration may play roles in bizarre ball-lightning anecdotes. Some observations may be extreme examples of electric-discharge phenomena (GLD), such as St. Elmos fire.

Similar and Related Phenomena. Most electric-discharge phenomena (GLD); anomalous manifestations of lightning (GLL11, GLL23, GLL25, etc.); low-level meteor-like phenomena (GLM1).

Examples

X1. April 24, 1887, Mortree, France.

"On April 24, 1887, a storm burst over Mortree (Orne), and the lightning literally chopped the telegraph wire on the route to Argentan for a distance of 150 yards. The pieces were so calcinated that they might have been under the fire of a forge; some of the longer ones were bent and their sections welded together. The lightning entered by the door of a stable in the form of a fireball, and came near a person who was preparing to milk a cow; then it passed between the legs of the animal, and disappeared without causing any damage. The terrified cow raised itself on its hind legs with frantic bellowing, and its master ran away, frightened out of his wits, but there was no harm done.

"The inexplicable phenomenon was that at the precise moment when the lightning crossed the stable, a great quantity of incandescent stones fell before a neighboring house. 'Some of these fragments, of the size of nuts,' wrote the Minister of Post and Telegraphs at the Academy, 'are of a not very thick material, of a greyish-white, and easily broken by the fingers, giving forth a characteristic odour of sulphur. The others, which are smaller, are exactly like coke.'" (R1)

X2. September 8, 1981. Te Ngaere, New Zealand. Inside a house during a thunderstorm.

"The next lightning seemed directly overhead and very bright and was accompanied by a simultaneous very loud clap of thunder. I looked up as the whole house shook and then looked down and saw a flow of light come in under the door. It settled in a blob near the edge of the area where the tools were laid out. It was not in any true shape but about 3 or 4 inches long and 2 inches wide, moving along the floor, less than half an inch thick, seemingly fluid in shape and texture. It reminded me of quicksilver, being a bluish-silver colour and it had rounded sides like a blob of mercury. It was brighter at the edges than in the middle, but it did not seem, especially in the light of the room, to glow, nor did it give out sparks. From the central body arms flowed out like runs of oil among the tools. The trails weaved through the tools---not actually over them but round them---moving back into the main body of the blob and then going out doing the same kind of movement over again. There was no sound or smell. The arms finally all went back into the blob which disappeared again suddenly out under the door. There was no bang and when I ventured to touch the tools there was no charge on them." (R2)

A subsequent magnetic survey of the area showed a weak correlation between the patch's motion and regions of intense magnetic field. Such a correlation would be expected if the patch contained free magnetic dipoles or current loops.

X3. Summer 1996. Gmuend, Austria. Ball lightning (BL) may assume many weird forms, which is one reason some scientists claim it is more likely an illusion than physical reality. Those physicists who admit that BL exists think that some electromagnetic mechanism might account for any nicely spherical, luminous globes with lifetimes of just a few seconds, but their equations cannot handle the phenomenon now described.

A. Reisinger was working in her garden about 10 meters from an apple tree when she observed a phenomenon that seems to have been an elaborate and hard-to-explain form of ball lightning.

"When the BL appeared suddenly from behind the tree, it caught the attention of the witness who said that it looked like it 'sat down on to the tree.' It had the dimensions of 'a small truck tyre, not as large as a tractor one,' and it had a definite torus shape. What made

the dark object an even stranger sight was a considerable number of 'Xmas candies,' all hanging down from its underside 15 to 20 centimetres long and 'sparkling,' which means changing brightness with an emission of sparks at the same time. A humming and sizzling sound was associated with the optical effect, but there was no static electricity. The strange light was not blinding, but irritated the eyes of the witness who looked at it only intermittently. Mrs. Reisinger continued her work in the shed, not moving closer to the object and getting more nervous over the 10 minutes that the phenomenon lasted. Her eyes started to water towards the end of the observation. Another phenomenon that she remembers was the irregular extinction of the 'candies' which went out piece by piece." (R3)

X4. Summer 1968 or 1969. Shipston-on-Stour, Warwickshire, England. The following experience was reported by E. Lockyer.

"She was in the kitchen, cleaning a pair of steel-tipped shoes, when she heard a loud bang like a pistol shot. 'This happened three times, and each time a flame shot off the heel of the shoe in my hand. Then the flame leaped to the cooker and did the same thing around one of the metal plates. After this the flame seemed to form itself into a ball; it rolled down a passage...My parents watched it roll up the stairs, where it disappeared, presumably out through an open window.' Mrs Lockyer's father said the ball was the size of a small football. It was bright, but not too bright to look at; the edge was sharp; it was white in the kitchen, but became reddish when it formed into a ball; there was no small. A thunderstorm occurred shortly afterwards." (R4)

X5. June 16, 1998. LaGrange, Georgia.

"The witness of the 16 June LaGrange incident, Melvin Smith, owner of a large cab company and garage, said while stopped at the intersection of Colquitte and Ogletree Streets he initially heard a 'loud roaring noise.' Looking slightly to his left (southwest) he saw a 'ragged fireball' come 'rolling' over Colquitte Street. As the red fireball passed in front of him, it 'rocked' his car. The round fireball, he said, had a diameter of five feet and traveled to the northeast in excess of a 100 miles-per-hour. During the brief fly-over, the bright red fireball showed no sign of growing smaller, slowing or going down. The sighting of the fireball, Smith also said, came after the worst of the storm had passed." (R5)

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GLD DIFFUSE ELECTRICAL DISCHARGE PHENOMENA

Key to Phenomena

GLD0 Introduction

Everyone is familiar with fast, concentrated discharges of electricity, such as lightning. More rare are the slower, more diffuse flows of natural electricity. In these the passage of electrical currents is gentle and almost soundless in contrast to the violent thunderbolt. Even so, these slow discharges frequently give rise to luminous, often strangely beautiful phenomena.

Slow electrical discharges usually proceed from projections and sharp points, such as ship masts, radio antennas, and even human fingers held aloft. Pointed structures tend to concentrate electrical fields and, if the fields are intense enough, will encourage a slow flow of electricity from the point into the surrounding air. When these discharges become luminous, they are called St. Elmo's Fire. In damp and stormy weather, high voltage power lines may exhibit eerie luminous discharges around insulators and other structures. These bluish glows are termed 'corona discharges.' Reports from ships at sea and mountain-top scientific observatories tell of St. Elmo's Fire in the form of cold lambent flames and auras streaming from scientific instruments, guy wires, and even peoples' heads. St. Elmo's

Fire also appears infrequently in snowstorms and sandstorms, as the falling and blowing particles transfer electricity between the earth and the air like those Wimshurst electrostatic machines so common in high school physics laboratories.

Corona discharge and St. Elmo's Fire are not particularly mysterious to physicists; they therefore constitute a good starting point for a journey into more controversial territory.

The next stop is a truly spectacular one: the so-called Andes Glow or, to be more general, the mountain-top glow. Since many mountains pierce the atmosphere with sharp projecting surfaces, the appearance of slow electrical discharges from their crests is not especially surprising. It is the scale of the process that is awe-inspiring. The sheets of flame and aurora-like beams of light projecting into the stratosphere may be visible for hundreds of miles. Where does this mountain electricity go? Into outer space? And why are mountain-top glows greatly enhanced during major earthquakes? No one has really studied this phenomenon carefully. It is in essence St. Elmo's Fire on a massive scale.

On a smaller, less-violent scale, intense electrical storms may create ground-level patches or waves of luminous electrical activity that may engulf humans in their paths, electrically shocking them or wrapping them in a garment of St. Elmo's Fire. In some ways, these surface displays resemble the marine phosphorescent displays, particularly the rotating phosphorescent wheels, described later in this volume of the catalog.

Considerably more mysterious are the glowing, enigmatic, floating spheres that observers often compare to toy balloons. These cavorting softly-lit bubbles are certainly not ball lightning and may not even be electrical at all. Whatever they are, modern science has paid little attention to them, perhaps because their explanation is so difficult and their existence so improbable.

These subjects bring us to those strange glows, flashes, and fireballs seen so often near earthquake epicenters. Earthquake lights also take the shapes of auroral beams, mountain-top glows, ball lightning, and moving waves of rock luminosity. Since modern scientific observations demonstrate that earthquake shock waves may penetrate the atmosphere into the ionosphere, it is possible these atmospheric disturbances may help create low-conductivity paths for earth-to-space electrical discharges. The ball lightning, the sheets of flame issuing from the ground, and other localized luminous phenomena may be generated by large-scale piezoelectric effects (i.e., the creation of electricity by stresses in rocks). An alternate explanation of earthquake lights involves the spontaneous ignition of natural gas liberated by the quaking earth.

Violent volcanoes and tornadoes also display unusual lights. Of course, normal lightning and ball lightning are to be expected in violent storms, but whence the peculiar shafts of light reported in tornado funnels and the strange glowing patches in and above storm clouds? The precise role of electricity in tornado action, if any, is highly controversial. Superficially at least, the funnel light columns may, like neon lights, arise from large-scale glow discharges in these naturally formed tubes.

That the earth-as-a-whole is a gigantic electrical machine cannot be doubted. The constant turmoil of the atmosphere, its never-ceasing bombardment by the solar wind, the electically charged wind-blown dust and snow, and the intense forces squeezing terrestrial rocks, all conspire to creat a wide spectrum of curious and poorly understood luminous effects.

GLD1 Mountain-Top Glows

Description. Rays, undulating streamers of light, flashes, and steady glows appearing along mountain crests and ridges. The color is usually yellowish white, with green and orange being more rare. This phenomenon is observed in the Andes, the Alps, the Rockies, the Arctic, and probably many other places.

Background. Despite the widespread occurrence of mountain-top glows, science has taken little note of them. Instrumented studies are essentially unknown.

Data Evaluation. Many high quality observations, especially from the Andes and Alps. Rating: 1.

Anomaly Evaluation. Mountain-top glows are probably large-scale discharges on terrestrial electricity into the atmosphere---that is, greatly magnified St. Elmo's Fire. The anomalous aspects are: (1) The very large scale of the phenomenon; (2) The apparent heightening of the displays during earthquakes; (3) The possible periodicity of the flashes; (4) The close resemblance to auroras, which seems to underscore the reality of low-level auroras (GLA4). Rating: 3.

Possible Explanation. Large-scale discharge of terrestrial electricity.

Similar and Related Phenomena. Low-level auroras (GLA4); aurora-related fogs and mists (GLA21); earthquake lights (GLD8).

Examples of Mountain Top Glows

X1. September 25-30, 1868. Near Spitzbergen. "On returning from the island, where the instruments for the magnetic observations had been deposited, I perceived upon the ridge of the mountain, to the south, a brilliant polar light rising from 10^{o} to 15^{o} above the mountain in undulating rays, distinctly defined, at their base appearing as a diffuse yellowish light, but higher up as vertical orange beams, while at the top they formed a series of sharp points. The rays had an undulating motion, and the crest of the mountain was covered with a light fog, which the wind was moving from east-northeast to west-southwest. In a few moments the cloud of mist passed the mountain and the rays disappeared, but the crest of the mountain continued to be illuminated by a pale wandering light, which floated along the mountain.....On the 27th of September, after having observed in the morning a radiation of yellowish-white light proceeding from one edge of a cloud which stood out prominently from a wall of clouds, I perceived in the evening, at 11 o'clock 30 minutes, a pale, wandering light moving distinctly along the ridge of the mountain. The light appeared for a few moments in the form of rays of a clear and brilliant yellow, following every detail of the sinuosities of the mountain. The pale glimmer of light seemed to follow the ridge of the mountain, and I was convinced, from the movement of the mists, that the luminous phenomenon was formed upon the ridge itself. On the 30th of September, at 9h. 30 m., I witnessed on the island of Amsterdam a very intense luminous phenomenon, during which every peak and ridge, the most elevated, was illuminated with a pale light, particularly when covered with a vail (sic) of mist." (R1)

X2. August 14, 1903. Swiss Alps. Observing the peaks and ridges. "About 8 p. m. I noticed a faint quivering light overhead, supplemented by occasional flashes of greater brilliance and different colour. These manifestations rapidly increased in distinctness, and continued to play only along the opposite mountain-ridge, not extending into the regions beyond, so far as these could be seen from here, though I have since learnt that an independent series of flashes was seen around the Schilthorn on this side of the valley. Not a single peal of thunder was at any time audible.....As one watched the display it was easy to distinguish more definitely the two kinds of discharge. One of them took the form of a faintly luminous reddish or pink light, which shot with a tremulous streamer-like motion in horizontal

beams that proceeded apparently from left to right, as if their starting point lay somewhere about the back of the Jungfrau. These streamers so closely resembled the aurora borealis that, had they appeared alone, one would have been inclined to wonder whether the 'northern lights' had not here made an incursion into more southern latitudes." (R2)

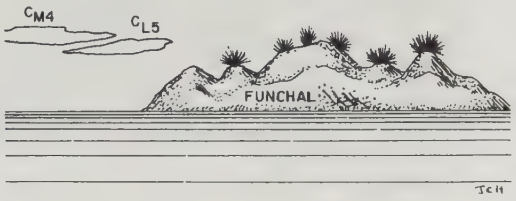
X3. August 21, 1911. Swiss Alps. "On the night of August 21, about ten o'clock, semicircular flashes of light shot up apparently behind the Monch, quivered for a few seconds, and then disappeared. I counted twenty-eight in a minute. The light was sometimes intense at a central point, which was steady, and from this quivering glow proceeded and lighted up from 15° to 20° of the horizon... The appearance seemed to me very like an aurora borealis which I saw in Scotland in the 'fifties, but the centre of the light here was to the south-west of where I stood." (R3)

X4. September 18-19, 1941. Mount Adams, New Hampshire. During the great auroral display to the south. "During the early stages of this display, the picture below (not reproduced) was taken by Howell, showing the green arc a few degrees above the horizon, and therefore in actual position some few hundred miles or so to the north, and bright enough to light up the peaks. Outlining the mountain can be seen a faint rim of light, greenish to the eye." (R4)

X5. Spring 1944. Algeria. "In the spring of 1944, one clear dark night, I observed the flash type of discharge being made repeatedly at the summit of what I believe is called Mont Leon to the north-west of Bone airport in Algeria. The night in question was clear and starlit and the top of Mont Leon was covered with a little cap of cloud; evidently it coincided with the inversion top, and it was in this cloud that the flash occurred. Enquiry seemed to show that this was commonly seen in the winter there." (R5)

X6. Early 1950s. Peru. While camped in the high Andes. "From our camp we had at least 50 km of the crest in direct view across the gorge. After supper, we noticed occasional lightning flashes and glows along the whole visible crest. The skies were fairly clear over us, and we heard no thunder. The nearest part of the crest was at least 10 km distant. As it grew darker, they became spectacularly frequent: there was hardly any instant without at least one flash somewhere, and often several blazed simultaneously. This Jovian show was still going undiminished when I went to sleep about midnight." (R6)

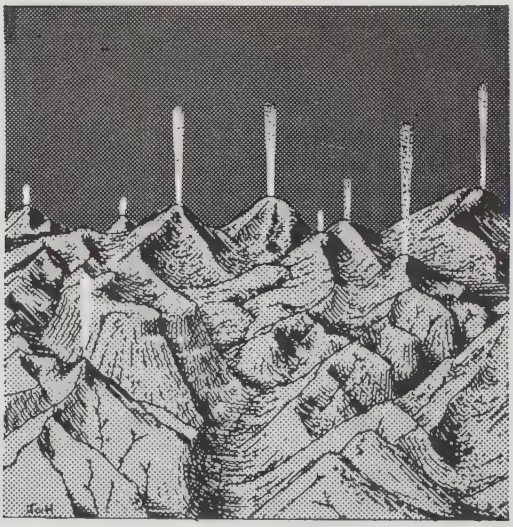
X7. June 7, 1954. Madeira. "On approaching Madeira from sw the island was completely covered with low cloud, St and Sc. On arriving within 16 miles of the island the cloud rapidly lifted and numerous brilliant white flashes were observed at frequent intervals on various mountain peaks. At the time of these occurrences the cloud was clear of the island, although there was some Sc to NW. After the flashes had continued for some 20 min a low rumbling was heard like distant thunder. (R7)



In 1954, officers on a ship approaching Madeira observed brilliant, white flashes on some of the island's mountain peaks. (X7)

X8. General observation. The Andes. "Thunderstorms are rare in Chile, and this fact may possibly be explained on the assumption that the Andes act as a gigantic lightning rod, between which and the clouds silent discharges take place on a vast scale. The visible discharges occur during the warm season, from late spring to autumn, and appear to come especially from certain fixed points. According to Dr. Knoche they are confined almost exclusively to the Andes proper, or Cordillera Real, as distinguished from the coast cordillera. Viewed from a favorable point near their origin there is seen to be, at times, a constant glow around the summits of

the mountains, with occasional outbursts, which often simulate the beams of a great searchlight, and may be directed westward so as to extend out over the ocean. The color of the light is pale yellow, or rarely reddish. One striking feature of these discharges is that they are especially magnificent during earthquakes. At the time of the great earthquake of August, 1906, throughout central Chile the whole sky seemed to be on fire;



Aurora-like pillars of light sometimes appear above some of the peaks in the Andes. (X8)

never before or since has the display been so brilliant." (R8, R21)

X9. General observation. The Andes. "'Andes glow' or 'Andes lights' are terms used to describe illumination seen at night in the vicinity of certain mountain peaks. While the majority of reports have come from the Andes mountains of Bolivia, Chile and Peru, this phenomenon has also been reported in the European Alps, Mexico and Lapland and presumably could occur in many mountainous regions under favourable conditions. While sometimes thought to be lightning, for lack of a more obvious explanation, the interesting property of these light displays is that they can occur under cloudless skies. Sometimes they are but one single flash, while at other times they may persist intermittently for hours. On occasion, a periodicity has been noted in the time between flashes. At their most spectacular they have been described as '...not only clothing the peaks, but producing great beams, which can be seen miles out at sea.' They seem to favour particular mountain peaks where often they can be seen during the dry season." (R9, R23-R29)

X10. General observation. The Andes. Radial rays shooting up as far as the zenith. (R10)

X11. August 10, 1854. Mont Blanc, Switzerland. Mountain ridges seemed on fire. Climbers felt effects of static electricity. (R11)

X12. August 6, 1885. Jura Mountains, Switzerland. Mont Galene illumined by an inphosphorescent light. (R12, R13)

X13. December 17, 1937. Mt. Wachusett, Massachusetts. On top of the mountain everything tinged with violet. Tingling sensation felt. (R14)

X14. General observation. The Andes. Flashing along the crests. (R15)

X15. General observation. Andes glow may result as snow is blown over the peaks, creating strong electric fields. (R16)

X16. No date given. Bohul Mountain, Russia. See description GLB3-X4. (R17)

X17. General observation. Mountain-top glows seen in Spitzbergen and Lapland; Lemstrom's observations. (R18)

X18. No date given. Skye, Great Britain. Sir Edward Sabine noticed that the cloud caps on the highest hills were permanently luminous at night, occasionally producing aurora-like flashes. (R19)

X19. General observation. Andes lights can be seen far out at sea. (R4)

X20. General observation. Mount Ida, near the Dardanelles. Mountain-top glow is common. (R4)

X21. General observation. Rocky Mountains. Continuous, silent electric discharges. (R20)

X22. 1929. Pikes Peak, Colorado. Ghostly flares seen about the summit at night. (R22)

A bit more information about these "flares"---presumed here to be mountain-top glows---was printed in the New York Times.

"Static electricity, which charges the atmosphere of the higher mountain peaks when storms are brewing, has appeared on Pikes Peak in the manifestation of ghostly flares about the summit at night.

"So brilliant have the lights become that airplanes were sent to observe the slopes and summit to see if the flares could have been caused by stranded hikers." (R29)

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R3. Brunton, Lauder; "A Pseudo-Aurora," Nature, 87:278, 1911. (X3)

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R5. Young, J.R.C.; "The Andes Glow," Weather, 26:39, 1971. (X5)

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R20. "Electric Phenomena in the Euphrates Valley," Monthly Weather Review, 28: 290, 1900. (X21)

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GLD2 Intermountain Electric Discharges

Description. Luminous discharges or lightning between mountain peaks accompanied by the sound of thunder.

Data Evaluation. The existence of this phenomenon is suggested primarily by testimony, some of questionable value. In addition, it is very difficult to judge the distance and location of a distant lightning flash in an active storm. Rating: 3.

Anomaly Evaluation. While ball lightning may be generated by high-current electrical apparatus (GLB15) and has been seen emerging from electrical equipment, it still seems unlikely that appropriate conditions exist for the creation of ball lightning or normal lightning between adjacent mountain peaks, although we are really steeped in ignorance in this matter. Rating: 2.

Possible Explanations. Possibly local geological conditions, say, ore bodies, might contribute to this phenomenon.

Similar and Related Phenomena. Mountain-top glows (GLD1); ball lightning (GLB).

X1. General observation. Taurus Mountains, Euphrates Valley. Ellsworth Huntington, the noted geographer, found the following phenomenon described in consistent terms by a dozen people in widely separated localities. "The facts, upon which all agree, are as follows: A ball of fire is sometimes seen to start from one mountain and to go like a flash to another. At the same time there is a sound like thunder. This occurs by day or by night, although by day no light is seen. It always occurs when the sky is clear and never when it is cloudy. It sometimes happens two or three times in a year, and then again is not seen for several years. For the last two years it has not been seen. It is most common (or possibly never happens except) in the fall at the end of the long, dry season of three months." One of the mountains involved, Karaoghlon, is 7,350 feet high and flat-topped. (R1)

X2. General observation. Comment on Huntington's item notes that interpeak lightning has not been scientifically observed though poets sometimes write of it leaping from crag to crag. (R2)

X3. No date given. Maryland. Lightning seemed to leap from peak to peak in the Appalachians. (R3)

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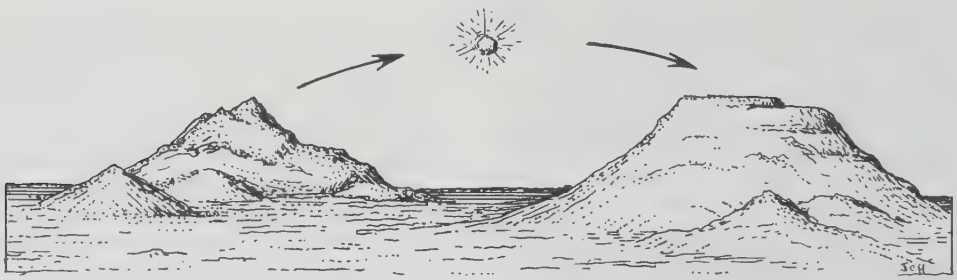

Artist's interpretation of anecdotes of intermountain fireballs reported in the Euphrates Valley. (X1)

GLD3 Electric Fluids: Large-Scale St. Elmo's Fire

Description. The envelopment of people, buildings and large tracts by transient, flame-like electrical discharges. This phenomenon is usually preceded by a strong clap of thunder. Despite being completely surrounded by flames, people are not hurt by large-scale St. Elmo's Fire, although there are some minor electrical sensations and difficulties in breathing.

Background. Large-scale St. Elmo's Fire seems to fill a gap between ordinary St. Elmo's Fire (flames on isolated sharp points) and brush discharge (a large-area discharge of electricity more audible than visible).

Data Evaluation. Although this phenomenon is not particularly mysterious, it is supported by only a few rather old reports. Rating: 3.

Anomaly Evaluation. St. Elmo's Fire is, of course, well-known. It is the magnitude of the manifestations described below that merit consideration at least as a curiosity if not a significant anomaly. Rating: 3.

Possible Explanation. Extremely strong potential gradients in electrical storms are the undoubted cause, although the areas involved are very large.

Similar and Related Phenomena. Mountain-top glows (GLD1); low-level auroras (GLA4); electrified clouds (GLD4), auroral fogs and mists (GLA21).

Examples of Large-Scale St. Elmo's Fire

X1. February 19, 1837. Orkney, Great Britain. Describing a boat moored to the shore. "....she was during this time attached to the shore by an iron chain, about 30 fathoms long, which did not touch the water, when, to my astonishment, I beheld a sheet of blood-red flame, extending along the shore for about 30 fathoms broad and 100 fathoms long, commencing at the chain and stretching along the shore and sea in the direction of the shore which was E.S.E., the wind being N.N.W. at the time. The flame remained about ten seconds, and occurred four times in about two minutes." (R1, R14)

X2. Circa 1842. Perthshire, Scotland. "I beg to observe that in the Highlands of Perthshire, some forty years ago, two men found themselves enveloped in flames, somewhat in the same style as Mr. Moir was on February 18 last. One Mr. John Stewart, who, for many years, drove the Mail gig between Dunkeld and Aberfeldy, told me that on a certain dark night, he and another man, climbing a rocky, heathery height in Rannock, were all at once set on flames by some mysterious fire, which appeared to proceed from the heather, which they were traversing, and the more they tried to rub the flames off the more tenaciously they seemed to adhere, and the more the fire increased in brightness and magnitude. Moreover, the long heather agitated by their feet, emitted streams of burning vapor, and for the space of a few minutes they were in the greatest consternation. They believed that they barely escaped a living cremation." (R2)

X3. August 5, 1879. Jura Mountains, Switzerland. As dark storm clouds approached. "At this moment the pine forest round St. Cergues was suddenly illuminated and shone with a light bearing a striking resemblance to the phosphorescence of the sea as seen in the tropics. The light disappeared with every clap of thunder, but only to reappear with increased intensity until the subsidence of the tempest." (R3, R4, R13)

X4. June 1880. Clarens, Switzerland. A thunderstorm in the distance; a heavy peal of thunder shakes the area. "At the same instant a magnificent cherry-tree near the cemetery, measuring a metre in circumference, was struck by lightning, Some people who were working in the vineyard hard by saw the electric 'fluid' play about

a little girl who had been gathering cherries and was already 30 paces from the tree. She was literally folded in a sheet of fire. The vine-dressers fled in terror from the spot. In the cemetery six persons, separated into three groups, none of them within 250 paces of the cherry-tree, were enveloped in a luminous cloud. They felt as if they were being struck in the face with hailstones or fine gravel, and when they touched each other sparks of electricity passed from their finger-ends. At the same time a column of fire was seen to descend in the direction of Chatelard, and it is averred that the electric fluid could be distinctly heard as it ran from point to point of the iron railing of a vault in the cemetery. The strangest part of the story is that neither the little girl, the people in the cemetery, nor the vine-dressers appear to have been hurt...." (R5, R6)

X5. August 12, 1884. Scotland. During a thunderstorm on a moor. "As Sir Alexander described it to me, he was enveloped in a sheet of light which seemed to him like illuminated steam. He does not remember noticing any pricking sensation, and on my asking him what the feeling was, he said it was indescribable, but a more uncomfortable and weird feeling he never experienced. The gamekeeper, who was standing about ten yards from him, saw him enveloped in the luminous cloud....." (R7)

X6. February 10, 1888. Off the English coast. Thunderstorm in the distance. "At about 6 a tremendous report was heard, sounding like thunder, and the captain describes the appearance of the vessel as if it were shrouded in a mass of bright red flames, which lit up the surrounding waves. The phenomena was all the more surprising as the thunder and lightning appeared to be at some considerable distance from the steamer, and it could not be compared to an ordinary thunder clap and lightning flash, being far too violent and no regular flash of lightning being seen." (R8)

X7. November 8, 1930. Rapura, New Zealand. During a thunderstorm, an entire house was wrapped in a blue flickering flame for "an appreciable period." In a field, three horses were likewise enveloped in blue flames. (R9)

X8. May 30, 1869. Greiffenberg, Germany. People outside in a thunderstorm seemed wrapped in fire and deprived of air. (R10, R11)

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R2. Cameron, Donald; "A Strange Phenomenon," Nature, 25:437, 1882. (X2)
R3. Nature, 20:423, 1879. (X3)
R4. "The Fires of St. Elmo," Scientific American, 41:234, 1879. (X3)
R5. Nature, 22:204, 1880. (X4)
R6. Tomlinson, C.; "Atmospheric Electricity," Nature, 40:102, 1889. (X4)
R7. Tomlinson, C.; "Effects of Lightning," Philosophical Magazine, 5:27:208, 1889. (X5)
R8. "Remarkable Discharge of Atmospheric Electricity," Scientific American, 58: 210, 1888. (X6)
R9. "Unusual Lightning Phenomena," Meteorological Magazine, 66:41, 1931. (X7)
R10. "Extraordinary Phenomenon," Scientific American, 21:231, 1869. (X8)
R11. "Extraordinary Phenomenon," Eclectic Magazine, 10:507, 1869. (X8)
R12. Tomlinson, Charles; "Remarks on the Weathering of Rocks and Certain Electrical Phenomena," Philosophical Magazine, 5:26:475, 1888. (X4)
R13. English Mechanic, 29:622, 1879. (X3)
R14. Traill, William; "St. Elmo's Fire Seen in Orkney," Edinburgh New Philosophical Journal, 23:220, 1837. (X1)

GLD4 Moving, Surface-Level, Electrified Light Patches

Description. Electrified luminous clouds or patches of light that drift over the surface of the ground. Sometimes the patches seem to move in waves over people and objects. Slight electrical shocks and sensations often accompany the enveloping patch of light. Usually, electrical storms are in the neighborhood.

Data Evaluation. This curious phenomenon has been well-described several times by competent observers. Rating: 2.

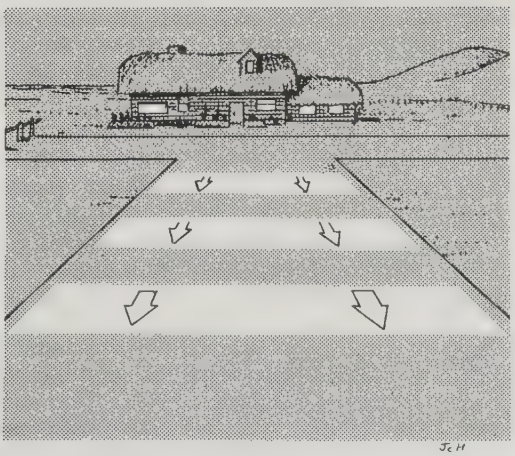
Anomaly Evaluation. The wavelike patterns and progressive motion of the luminous patches suggest an unrecognized regular structure for atmospheric electrical fields. Rating: 2.

Possible Explanation. Moving patterns of atmospheric electrical fields, a sort of St. Elmo's Fire with large-scale structure.

Similar and Related Phenomena. Large-scale St. Elmo's Fire (GLD3); auroral fogs and mists (GLA21); and, in appearance at least, the bar-type of marine phosphorescence display (GLW2). Some earthquake lights, especially GLD8-X5.

Examples of Moving Electrified Patches of Light

X1. November 30, 1858. Boscastle, Great Britain. "Last night (Nov. 30), at 15 minutes to 9, it being very dark and raining heavily, I was ascending one of the steep hills in this neighborhood, when suddenly I was surrounded by a bright and powerful light which passed me a little quicker than the ordinary pace of man's walking, leaving it dark as before. This day I have been informed that the light was seen by the sailors in the harbour, coming in from the sea and passing up the valley like a low cloud." (R1, R2, R8)



Waves of light swept across the ground in Midlothian in 1885. Note the curious resemblance to the bioluminescence described in GLW2. (X2)

X2. July 23, 1885. Midlothian, England. "About ten o'clock in the evening of July 23 a party of four of us were standing at the head of the avenue leading to this house, when we saw a feebly-luminous flash appear on the ground at a distance of some thirty yards down the avenue. It rushed towards us with a wave-like motion, at a rate which I estimate at thirty miles an hour, and seemed to envelope us for an instant. My left hand, which was hanging by my side, experienced precisely the same sensation as I have felt in receiving a shock from a weak galvanic battery. About three minutes afterwards we heard a peal of thunder, but, though we waited for some time, we neither saw nor heard anything further. The gardner who was one of the four, thus described what he saw:---

I thought it was a cloud of dust blowing up the avenue, and before I could think how that could be when there was not a breath of wind, I saw you three gentlemen covered for a second in a bright light, and that was all. Another of the party says that he observed what seemed to be a luminous cloud running up the avenue with a wavy motion. When it reached the party it rose off the ground and passed

over the bodies of two of them, casting a sort of flash on their shoulders. The distance traversed was about twenty yards,and the time occupied between two and three seconds." (R3)

X3. July 23, 1885. Dalkeith, England. Same time and general locality as X2. "When driving home from a professional visit in the country, and a mile south of this town, about ten o'clock I was suddenly startled by a peculiar sensation or slight shock, and immediately perceived, ten yards in front, on the road, a bright opalescent luminosity which travelled deliberately away in a northerly direction. This cloud or wave of light covered the whole breadth of the road, and was distinctly visible for some seconds. It seemed to rest entirely on the ground, and in character reminded one somewhat of the illumination resulting from the electric light. I should imagine it was travelling at the rate of twenty miles an hour.....I heard no thunder and saw no lightning or meteor to account for the strange and weird-looking light." (R4)

X4. February 22, 1912. Rochdale, England. Atmosphere close and heavy, with no breeze. "Suddenly, without the slightest warning, there appeared an area of faint electric-blue light, almost circular in shape and about 70 yards in diameter, which covered the plateau. The edge of this area was not more than 10 yards from where the observations were made. The whole electric field seemed to be three or four feet above the ground-level, and was in a state of intense agitation. Within the general blue ground there appeared flashes of a more decided blue, very similar in character to forked lightning, but not nearly so distinct. Sounds of two distinct types accompanied the agitation. The first consisted of whistling sounds, like that of numerous long-lashed whips swishing rapidly through the air, or perhaps that of the whistle of bullets. These sounds seemed to be associated with the general field of fainter blue. The other sounds consisted of the characteristic crackle of electricity, and these became so numerous as they approached the climax that they resembled a magnified rustle. These cracklings seemed to be associated with the forked discharges, and were probably due to the more distinct flashes coming into contact with the bushes which surround the plateau. The phenomenon lasted about fifteen to twenty seconds, and disappeared as spontaneously as it had arisen." (R5)

X5. September 1949. Yellowstone Park, Wyoming. While observing a violent thunderstorm. "It was then that I noticed a bluish light coming from over the low ridge to the west of Swan Lake. My first though was of a fire, perhaps caused by lightning. I watched the ridge for a moment and was amazed to see what can best be described as a hazy patch of blue light coming over the ridge and moving down the hill slope toward the flats around the lake. It was then that I observed a very low lead-gray cloud moving swiftly above the patch of light. The patch moved through the marshy north end of Swan Lake and caused several waterfowl to rise in hurried flight. The patch of light moved off the lake and onto the flats at a steady rate and proceeded directly toward my viewpoint. When the patch was but a few yards away, I noted a sudden calm in the air and a marked change in temperature, as well as what I believe was the odor of ozone. It was then that I realized that the display before me was some manner of static electricity, comparable perhaps to St. Elmo's fire and directly controlled by the low cloud moving above. The patch, which was actually a static field, enveloped my immediate area. To describe the weird feeling caused by viewing the progress of this phenomenon is difficult. It kept low to the ground, actually 'flowing around' everything that it came in contact with, coating it with a strange pulsating light. Each twig on the sagebrush was surrounded by a halo of light about two inches in diameter. It covered the automobile and my person but did not cover my skin. There was a marked tingling sensation in my scalp, and brushing my hair with the hand caused a snapping of tiny sparks." (R6)

X6. No date given. Natal. On a calm morning approaching a small airfield across farmlands. "But what had caught our attention in the misty dawn was an eerie reddish glow on the runway and about three hundred yards from the house. We were not more than two hundred yards away and walking

down hill directly towards the phenomenon. My first thought was that it could be a very large bubble of irridescent marsh gas about 100 feet in diameter, bright pink in the centre and fading gradually towards the circumference..... By this time we were only a stone's throw away and the pinkish glow had started to rise eerily into the air. There was no sound, no rush of air, and with a sort of involuntary reaction we both broke into a run towards the phenomenon, Jock exclaiming, 'Just look at those sheep!' My eyes were following the rapid disappearance of the 'bubble' into the mist above, but as we reached the point where the glow had been I also looked at the sheep and noticed with amazement that they all appeared to be standing on tiptoe like ballet dancers with their heads held unusually high, just as if they were suspended in space with their hooves barely touching the grass. It was then that we both first experienced a peculiar feeling, almost of weightlessness." The Zulu name for this phenomenon (see article title) is translated as 'The red sun that rises straight up.' (R7)

X7. No date given. Constamon (R8) or Courtamon (R9), France. Allusion to sparks coursing over the prairies. (R8)
A bit more information in the following quotation.

"Finally, the curious fact of moving electricity coursing over the prairies observed by M. Quiquerez near Courtamon may be likened to a kind of lightning, a discharge in miniature, resulting from the electrified cloud brushing over the earth and discharging itself over its whole surface by a thousand sparks which were seen to course over the meadows. It is possible that these phenomena ought to be divided into several categories of which the causes are not the same. Some arise from statical tension, others from a series of discharges which have some analogy with lightning." (R9)

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R1. Brown, Jabez; Report of the British Association, 1858, p. 156. (X1)
R2. Tomlinson, C.; "Atmospheric Electricity," Nature, 40:102, 1889. (X1)
R3. Watt, J. B. A.; "Electrical Phenomenon," Nature, 32:316, 1885. (X2)
R4. Lucas, Robert; "Electrical Phenomenon in Mid-Lothian," Nature, 32:343, 1885. (X3)
R5. M., J. McV.; "St. Elmo's Fire," Nature, 89:7, 1912. (X4)
R6. Sanborn, William B.; "An Electrical 'Bath' in Yellowstone," Natural History, 59:258, June 1950. (X5)
R7. Stocks, H. G.; "Hanga Elibovu Elisbonu Pezulu," Air Facts, 33:55, October 1970. (X6)
R8. Tomilinson, Charles; "Remarks on the Weathering of Rocks and Certain Electrical Phenomena," Philosophical Magazine, 5:26:475, 1888. (X1, X7)
R9. de Saussure, Henri; "On the Humming Produced on Mountains by Electricity," Philosophical Magazine, 4:35:123, 1868. (X7)

GLD5 Unusual Electric Discharge Phenomena during Duststorms and Snowstorms

Description. Ground-level lightning, subdued soundless flashes, dangerously electrified wire fences, widespread St. Elmo's Fire, stalled automobiles, sparking from projections, and other types of electrical discharges experienced during duststorms and snowstorms.

Background. Dust and snow particles carry electrical charges and can establish large potential differences at very low altitudes.

Data Evaluation. Many casual observations, backed in some cases (X4) by instrumented observations of atmospheric electrical gradients. Rating: 2.

Anomaly Evaluation. These manifestations of high electrostatic fields can be regarded only as curiosities. Rating: 3.

Possible Explanation. Frictional electricity created by blowing particles.

Similar and Related Phenomena. St. Elmo's Fire and corona discharge.

Examples of Unusual Electrical Discharges during Duststorms and Snowstorms

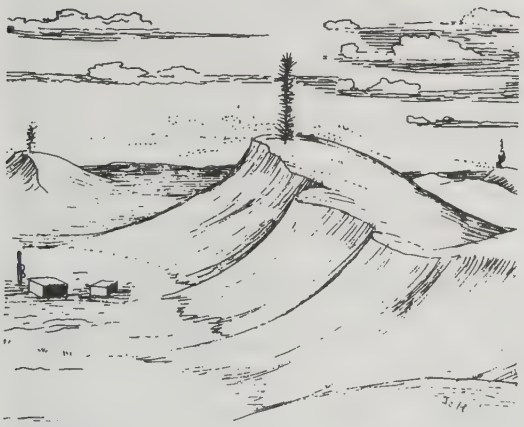
X1. March 1813. In a boat on Lochawe, in Argyleshire; storm approaching. "In a few minutes, however, they were overtaken by a shower of snow; and immediately after, the lake, which was of glassy smoothness, with their boat, clothes, and all around, presented a luminous surface, forming one huge sheet of fire. Nor were the exposed parts of their bodies singular in this respect, for to the eye they all seemed to burn, although without any feeling even of warmth. When they applied their hands to any of the melting snow, the luminous substance adhered to them as well as the moisture, and this property was not lost by the snow for twelve or fifteen minutes." (R1)

X2. December 20, 1894. Ft. Laramie, Wyoming. During a fierce windstorm. "Reliable information, obtained from over a section of country extending 12 miles south and 20 miles east, states that the electrical current was freely felt in many localities embraced in that area. Mr. Silas Doty, a very reliable man living 8 miles south, reports that he discovered a fence post on fire 200 yards north of his house, and upon going to it to extinguish the fire found it burnt more than half through where one of the fence wires was fastened, and partly burned where another wire was in contact with it. Other fence posts were slightly marked by the electric sparks. Mr. John F. Barnes, another reliable man, living 11 miles south of here, states that in going from his stable to his house he caught hold of a fence wire to assist him in walking against the strong wind and received a severe electric shock from which he was some time recovering. He had a strong healthy cow in a lot inclosed with wire fence. The wind drifted the cow into a corner against the fence and held her there, where Mr. Barnes found her dead late in the evening." (R2)

X3. March 3, 1964. Tucson, Arizona. During a heavy snowfall of large, wet flakes. "Short flashes of 'lightning' were seen to be occurring at intervals estimated to be about 15-20 seconds and at random places around the town. The flashes continued to occur throughout the storm, until the snow ceased at about 11.30 pm. Visibility was about 1 mile at first, but later decreased during the heaviest snowfall to about 200 yards. The flashes of 'lightning' contained several unusual features: they appeared to be single, short flashes of light without the 'flicker' normally associated with lightning. They were less intense than normal lightning and were not observed to cast sharp shadows. Moreover, thunder was not heard at any time, nor could correlation between the flashes and 'static' over the radio be found. The 80-foot high observation tower affords a good view over the

surrounding town, which is mainly occupied by single-story dwellings. From this elevation, the lightning was seen to originate from points at or very close to the ground. No brilliant, illuminated track such as is usually associated with lightning could be detected, although several discharges as close as 200 yards were observed. The illumination seemed to emanate from a single point which lit up the falling snow and surrounding cloud. The phenomenon was observed by several trained meteorological observers..." (R3)

X4. May 11, 1971. White Sands National Monument. "I made a fascinating observation of electrical activity on May 11, 1971, when a thunderstorm passed over the site. Strong winds were blowing large quantities of sand into the air, and atmospheric temperatures were lower and relative humidities were higher than usual for the month of May in that region.... Electric sparks were observed extending from the top of the sand dunes up into the air terminating at a height of a few metres. At least five sparks, all on different dune tops, were observed within the period 1510 to 1600 MDT. These sparks extended stright up, and no branches were observed." (R4)



In 1971, long sparks were observed rising from the gypsum dunes in White Sands National Monument, New Mexico, during a thunderstorm. (X1)

X5. General observation. Kansas. "No thunder or lightning occurs during these electrified dust storms, nor is there any known relation between them and earth magnetism. Any metallic object insulated from the earth seems to become highly electrified as the fine dust blows past it. One rancher relates an instance of driving cattle in one of these odd electrical displays and seeing a glowing light at the tips of the horns of each steer. When autos were new to the country, drivers were puzzled to find their engines stalled in these disturbances and nothing apparently wrong with them." (R5)

X6. January 18, 1817. Vermont. During a rapid fall of wet snow, people were enveloped by light. Much St. Elmo's Fire on fence posts, hourses, etc. (R6)

X7. January 20, 1895. Oklahoma. Flashes of light seen during dust storm. (R7)

X8. November 19, 1903. Geneva, Ohio. Purple and milky-white flashes during a snowstorm. Faint rolling thunder. (R8)

X9. General observation. Lake Maracaibo, Venezuela. Constant silent lightning seen near the bar as the southern end of the lake. Called the Faro of Maracaibo since the Spanish Conquest. (R9) See also GLN1-X1.

X10. General observations. Khartum, Sudan and Kano, Nigeria. Observations of blue sparks. Attributed to wind-driven sand. (R10)

References

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R2. "Local Electricity in a Windstorm in Wyoming," Monthly Weather Review, 22:509, 1894. (X2)

R3. Matthews, J. Brian; "An Unusual Type of Lightning," Weather, 19:291, 1964. (X3)

R4. Kamra, A.K.; "Visual Observation of Electric Sparks on Gypsum Dunes," Nature, 240:143, 1972. (X4)

R5. "Electrified Dust Storms of the West," Popular Mechanics, 49:226, February 1928. (X5)

R6. Allen, J.A.; "On Luminous Appearances in the Atmosphere," American Journal of Science, 1:4:341, 1822. (X6)

R7. "A Silent and Electrical Dust Storm in Oklahoma,: Monthly Weather Review, 23:18, 1895. (X7)
R8. "Lightning Phenomenon," Monthly Weather Review, 31:534, 1903. (X8)
R9. "Infernito," Nature, 40:429, 1889. (X9)
R10. "Blue Sparks Explained," Fortean Society Magazine, 1:7, September 1937. Credited to the New York Times of August 1, 1937. (X10)

GLD6 Unusual Manifestations of St. Elmo's Fire

Description. Unusual tongues of flame, luminous halos, and marching spheres of light, frequently accompanied by curious sound effects. Many odd occurrences of St. Elmo's Fire are experienced on mountain tops where climbers may become wreathed in luminous auras, while the surrounding rocks buzz noisily with electricity. If the atmospheric electrical fields are strong enough large areas of the surface seem to burst into flame. Usually, the luminous jets and spheres remain attached to conducting surfaces, but rarely they detach themselves and drift in the air like ball lightning.

Background. Sometimes it is difficult to differentiate between the less energetic forms of ball lightning and detached spheres of St. Elmo's Fire; if indeed there is a difference. Complicating the picture are the luminous air bubbles (GLD7) which seem to have some properties of both ball lightning and St. Elmo's Fire.

Data Evaluation. St. Elmo's Fire is a well-recognized phenomenon. Rating: 1.

Anomaly Evaluation. The manifestations of St. Elmo's Fire reported below pose at least two problems: (1) How do freely moving balls of St. Elmo's Fire maintain their existence? (2) Why do spheres of St. Elmo's Fire move along conductor surfaces rather than inside? Rating: 3.

Possible Explanation. Ordinary St. Elmo's Fire appears around sharply pointed objects when atmospheric electric field strengths are very high. It is simply the luminous flow of electricity through the air. These observations, however, do not explain detached masses of St. Elmo's Fire and its movement along conductor surfaces.

Similar and Related Phenomena. Ball lightning (GLB), luminous aerial bubbles (GLD7), earthquake lights (GLD8).

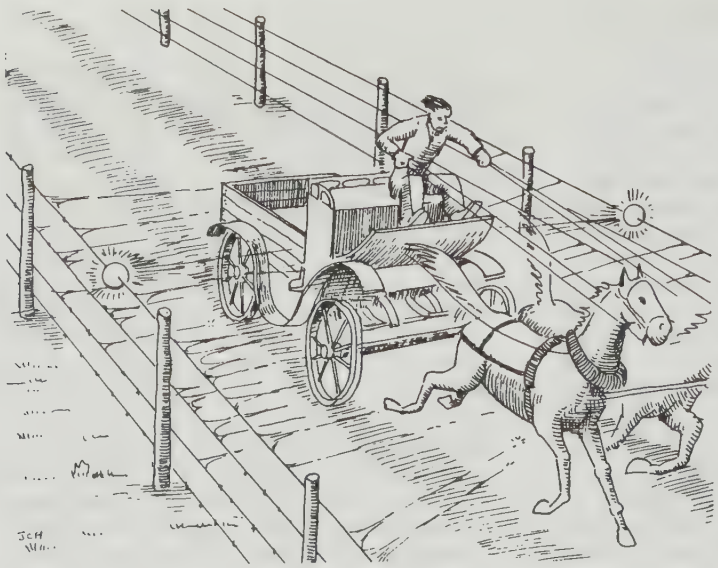
Examples of Pranks of Pranks of St. Elmo's Fire

X1. June 7, 1882. Pike's Peak, Colorado. St. Elmo's Fire everywhere. "In placing my hands close over the revolving cups of the anemometer---where the electrical excitment was abundant---not the slightest sensation of heat was discovered, but my hands instantly became aflame. On raising them and spreading my fingers, each of them became tipped with one or more beautiful cones of light, nearly three inches in length. The flames issued from my fingers with a rushing noise, similar to that produced by blowing briskly against the end of the finger when placed lightly against the lips, accompanied by a crackling sound. There was a feeling as of a current of vapor escaping, with a slight tingling sensation. The wristband of my woolen shirt, as soon as it became dampened, formed a fiery ring around my arm, while my moustache was lighted up so as to make a veritable lantern of my face. The phenomenon was preceded by lightning and thunder, and was accompanied by a dense driving snow, and disappeared suddenly at 8:55 o'clock, simultaneously with the cessation of the snow." (R1, R2)

A display of St. Elmo's Fire on top of Pike's Peak, Colorado, in 1882. (X1) For the flares observed on this peak, see GLD1-X22..

X2. No date or place given. "In the Zeitschrift fur Elektrotechnik a description is given of the following unique display of atmospheric electricity which was observed by a farmer while driving along a narrow private road having a wire fence on each side. When his vehicle had gone about 400 feet from the commencement of the wire fences his attention was attracted by a bright light behind him. On looking round he saw fire balls about the size of a man's hand travelling towards him along the wire on both sides. In a moment they were abreast of the carriage, and then travelled along with it pari passu, while brush discharges and audible crackling, as from a large electrical machine, were observed to proceed from the fire balls towards, apparently, the iron parts of the carriage. Vibrations of the wires could be distinctly heard, and a torrent of sparks sprang over from the fences to the carriage and horses. The frightened horses now ran away, but they could not shake off their fiery escort till the fences were interrupted by gaps on each side. No detonation or noise, other than the crackling already mentioned, was heard. The whole phenomenon lasted about 12 seconds." (R3)

X3. No date given. Worcester, Massachusetts. "While walking upon the Worcester and Norwich Railroad track about a mile south of Worcester Junction, I suddenly saw a ball of fire, or what looked like it, about the size of a large marble, running along on top of one of the rails just ahead of me. It was going at so slow a rate that I could have overtaken it in a few seconds, and my first impulse was to do so; but the sober second-thought warned me against making the attempt. I, however, watched it move until it came to the end of a rail separated from the adjacent one by something like half an inch, when it stopped, and in a second or two vanished, when there was a clap of thunder in a cloud overhead which I had not before noticed as being a thunder-cloud. The brightness of this small ball was not excessive, nothing to be compared with an electric arc. It was more like that of a red-hot bullet. It did not scintillate or make any noise, that I noticed. Now, while this was an accompaniment of a thunder-cloud, as are such manifestations generally, I think



Balls of St. Elmo's Fire follow a carriage traveling between two wire fences. (X2)

there is some reason for not calling the phenomenon itself an electrical one in the same sense as lightning is electrical. If electricity can gather itself up into a spherical form as if it was subject to some sort of cohesion, and if it can roll along on top of a good conductor instead of traversing the body of the conductor subject to Ohm's law, then there are some exceptions to this latter law." (R4)

X4. March 7, 1932. Hilversum, Holland. On a broadcasting antenna consisting of five horizontal wires. "Again, on March 7, at 17.00, when the antenna power was raised from 7 kw. to 20 kw., the corona on the antenna reappeared. It consisted of slowly moving luminous spheres of about 10 cm. diameter. They first appeared at one end of an outer wire, they slowly moved following the wires towards the down leads and disappeared at a distance of about 15 m. from their origin. Several of these luminous spheres were observed to occur simultaneously with a mutual distance of 0.5 m., so that the phenomenon made the impression of a string of beads, moving towards the centre with a speed of the order of 1 m./sec." (R5)

X5. January 1924. No place given. Seen on a barn roof on a clear, starry night. "There were six incandescent globes or disks or hemispheres, it is impossible to state exactly which, upon the ridge of the barn, seemingly about three feet in diameter and spaced exactly even with a distance of six inches between their edges---for a distance of four rods around the barn everything was clearly illuminated. Edward then called our rapt attention to the disk on the north end of the barn with the exclamation: 'It's falling!' Sure enough it did fall, leaving the ridge with a sort of jump and landing, without loss of brilliance, half way down the roof, then bouncing from there over the eave and disappearing before reaching the ground. Immediately upon extinction of the first light the second disk started to fall, and then the rest, one after another, in exactly the same way at regular intervals. Abruptly as the last one disappeared the light around the barn vanished and all again was dark." (R6)

X6. No date given. Giza, Egypt. "Towards eight o'clock in the evening, I noticed a light which appeared to turn slowly around the third pyramid almost up to the apex; it was like a small flame. The light made three circuits around the pyramid and then disappeared. For a good part of the night I attentively watched the pyramid; towards eleven o'clock I again noticed the same light, but this time it was of a bluish colour;

it mounted slowly almost in a straight line and arrived at a certain height above the pyramid's summit and then disappeared." (R7)

X7. No date given. Virginia City, Nevada. "The city was interested, last evening, says my report, by the appearance on C-street of a strange phenomenon. At first it had the appearance of sparks of fire coming up through the pools of water beside the street. These sparks seemed to explode on reaching the surface, in many instances producing reports loud enough to be heard across the street, and being accompanied by a little cloud of smoke, and emitting a decidedly sulphurous smell. It was noticed that the phenomena occurred only on one side, under the telegraph wires. The sparks seemed to be caused by drops of water falling from the wires of the telegraph, which exploded when striking the pools of water. This solution was seeminly confirmed by the fact that when the wires became dry the phenomena ceased. It still remains to be explained, however, why, under the circumstances, such results should follow the falling of the water drops from the wires. (R8)

X8. August 18, 1876. France. "M. Trecul, in a note to the Comptes Rendus, states that on the 18th August 1876, while writing at an open window between 7 and 8 a.m., he observed simultaneously with some loud thunder, small luminous columns descend obliquely on his paper, about two metres long, and half a decimeter broad at the widest part; obtuse at the further end, but gradually thinning towards the table. They had mostly a reddish yellow tint, but near the paper the tints were more intense and varied. In disappearing they left the paper with a slight noise like that produced by pouring a little water on a hot plate." (R9-R12)

X9. January 12, 1748. No place given.

"The 12th January, 1748, easterly wind and great cold. I stretched out a large cat on the coverlet of my bed, and on rubbing it I obtained in the darkness sparks of fire, the sound of which much resembled that of a comb when the hand is passed over the teeth. A thousand little points of fire danced about here and there, and, by continuing the friction, the sparks augmented to such an extent that they appeared like spheres or balls of fire, of the size of a hazel nut. I observed these little globes detach themselves from the body of the cat, fall upon the coverlet, rebound like footballs...A thousand balls of fire were moving over the cat and on the coverlet. I approached my eyes to a ball which appeared more luminous than the others. Immediately I heard a kind of explosion or crackling, and felt a pricking sensation in the eyes. There was no shock in any other portion of the body; but the pain was followed by a weakness which caused me to fall on my side. It was some minutes before I recovered." (R13)

X10. February 18, 1877. North Atlantic Ocean. A violent storm was in progress.

"...during the height of the storm there appeared on the trucks, yards, and stays large balls of fire of a phosphorescent nature, strung at intervals of one or two feet and giving the ship the appearance of being decorated with Chinese lanterns, only the lights were far more brilliant. They settled on the vessel like a shower of meteors, and disappeared almost as suddenly as they appeared---an occasional one dropping from the yards and bursting with a loud report. One of them fell and burst almost in the face of the chief officer, but beyond dazzling him for a moment, it caused him no inconvenience." (R14)

It is very unusual for balls of St. Elmo's fire to explode violently, but it occured again in the next example.

X11. December 3, 1894. North Atlantic Ocean. The British ship Mercedes experienced a remarkable electrical storm.

"On the Grand Banks of Newfoundland during the nights of December 3 and 4, the ocean appeared like a mighty mass of flames or an endless stretch of prairie fires. Balls of electric fire hissed and exploded in all directions and darted among the vessel's masts and rigging. ...Soon afterward the storm partially subsided, when the electrical fire ap-

peared in all directions. It hung in big balls for two nights from the masts and fore and aft stays, and practically turned night into day. As the big fire balls came together, they would burst with a loud report upon the vessel and disappear. Under this light at night such temporary repairs were made as were deemed necessary to reach port. (R15)

X12. April 17, 1994. Strait of Malacca. Aboard the m.v. Newport Bay, enroute Singapore to Suez. There is nothing anomalous in the following account, but it is engaging and very similar to the discharge phenomena experienced by hikers in high mountains during electrical storms.

"At about 1640 UTC, the ship was experiencing almost continuous lightning, the flashes often being only 0.5 second apart. At 1840 a bright blue/purple glow was seen on the forward corner of the bridge wing taffrail. On closer inspection it was discovered to be electrostatic discharge into the surrounding air. When the lookout raised his hand into the undisturbed atmosphere beyond the taffrail the discharge increased and was clearly visible extending 3-4 cm from the tip of each finger in a similar blue/purple, almost flame-like pattern; at the same time a crackling or buzzing sound was very clearly audible. This phenomenon continued for almost an hour, much to the amusement of the observers." (R16)

X13. August 20, 1996. North Atlantic Ocean. Aboard the m.v. Eastern Bridge enroute Port Talbot to Mobile. Luminous and acoustic phenomena similar to those described in X12. An interesting and curious feature was that, when one waved one's hand, luminous flames emanated from all five fingers whereas only two of three fingers were luminous when one's hand was kept still. (R17)

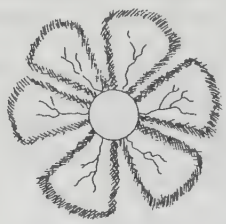
X14. February 8, 1999. North Sea. Aboard the m.v. Repulse Bay, enroute Rotterdam to Hamburg. In this marine anecdote, the St. Elmo's fire was "contagious!"

"Whilst the vessel was in the German Bight, in position 53°57' N. 07°08' E, a classic example of St. Elmo's fire was observed at 0230 UTC. A high-pitched buzzing sound was heard on the corner of the bridge wing, and what seemed to be a glow was also present. Observers were able to pick up the static and saw short flame-like 'tufts' of blue and violet appear on the ends of their fingertips, as if the fingers had ignited. The 'flames' were able to be passed from person to person, and were even placed upon another observer's forehead!

"There were no electrical storms in the area but there was a mixture of hail and snow falling at the time. Two of the observers experienced strong electrical shocks from each other, and also electric shocks each time snow landed on their skin---a very peculiar experience!" (R18)

X15. May 8, 1998. North Atlantic Ocean. Aboard the m.v. Flinders out of Philadelphia bound for Pennington. The vessel had just passed through a weather front that produced frequent, violent sheet lightning. Green St. Elmo's fire was glowing on the aerials.

"At about 2310 it was also noted that the lever extending about 18 cm over the ship's starboard bridge wing to position a deck light was also radiating light. This light was a pale violet glow extending in 'spokes' of 10 cm in length from the round end of the lever which was about 3 cm in diameter. There were six individual and



uniform spokes shot through with brighter purple and white bolts resembling lightning. Over the noise of the wind a sharp crackling and hissing sound could be heard coming from the phenomenon.

"The seaman was called to have a look at the light, he attempted to touch it but the light receded as his finger approached within 3 cm of it. The effect died away at

about 2340 as soon as rain started to fall." (R19)

Curiously, the corposant's six-fold symmetry resembles that of snowflakes. Strange as it may sound, there may be a logical connection between the seemingly unrelated phenomena. We see this in some reflections J. Maddox, a past Editor of Nature, once penned about the "snowflake problem."

"But the symmetry of the whole crystal, represented by the exquisite six-fold symmetry of the standard snowflake, must be the consequence of some cooperative phenomenon involving the growing crystal as a whole. What can that be? What can tell one growing face of a crystal (in three dimensions this time) what the shape of the opposite face is like?"

The speculation here is that electrical forces may control the long-range symmetry of snowflakes as well as the unusual six-fold symmetry of the corposant described above. It's just an idea!

X16. General observations. Insects. In an unlikely experiment, physicist P. Callahan placed insects in an electric field. Surprisingly, the spines on their antennae lit up in what seems to be a form of St. Elmo's fire. Callahan speculated that clouds of migrating insects might collectively produce strange luminous phenomena when flying in electrical storms! This is not as crazy as it seems. Insect swarms can be very dense and may stretch for miles. (R20)

X17. Occasional occurrence. Zeitoun (Cairo), Egypt. The well-publicized Zeitoun phenomenon is assumed here to be a type of St. Elmo's fire. This sort of luminous electrical discharge is not uncommon on church steeples during electrical storms. Near Zeitoun, the Giza pyramids sometimes display St. Elmo's fire. (X6) However, it must be added that many observers believe that the Zeitoun luminosities have a mystical source.

Eschewing the mystical claims, J.S. Derr and M.A. Persinger present data below that suggest that the Zeitoun LPs (Luminous Phenomena) may be related to seismic rather than atmospheric conditions. Of course, seismic and atmospheric conditions may themselves be causally connected, thereby raising the possibility that seismic, atmospheric. and the Zeitoun luminous phenomena are all interrelated.

"Between April, 1968 and May, 1971, hundreds of thousands of people reported complex luminous events over a church in Cairo (Zeitoun), Egypt. Many of these events were photographed. Most of the luminous phenomena (LP) occurred during 1969 when seismic activity within the radius of less than 500 km was approximately a factor of 10 greater than for any single year before or afterwards. Whereas the distribution of epicenters around Zeitoun was randomly distributed for the years 1966 through 1968 and 1970 through 1972, there was a significant focus of their frequency during the year 1970. Most of them occurred off the coast of Gemsa, approximately 375 km to the southeast of Cairo." (R21)

Analysis of the LP and seismic records demonstrated a significant increase in the number of LP during the month of, or the month before, increases in the number of earthquakes per month. The relationship between LP and quakes was not, however, as strong as it had been for episodes of luminous phenomena in Toppenish, Washington; the Uintah Basin, Utah; Carman, Manitoba; and the New Madrid region in the central US. Still, the Zeitoun phenomena must be considered as supportive of the hypothesis that many LPs are associated with tectonic strain in the earth's crust. (R21)

The physical nature of the Zeitoun luminous phenomena were set out in more detail in another joint paper by Derr and Persinger.

"Between April 1968 and May 1971 hundreds of thousands of people reported seeing apparitions of the Virgin Mary over a Coptic Orthodox Church in Zeitoun, near Cairo, Egypt. When photographed, these phenomena appeared as irregular blobs of light. Primarily there were two types of events: small short-lived, highly kinetic lights ('doves') and more persistent coronal-type displays that were situated primarily over the apical structures of the church. More detailed descriptions of the phenomena, such as visions often occurred as

'flashes'; their details usually reflected the religious background of the experient." (R22)

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GLD7 Luminous Aerial Bubbles

Description. Large assemblages of colored spheres or bubbles drifting randomly, quietly, almost playfully. Observers often compare them to toy balloons and soap bubbles. Their changing colors and irridescence strengthen the soap-bubble analogy. These softly glowing spheres do not detonate destructively like ball lightning but disappear silently like real soap bubbles. Hundreds of bubbles may fill the air during this phenomenon.

Background. Two possibly distinct phenomena are lumped together here: (1) Low-level objects that superficially resemble soap bubbles; and (2) Swarms of higher-altitude objects that appear primarily as moving points of light but seem to drift with the wind in a buoyant manner. Example X1 below mentions a gelatinous residue from one group of low-level bubbles; this characteristic brings to mind the even-more-bizarre gelatinous meteors or pwdre ser (GFG). Also, some cold flames seen issuing from the ground (GLN1) may leave a residue. The luminous aerial bubbles may in fact become nocturnal lights once the sun sets.

Data Evaluation. This bizarre phenomenon is difficult-to-believe, but it is confirmed by many reports. Rating: 2.

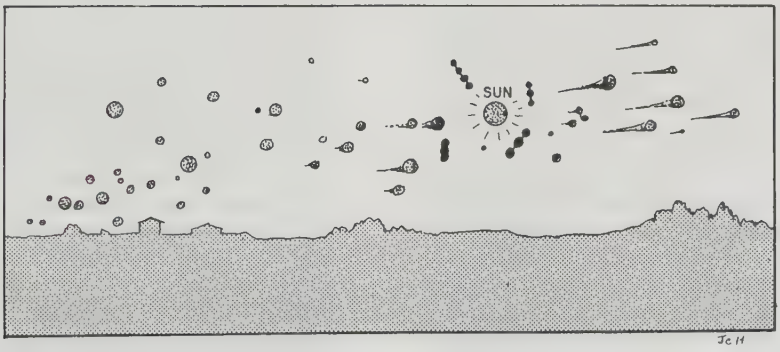
Anomaly Evaluation. Although very puzzling, aerial bubbles are probably explainable without gross modifications of chemistry and physics; but we know so little about the phenomenon that this is only a surmise. Rating: 2.

Possible Explanations. (1) An electrical origin similar to that of ball lightning; (2) A chemical origin similar to that proposed for some will o' the wisps; (3) An optical origin, say, the reflection of light off windborne specks of material, as in the case of telescopic meteors; (4) They may be real bubbles from some natural source.

Similar and Related Phenomena. Ball lightning (GLB); will o' the wisps (GLN); St. Elmo's Fire (GLD); telescopic meteors (ATO); pwdre ser (GFG), kaleidoscopic suns (GEL).

Examples of Luminous Aerial Bubbles

X1. May 16, 1808. Biskopsberga, Sweden. "On the 16th of last May, being a very warm day, and during a gale of wind from south-west, and a cloudless sky, at about 4 o'clock, P.M. the sun became dim, and lost his brightness to that degree, that he could be looked at without inconvenience to the naked eye, being of a dark-red, or almost brick colour, without brilliancy. At the same time there appeared at the western horizon,

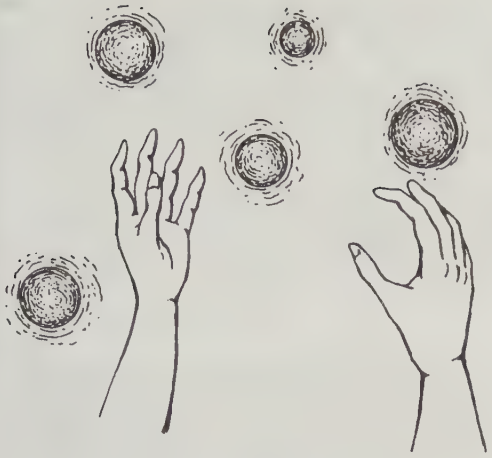


Curious spherical bodies drift over Biskopsberga, Sweden, in 1808. (X1)

from where the wind blew, to arise gradually, and in quick succession, a great number of balls, or spherical bodies, to the naked eye of a size of the crown of a hat, and of a dark brown colour. The nearer these bodies, which occupied a considerable though irregular breadth of the visible heaven, approached towards the sun, the darker they appeared, and in the vicinity of the sun became entirely black. At this elevation their course seemed to lessen, and a great many of them remained, as it were, stationary; but they soon resumed their former, and an accelerated motion, and passed in the same direction with great velocity and almost horizontally. During this course some disappeared, others fell down, but the most part of them continued their progress almost in a straight line, till they were lost sight of at the eastern horizon. The phenomenon lasted uninterruptedly, upwards of two hours, during which time millions of similar bodies continually rose in the west, one after the other irregularly, and continued their career exactly in the same manner. No report, noise, nor any whistling or buzzing in the air was perceived. As these balls slackened their course on passing by the sun, several were linked together, three, six, or eight of them in a line, joined like chain shot by a thin and straight bar; but on continuing again a more rapid course, they separated, and each having a tail after it. apparently of three or four fathoms length, wider at its base where it adhered to the ball, and gradually decreasing, till it terminated in a fine point. During the course, these tails which had the same black colour as the balls, disappeared by degrees. It fortunately happened, that some of these balls fell at a short distance, or but a few feet from Mr. Secretary K.G. Wettermark, who had then for a long while been attentively looking at the phenomenon, in the aforesaid village. On the descent of these bodies, the black colour seemed gradually to disappear the nearer they approached the earth, and they vanished almost entirely till within a few fathoms distance from the ground, when they again were visible with several changing colours, and in this particular exactly resembling those air-bubbles, which children use to produce from soadsuds by means of a reed. When the spot, where such a ball had fallen, was immediately after examined, nothing was to be seen, but a scarcely perceptible film or pellicle as thin and fine as a cobweb, which was still changing colours, but soon entirely dried up and vanished." (R1)

X2, January 1871. Remenham, England. A cold, gray day, with low, rusty-colored clouds. "The wall paper and furniture of the room in which the lady was sitting were suddenly flushed with rose colour, which gradually deepened into crimson, passing through bright gold into orange, lilac and deep violet. It was then seen that from the centre of the level space of snow within view, a group of air bubbles, of the shape and apparent size of the coloured India rubber balls sold in the streets, rose to a considerable height and then began to move up and down within a limited area, and at an equal distance from each other, some descending others descending. The appearance lasted about two minutes, at the expiration of which the balls were carried away by a current of wind to the eastward and disappeared. Another group of balls arose subsequently from the same spot, and the phenomena were precisely reproduced. It was remarked that the balls assumed in succession the tints which had been observed on the walls of the room." (R2, R3)

X3. August 17, 1876. Ringstead Bay, England. "Between 4 and 5 p.m. two ladies who were out on the cliff, saw surrounding them on all sides, and extending from a few inches above the surface to two or three feet overhead, numerous globes of light, the size of billiard balls, which were moving independently and vertically up and down, sometimes within a few inches of the observers, but always eluding the grasp; now gliding upwards two or three feet, and as slowly falling again, resembling in their movements soap bubbles floating in the air. The balls were all aglow, but not dazzling, with a soft, superb irridescence, rich and warm of hue, and each of variable tints, their charming colours brightening the extreme beauty of the scene. The subdued magnificence of this fascinating spectacle is described as baffling description. Their numbers were continually fluctuating; at times thousands of them enveloped the ob-



Numerous luminous spheres evade grasp at Ringstead Bay in 1876. (X3) For similar drifting spheres, see GLN1.

servers, and a few minutes afterwards the numbers would dwindle to perhaps as few as twenty, but soon they would be swarming again as numerous as ever. Not the slightest noise accompanied the display." (R2, R4-R6)

X4. March 22, 1880. Trakehnen, Germany. "A remarkable phenomenon was observed at Kattenau, near Trakehnen (Germany), and in the surrounding district, on March 22. About half an hour before sunrise an enormous number of luminous bodies rose from the horizon and passed in a horizontal direction from east to west. Some of them seemed of the size of a walnut, others resembled the sparks flying from a chimney. They moved through space like a string of beads, and shone with a remarkably brilliant light. The belt containing them appeared about 3 metres in length and 2/3 metre in breadth." (R7)

X5. Circa 1882. Glenora, New York. "I was walking home just at dusk during an evening of thunderstormy weather. The air was sultry and there were flashes of heat lightning on the horizon. When I came to what we called in New England the village green, I saw a remarkable exhibition of what I assumed to be static electricity. There were twelve or more round balls of luminescence bouncing around in the most undisciplined manner in all directions. They would apparently strike the ground, then bounce up into the air in the lightest and most buoyant fashion. They looked to be about the size of a football." (R8)

X6. April 1886. Cherry Valley, New York. Towards sunset on a warm, thawing day. "...as they rode down the long hill towards this village from the east, (they) saw what appeared to be innumerable spherical bodies floating in the air like soap bubbles. Both men saw and wondered at the appearance for some moments before either spoke. Capt. H. then said, 'I wonder whether I am dreaming?' The other rubbed his eyes and echoes the sentiment. 'Well,' said the captain, 'I wonder if you see what I see; what do you see?' They questioned each other, and both agreed as to their impressions. An orchard lay along the lower and northwesterly side of the road, and all in among the apple trees were thick, gently descending multitudes of these bubbles, pretty uniform in size, say, 8 or 9 inches in diameter, apparently; none less than six; no small ones being observed. The observers state that they carefully fixed their attention on particular bubbles, in order to compare notes, and saw them seem to rest on the bough of a tree, or the top board of the fence, and then gently roll off and disappear or go out of sight. The sun was sinking and dropped below the opposite hills as they reached the foot of the long descent and entered the village, and the appearance came to an end. But up to this time the air seemed to be filled with these transparent floating spheres. The position of the observers with regard to the light seems to have made some difference as to seeing well this or that large aggregation or swarm that one or the other pointed out. The bubbles were highly colored, irridescent, gave the same sort of reflections as soap bubbles, and apparently vanished individually in much the same way." (R9)

X7. June 1898. Kailana, Himalayas. Air hot and misty after the passage of a thunderstorm. "In the dense mist a succession of pale, round lights were seen floating in the direction of the storm; each was wat-

ched till it was out of sight. The balls appeared about 6 ins. in diameter, but the edges were not well-defined. The colour was similar to that of a firefly, but the behavior of the lights proved that they were not fireflies; moreover, no fireflies were found in the locality!" (R10)

X8. December 18, 1922. Salisbury, England. "There was in this locality on December 18th. between 6 and 8 p.m., an extraordinary display of the so-called ball lightning. The phenomenon took the form of balls of bluish, misty flame, which either hovered stationary or darted about the heavens in a curiously irregular manner. Vivid lightning of the ordinary kind accompanied the display, which must have lasted at least two hours." (R11)

X9. May 15, 1836. Havana, Cuba. During the solar eclipse, many luminous globules detached themselves from the sun and moved in various directions. (R12)

X10. May 21, 1877. Venice, Italy. Balls of fire rise from a dark cloud and burst. The balls looked and moved like soap bubbles. (R13)

X11. November 15, 1899. Wiltshire, England. The air seemed to be full of small luminous bodies. (R14)

X12. May 10, 1902. Devonport, England. At sunset the sky seemed to be filled with violet, yellow, and green "suns" that looked like toy balloons. (R15)

X13. September 21, 1910. New York, New York. A great number of round objects passed west to east over the lower part of the city. They were ~~though~~ to be little balloons. (R16)

X14. September 1943. South Atlantic Ocean. Enroute South Africa to Brazil. Observer: C.L. Reifenhler.

"During the voyage, a multicolored object about the size of a basketball appeared and the ship changed course to parallel the course of the object. The object was in view for about 20 minutes, moved slowly across the water at a height of 5 feet, and finally disappeared. It looked like a glass ball and appeared to have a membrane enclosing it. Its motion was from the NW to SE and it was seen sometime between 3:00 and 5:00 in the afternoon sometime in September 1943. The color was at times orange and yellow, sometimes green, blue, and red. The sky was overcast and the object was on the starboard side of the ship as it moved towards the NW. The ship's crew, consisting of about 20 men, saw the event and concluded that it might be a 'fireball.'" (R17)

X15. August 4, 1984. Winchester, England. H. Curtis gives us a first-hand account of another one of those strange bubble-like phenomena that are sometimes, but not always, associated with atmospheric electrical disturbances.

"In August 1984 I had just left work at 5.30 p.m. and was walking along an unfrequented side street as a short cut to get to my bus. The weather was cloudy and sultry, but there had been no reports of thunder in the area that day. I came to a junction in the pavement which led only to car-parking for buildings lying farther back when a bubble about the size of a tennis ball sailed out of this side-way, in a straight line, about the level with my shoulders, at a distance of some five or six feet. I stared at it in amazement, for where could a bubble have come from at such a place and time?

"I was further amazed that it did not disintegrate...While gazing at the bubble it seemed to me that there was a dark band round it, which I interpreted as being a reflection of the tarmac road, although subsequently when experimenting with childrens' bubble mixture I discovered that bubbles never reflect anything so discernible.

"The bubble proceeded at its original speed, curving around me, and drifting down the centre of the road in the direction from which I had come. It then curved further round and descended towards a grass verge (which I had just passed). Here, I expected it to burst, but when it was about to land it ascended again and proceeded upwards, drifting, as it were, with various air currents, up over a six-foot wall on the other side of the road to the height, approximately, of the buildings. It then drifted out of sight into what is a public

park. I could not believe how it could remain intact for so long." (R18)

The percipient was interviewed, and further facts suggested that this may have been a form of ball lightning.

X16. Annual occurrence. Mekong River, Thailand. The following observation and question was presented in a 1997 issue of the New Scientist.

"My wife and I saw a puzzling sight in October 1994, in the Mekong River near Nongkhai, Thailand, during a full moon, in the evening. Lights appeared under the water for a few hundred metres along the Mekong River. They rose from the bottom of the river and floated to the surface, then shot like missiles into the sky and out of sight. They were the size of beach balls, and many flew out of the water every few minutes, surfacing about 10 metres apart. I am told that this happens every year at the same time. Locals say it is caused by a serpent releasing her eggs. Does anyone know of this phenomenon?" (R19)

A. Pentecost responded, first noting the similarity of the Mekong phenomenon to the will-o'-the-wisp or ignis fatuus. (GLN1) The usual explanation of ignis fatuus blames the spontaneous combustion of marsh gas. However, the Mekong lights are initially seen under the water where there would not be enough oxygen to support combustion. Pentecost suggested instead phosphorescent bacteria or the "cold flame" of phosphorus vapor which might form through diphosphane decomposition.

These basketball-sized lights erupting from the Mekong River, Thailand, turn out to be a well-known annual event. Their official name is: the "Nekha Lights." They have even been filmed and shown on Thai TV. These weird luminous displays occur during the October full moon and last only about 30 minutes. The lights rise out of the river and nearby rice paddies, but only along a small stretch of the river that straddles the Thailand-Laos border. (R20)

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R16. New York Tribune, September 22, 1910. (X13)
R17. Seal, James; personal communication, June 25, 1986. (X14)
R18. Curtis, Mira; "Long-Lived Bubble in the Atmosphere," Journal of Meteorology, U.K., 20:214, 1995. (X15)
R19. Pentecost, Allan; "Mekong Mystery," New Scientist, p. 96, September 6, 1997. (X16)
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GLD8 Earthquake Lights

Description. Flashes of light in the sky, ordinary and ball lightning, aurora-like streamers and rays, flames issuing from the ground, sky glows, and St. Elmo's Fire observed in the general vicinity of an earthquake. Earthquake lights may appear before, during, and after the quake.

Background. Earthquake lights, like ball lightning, have been recorded since ancient times. Until recently, they have not been recognized as legitimate phenomena by most scientists. Some skepticism remains even today. One reason for this is the great variety of earthquake lights, many of which can be explained in terms of ordinary lightning in accompanying storms, the arcing of damaged power lines, and the ignition of ruptured gas lines. Furthermore, earthquake light observations may be contaminated by the psychological impact of strong earthquake shocks.

Data Evaluation. Scores of old and recent observations, including photographs, vouch for the reality of earthquake lights. Rating: 1.

Anomaly Evaluation. If all earthquake lights could be explained in terms of coincident thunderstorms, power- and gas-line phenomena, and even the spontaneous ignition of releases of natural gas, we would have no anomaly to explain. However, the fireballs, sky flashes, and aurora-like beams common to many earthquakes suggest that some other agent, probably electrical in nature, is at work here. Rating: 2.

Possible Explanations. The variety of earthquake lights may infer the existence of strong electrical fields, due perhaps to the piezoelectric effect as rocks are stressed by earthquake forces. The measured properties of rocks and the stresses exerted do not, however, seem to be adequate to explain the observations. Furthermore, earthquake lights have been seen at sea; a fact that weakens the piezoelectric theory while supporting the natural-gas-eruption theory. Another possibility is that the gases and dust injected into the atmosphere during a quake may alter the air's electrical properties, stimulating luminous phenomena and perhaps the hazes and thunderstorms that are reported so frequently. Earthquake lights may owe their existence to all of the mechanisms mentioned above.

Similar and Related Phenomena. Tornado lights (GLD10), volcano lights (GLD9), rock luminosities (GLD13), low-level auroras (GLA4), sky flashes (GLA14), transient lunar phenomena (ALO), nocturnal lights (GLN1).

Examples of Earthquake Lights

X1. Late 1811 through 1813. New Madrid, Missouri, and environs. "Dillard, in speaking of the shocks (not especially the first one), says: 'There issued no burning flames, but flashes such as would result from an explosion of gas, or from passing of electricity from cloud to cloud.' Lewis F. Linn, United States Senator, in a letter to the chairman of the Committee on Commerce, says the shock was accompanied 'ever and anon by flashes of electricity, rendering the darkness doubly terrible.' Another evidently somewhat excited observer near New Madrid thought he saw 'many sparks of fire emitted from the earth.' At St. Louis gleams and flashes of light were frequently visible around the horizon in different directions, generally ascending from the earth. In Livingston County, according to Mr. Riddick, the atmosphere previous to the shock of February 8 was remarkably luminous, objects being visible for considerable distances, although there was no moon. 'On this occasion the brightness was general, and did not proceed from any point or spot in the heavens. It was broad and expanded, reaching from the zenith on every side toward the horizon. It exhibited no flashes nor coruscations, but, as long as it lasted, was a diffused illumination of the atmosphere on all sides.' At Bardstown there are reported to have been 'frequent lights during the commotions.' At Knoxville, Tenn., at the end of the first shock, 'two flashes of light, at intervals of about a minute, very much like distant lightning,'

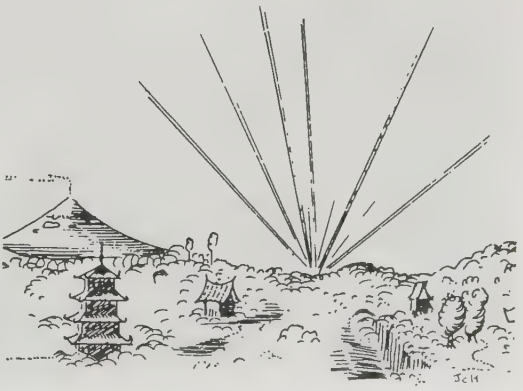
were observed. Farther east, in North Carolina, there were reported 'three extraordinary fires in the air; one appeared in an easterly direction, one in the north, and one in the south. Their continuance was several hours; their size as large as a house on fire; the motion of the blaze was quite visible, but no sparks appeared.' At Savannah, Ga., the first shock is said to have been preceded by a flash of light." (R1-R3)

X2. June 16, 1819. Cutch, India. "At the moment of the shock, vast clouds of dust were seen to ascend from the summit of almost every hill and range of hills. Many gentlemen perceived smoke to ascend, and in some instances fire was plainly seen bursting forth for a moment. A respectable native chieftain assured me, that from a hill close to the one on which his fortress is situated fire was seen to issue in considerable quantities; and that a ball of large size was vomited as it were into the air, and fell to the ground still blazing on the plain below, where it divided into four or five pieces,and the fire suddenly disappeared. On examining the hill next day (the chieftain stated), it was found rent and shattered, as if something within had sunk; and the spot where the fire-ball was supposed to have fallen, bore marks of fire in the scorched vegetation." (R4)

X3. Circa 1872. Cerrogardo, California. "Immediately following the great shock, men whose judgment and veracity are beyond question, while sitting on the ground near the Eclipse Mines, saw sheets of flames on the rocky sides of the Inyo Mountains, but half a mile distant. These flames, observed in several places, waved to and fro, apparently clear of the ground, like vast torches. They continued for only a few minutes." (R5)

X4. April 18, 1906. San Francisco, California. Many reports of luminous phenomena from the region. "The display of blue flames before the onslaught of the red ones, and their final yellow sequences was very remarkable. 'The appearance of the blue lights,' says Professor Larkin, 'was over a wider area than first thought. At Petaluma ...blue flames eighteen inches in height played over a wide expanse of marsh land.' Before the earthquake only 'a flickering ominous haze was seen playing above the ground.' 'A dark funnel-shaped mass was seen in Fourth Street, San Francisco, suspended in the air, and it was illuminated by scintillating lights, like fire-flies.' 'Blue flames were seen hovering over the bases of foothills in western San Francisco.' In San Jose, on the street called the Alameda, looking eastward, at the time of the shock the whole street was seen 'ablaze with fire, it being of a beautiful rainbow colour but faint. This, no doubt,' observes Professor Larkin, 'was an electrical display, for had gas been on fire all along the street the houses would have been ignited. And letters from a point north of San Francisco describe blue lights as flickering like an aurora over a wide area of marsh land with a troubled surface of adjoining water." (R6)

X5. August 16, 1906. Chile. A great earthquake with hundreds of observations of various types of luminous phenomena. Diffuse illuminations, will o' the wisps, lightning, and meteors. (R8) The Andes mountain-top glow burst forth greatly enhanced. (R9) The sky all over central Chile flashed with a quivering light. (R11) Ships at sea observed waves of light moving on the hills. (R13) (R7-R13)

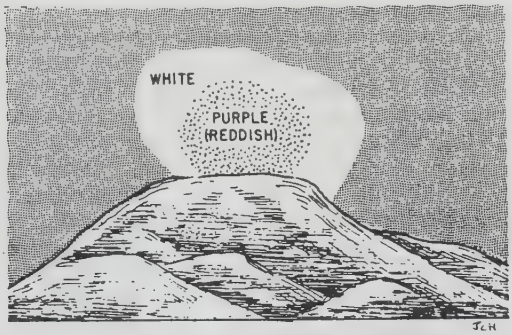


Sketch of light rays observed on the skyline during a Japanese earthquake in 1930. (X6)

X6. November 26, 1930. Idu, Japan. Reports from some 1500 observers were collected. "The lights were very strong---in one place brighter than moonlight. They were usually described as bluish in colour, but sometimes as reddish yellow, or reddish blue. In shape, they resembled the rays of the rising sun, search-lights, and fireballs. The duration of each light was longer than that of lightning, and some careful observers report that the same light continued more than a minute. The directions in which they were seen pointed usually, but not always, to the epicentral region of the earthquake." (R14-R21, R25)

X7. November 2, 1931. South Hyuga, Japan. 355 observations of luminous phenomena. "The directions in which the lights appeared are varied, but most observers on the coast saw them towards the district in which the submarine epicentre lies. The luminescence usually seemed to radiate from the horizon or to be like a search-light turned to the sky, in colour most often blue or bluish. The phenomena were clearly not due to houses on fire, or to lightning or landslides, though some may be assigned to electric sparking or to meteors." (R17, R19, R22)

X8. 1965-1967. Japan. The Matsushiro Earthquake swarm. Many luminous displays recorded around mountain peaks. The accompanying sketch shows a typical luminosity that appeared at the top of Mt. Noroshi on April 20, 1966, for 10 seconds. (R23)



A luminous display that appeared atop Mt. Noroshi, Japan, during the 1966 earthquake swarm. (X8) This luminous phenomenon could also be classified with the mountain-top glows (GLD1)

X9. General observation. From a study of 156 earthquakes, the following numbers were found to be accompanied by: auroras (23); meteors (73); will o' the wisps (2); light flashes exclusive of thunderstorms (15); and flames issuing from fissures (10). (R24)

X10. 1257. Kamakura, Japan. Bluish flames emerged from fissures. (R25)
X11. February 5, 1663. Along the St. Lawrence River, Canada. Many varieties of luminous phenomena preceded the earthquake. (R26)
X12. 1672. Tokyo, Japan. Flying luminous objects seen. (R25)
X13. 1698. Tosa, Japan. Wheel-like luminous phenomena in sky. (R25)
X14. November 4, 1704. Zurich, Switzerland. Preceded by a brilliant meteor. (R27)
X15. December 31, 1730. Tokaido, Japan. Luminous bodies in sky and luminous air. (R25)
X16. October 21, 1731. England. Quake followed by vivid lightning display. (R27)
X17. April 2, 1750. England. Multitude of blood-red rays converged from all parts of the sky. (R28)
X18. November 18, 1795. England. Ball of fire passed over Derby when shock was felt. Sky flashes. Some people experienced electric shocks. (R28)
X19. December 29, 1820. Island of Zante, Greece. Fire on the surface of the sea observed 3-4 minutes before the shock. (R29)
X20. March 22, 1821. Fiume de Canera, France. Column of fire passed over the village at time of quake. (R30)
X21. December 13, 1823. Bellay, France. The sky seemed to be on fire. (R30)
X22. August 1830. Kyoto, Japan. On the night preceeding the earthquake the sky was very bright and the illumination emitted from the ground made it bright as day. (R25)
X23. November 17, 1831. Sweden. Extraordinary light on the northern horizon during shock. (R31)
X24. October 22, 1835. Pyrenees, France. A burning column of sulfurous air enveloped a cirque. (R32)
X25. February 9, 1836. Hungary. Flames issued from the ground. (R33)
X26. April 24, 1836. Italy. Great beams of fire in the sky. (R30, R33)
X27. March 22, 1841. Coblentz, Germany A blue flame rose from a hill and then subsided. (R33, R34)
X28. July 4, 1841. France. Ball lightning

accompanies shock. (R34)

X29. April 2, 1851. Chile. Intense flash of light before an earthquake; no sound. (R35)

X30. December 16, 1857. Italy. Half an hour before an earthquake, a light as bright as the moon hovered over the area. Smell of sulfur. (R36)

X31. Circa 1867. Algeria. Atlas mountains enveloped in a luminous atmosphere. (R37)

X32. November 1879. West Cumberland, England. Vivid flash of light at instant of shock. (R38)

X33. April 3, 1881. Turkey. Broad flashes on light on the horizon. (R39)

X34. July 14, 1894. Fresno, California. Red cloud some 50 miles long settled over the Sierra Nevada. Electrical displays on edges of cloud reached maximum at time of quake. (R40)

X35. December 17, 1896. England. Many reports of vivid light flashes from region of earthquake. (R41)

X36. Circa 1901. French Alps. An avalanche of rocks was accompanied by brilliant sparks, forming a sheet of flame. (R42) Some earthquake lights may originate in such avalanches. (WRC)

X37. December 28, 1908. Calabria, Italy. Flash of light during quake. (R43)

X38. November 16, 1911. Germany and Switzerland. Widespread reports of diffuse illuminations, will o' the wisps, lightning, and meteors from quake area. (R8)

X39. September 1, 1923. Kwanto, Japan. Stationary fireball seen in sky. (R25)

X40. June 1932. Mexico City, Mexico. Dull red glow in sky and lightning during shocks. (R44)

X41. January 20, 1941. Cyprus. Bright flash in the direction of the epicenter. (R45)

X42. December 17, 1941. Taiwan. Widespread luminous phenomena. (R46)

X43. June 24, 1942. Wairarapa, New Zealand. Blue and green flashes seen in many places. (R47)

X44. 1961, Hollister California. Small sequential light flashes from random locations on a hillside. (R19, R21)

X45. January 5, 1968. Chiba, Japan. Fan-shaped light seen in sky. (R46)

X46. October 1, 1961. Santa Rosa, California. Flashes and streaks of colored light. (R19, R21, R48)

X47. February 9, 1971. San Fernando Valley, California. (R49, R50)

Photograph of a probable earthquake light taken near Mt. Kimyo, Japan, on September 26, 1966. The bluish-white glow lasted 96 seconds. (J.S. Derr)

X48. September 5, 1975. Eastern Turkey. Sky brightening in the direction of the epicenter. (R51)

X49. July 28, 1976. Tangshan, China. A brilliant light seen for hundreds of miles around quake area. (R20, R52)

X50. 1977. Romania. Earthquake lights seen on western horizon, but the epicenter was in an easterly direction. Author believes this emphasized the regional character of the phenomenon. (R53)

X51. General observation. Sheets of flame reported during some earthquakes may be due to the release and spontaneous ignition of subterranean reservoirs of methane. (R54)

X52. General observation. Earthquake lights seem most frequent when the lunar tidal force is decreasing. (R55)

X53. No date given. Derby, England. Black aurora seen at time of quake. See GLA22. (R56)

X54. April 13, 1750. England. Red rays seen converging at zenith. (R33)

X55. April 15, 1752. Stavanger, Norway. An octagonal luminosity in the sky emitted fireballs from its angles. (R33)

X56. February 1692. Sicily. One evening during an episode of earthquakes, the entire village of Alari seemed to be in flames for about 6 minutes. (R57)

X57. December 30, 1820. Ionian Isles, Greece. Three or four minutes before the earthquake shock, a 4-6-foot fireball was visible over the sea for 5 or 6 minutes. (R58)

X58. 1738. Pecs, Hungary. "A very mysterious event was observed. Near Pecs, a black cliff named Szennyes (=dirty or filthy) belched forth fire during three days, accompanied by an earthquake that was strongly felt in the town of Pecs. After this shock, fires were also seen on many occasions from the cliff. Naturally it was not a volcanic manifestation. The nature of this particular event is perfectly obscure." (R59)

The author, P. Hedervari, remarked that, "An earthquake light is improbable because of the long time during which the phenomenon was seen."

X59. June 26, 1830. Honan Province, China. Days before the quake, burning vapors filled the atmosphere, dull explosions were heard in the air, long bands of fire appeared on the horizon. (R60)

This item is only one of many to be found in Mallet's several, lengthy compilations of earthquake phenomena, not a few of which are anomalous in one way or another.

X60. September 30, 1924. Portland, Maine. An earthquake jolted all of northern New England.

"In Portland there was observed simultaneously with the shocks a brilliant flare of light across the clouded sky. A theory that this was caused by a meteor was rejected by the Rev. Joel H. Metcalf, an astronomer. No electrical storm was recorded at the Weather Bureau." (R61)

X61. May 1960. Arauco Peninsula, Chile.

"Several people reported luminous phenomena associated with the earthquakes. The most interesting reports come from the Arauco Peninsula, where, it was reported, people in Canete saw a luminous glow in the air associated with these larger aftershocks. The phenomenon was described by a pilot who, with three passengers, was trying to sleep in his plane. The plane bounced around a good deal during the night, sliding some 4 m. southward over the slippery surface of the field. The light was described as coming from the air, beginning abruptly with the sound from the aftershocks, and rising to a fairly constant level in less than 1 second. It continued for perhaps 40 to 50 seconds, dying out more slowly, with a decay time of a few seconds. It was seen only during the stronger aftershocks. The light was described as a 'forforescencia del aire un color azulverdoso.' The effect seemed brightest at the horizon to the south and east. The sky was quite clear. There was no electric power available anywhere on the peninsula, which could have caused the phenomenon, all the power having been shut off because of the earthquakes." (R62)

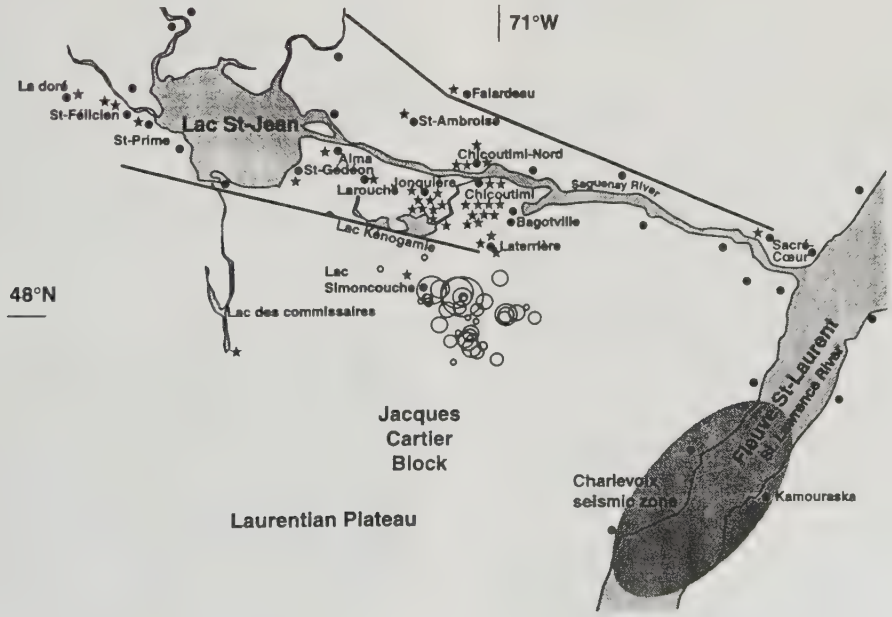
X62. Winter 1988-1989. Quebec, Canada. Numerous earthquake lights (EQLs) were reported between November 1, 1988, and January 21, 1989, in the Saguenay region of Quebec. These luminosities were associated with 54 seismic shocks recorded in this area. Most were small, but a strong foreshock (magnitude 4.8) occurred on November 23; the main quake (magnitude 6.5) hit 60 hours later. Through appeals by radio and newspapers, 52 observers of EQLs were located. They reported a wide spectrum of luminosities, some of which were very strange. In the sky, some observed silent sparkings, diffuse glows, and aurora-like stripes. For an account of the more enigmatic EQLs, we quote M. Ouellet directly:

"Fireballs a few metres in diameter often popped out of the ground in a repetitive manner at distances of up to only a few metres away from the observers. Others were seen several hundred metres up in the sky, stationary or moving. Some observers described dripping luminescent droplets, rapidly disappearing a few metres under the stationary fireballs. Only two fire-tongues on the ground were reported, one on snow and the other on a paved parking space without any apparent surface fissure. The colours most often identified were orange, yellow, white and green. Some luminosities lasted up to 12 min."

A decade following the above report by M. Ouellet, F. St-Laurent published additional details concerning the precise nature of the earthquake lights. She wrote that during this lengthy spate of tremors, 38 unusual luminosities were initially reported from the region, 8 of them before the foreshock, being in effect earthquake precursors. Afterwards, residents were queried for details and additional observations. A total of 46 reports sufficiently detailed for analysis were obtained.

These luminous phenomena were classified according to a scheme proposed by F. Montandon in 1948. Montandon's five categories are:

(1) Seismic lightning (no thunder);
(2) Luminous bands in atmosphere;
(3) Globular incandescent masses;
(4) Fire tongues, small mobile flames near the ground, like will-o'-the wisps; and
(5) Flames emerging from the ground.



Map of the Saquenay-Lac St-Jean region of Quebec. Open circles represent epicentral areas; stars signify observations of earthquake lights. (X62)

Artist's sketch based upon reports of witnesses of a fast-moving bluish-white light at the beginning of the main shock of the November 25, 1988, in the Saquenay region of Quebec, Canada. The light was accompanied by a crackling noise emitted by the trees. (X62)

The globular incandescent masses were by far the most common type of earthquake light during this Canadian "flap." Of these, F. St-Laurent writes:

"There were twenty-two reports coming from different places. Often they were seen far from the epicenter or when the seismic activity was low or quiet. Some were stationary (in one case, the yellow and orange mass presented a horizontal elongated form), others were seen emerging from the ground, some were very fast-moving near the ground, one was seen attached to a luminous band---all as described by Montandon. (R64)

X63. January 17, 1995. Kobe, Japan. This powerful quake produced many reports of anomalous lights in Japanese newspapers:

(1) Some residents of Kobe and nearby cities saw aurora-like phenomena in the sky just before and after the quake.

(2) A Kobe firefighter observed a bluish-orange light above a shaking road that lasted about 4 seconds.

(3) A hotel employee on his way to work on Rokko mountain: "saw a flash running from east to west about two to three meters above the ground shortly after the quake. The orange flash was framed in white."

(4) Flashes of light were widely observed. (R65)

Additionally, some geological evidence discovered by Y. Enomoto and Z. Zheng may provide a clue as to the source of some of the lights. Their abstract in Geophysical Research Letters follows.

"The Kobe earthquake of January 7, 1995, which had a magnitude of 7.2 was accompanied by earthquake lightning (EQL). The fault gouge near ground level at the Nojima fault, where the EQL was witnessed, was highly lithified and anomalously magnetized. The characterization of the fault gouge and the mudstone near the fault suggests that the anomalies might have been induced by an intense EQL current which passed through the fault plane. (R66)

X64. September 16, 1931. Yamanasi Prefecture, Japan. K. Musya, one of the pioneer researchers of earthquake lights, wrote at great length about the physical nature of earthquake lights, which have been reported in large numbers during Japan's frequent quakes. From his several detailed analyses of specific quakes, we select one that illustrates the great variety of luminous phenomena that may accompany quakes.

During the Yamanasi earthquake of September 16, 1931, intense luminosity was observed by many in the direction of the Hakone volcano. Musya collected 37 reports and catagorized the earthquake lights as follows:

(1) Lightning-like flash [9 observations];
(2) A part of the sky was lit up [4]);
(3) Indefinite flash [3];
(4) Dim round-shaped luminosity [3];
(5) Radiating light [1];
(6) Semi-circular light [1];
(7) Rainbow-shaped light [1];
(8) Long horizontal luminosity [4];
(9) Band-like luminosity [2];
(10) Pillar-like luminosity [2];
(11) Linear luminosity [2];
(12) Flash in the clouds [1];
(13) Others [4]. (R67)

The colors of the luminosities were as diverse as their shapes, but they tended to be reddish and yellowish, a few bluish, none were greenish.

A comparison of the observations noted in X62, X63, and X64 reveal that earthquake lights take on many forms, probably implying multiple mechanisms are at work.

X65. Explanations of earthquake lights. As in the case of ball lightning (GLB1), a wide spectrum of possible mechanisms has been proposed for the generation of earthquake lights. Since our intent is the cataloging of phenomena only, we devote just a few lines here to some of the papers we have collected since the first edition that propose explanations.

- Frictional heating of faults (R68)
- Sonoluminescence (R69)
- Fractoluminescance (crushing of rocks) (R70, R71, R73)
- Solution contact charging (R72)
- Earth currents (R66)
- Frictional heating, water vaporization, and resulting electric charge generation (R74, R76)
- Chemiluminescence (R75)

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GLD9 Volcano Lights

Description. Unusual exhibitions of lightning, expanding luminous arcs, bolts of light emanating from craters, and aurora-like beams associated with volcanic eruptions.

Background. The clouds of ash and water vapor emitted by active volcanos carry sufficient electric charge to guarantee ordinary lightning in the environs of many volcano eruptions. The phenomena reported here seem to transcend ordinary lightning.

Data Evaluation. Ordinary volcano lightning is rather common, but the more bizarre luminous phenomena described below are not seen often. Rating: 3.

Anomaly Evaluation. With so much charge-laden dust and steam accompanying volcanic eruptions, conditions exist for all manner of electrical discharges and associated luminous phenomena. Luminous structures may also originate in the powerful shock waves emitted from volcanic craters. In other words, most volcano lights are probably compatible with the extreme physical conditions generated. Rating: 3.

Possible Explanations. Electrical discharges between clouds of electrically charged dust and steam. Highly compressed shock waves.

Similar and Related Phenomena. Earthquake lights (GLD8), tornado lights (GLD10), low-level auroras (GLA4), visible sound waves (GE).

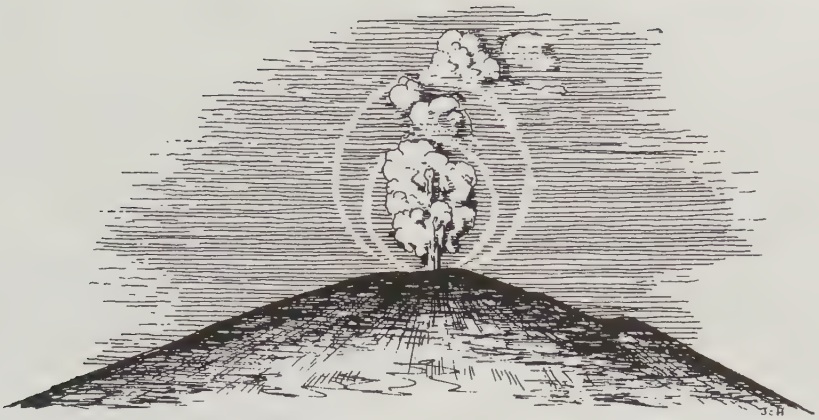
Examples of Volcano Lights

X1. No date given. Mount Vesuvius, Italy. "M. L. Palmeri first observed the flashes of volcanic lightning at a distance of a few hundred yards from the new crater at Torre del Greco. They always originated in large 'globes of smoke,' and were followed by explosions like pistol-discharges. Afterward from the Observatory he noticed similar flashes between the smoke and cinder masses and aqueous vapor above them, but very seldom between the 'globe of smoke' and the earth beneath it." (R1)

X2. April 7, 1906. Mount Vesuvius, Italy. During a vigorous eruption. "The frequency of the explosions varied from approximately one every three or four seconds to at least three per second. Although powerful, they were very sharp and sudden in their nature, and at the instant of each---but before it could be sensed by the eye or ear---a thin, luminous arc flashed upward and outward from the crater and disappeared in space. Then came the sound of the explosion and the projection of gas and detritus above the lip of the crater. The motion of translation of the arcs, while very rapid in comparison with that of the detritus, was not above the limits of easy observation and there could be no doubt as to the reality of the phenomenon, which was repeated some hundreds of times." (R2)

X3. August 4, 1979. Mount Etna, Italy. "Scientists at Catania's Institute of Volcanology said the eruption was accompanied by strange bolts of bright light shooting out of the craters that appeared to be lightning---a phenomenon never seen before on Etna. The scientists said the bolts of light, followed by loud, explosive roars, were apparently caused by electrical activity coinciding with the eruption, an occurrence they described as unprecedented. (R3)

X4. 1902. Mount Misery, Leeward Islands. "A fortnight after the destruction of St. pierre, however, a loud explosion was heard by labourers working on the side of Mount Misery; flames seemed to leap out of the ground, and a strong wind swept by, overturning two small houses. At the same time a heavy thunderstorm occurred, with vivid lightning flashes." (R4)



During a 1906 eruption of Vesuvius, thin luminous arcs were observed expanding outward from the volcano's crater. (X2)

X5. 1902. Mont Pelee, Martinique. "At 11 p.m., lightning shot out from the mountain in all directions, zigzagging and flickering flashes alternating with, or being accompanied by, reddish globes, which ascended and exploded, and shot out stars and long rays. Away towards the south-west was another large focus of electric energy, which appeared to me to have a distinct relation to the volcanic electric discharges from Mont Pelee. This spot was, I reckoned, at least forty miles from the volcano, from which it bore almost west two points north. This latter electrical display was similar, but less extensive than that from Mont Pelee, and it was accompanied by curious glowing globes, which burst and shot out tongues of lightning. The most curious part of the magnificent sight, however, was that occasionally long rays of light, very like to the rays of a searchlight, shot out from the direction of Mont Pelee downwards to the secondary and distant electrical display, and on this broad ray reaching the western focus, the lightning there became more vivid, intense and extensive." (R5) In other words there seems to have been an atmospheric "connection" between the two active centers.

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GLD10 Tornado Lights

Description. Glowing columns inside tornado funnels, blinking luminous patches in tornado clouds, searchlight beams, ground-level flashes of light, and general surface luminosity in the region near funnels. Waterspouts, too, may exhibit similar luminous phenomena but usually to a much lesser degree. Tornadoes and waterspouts are frequently accompanied by ordinary lightning, ball lightning (GLB1), and vivid, almost continuous flickers of electrical discharge; these are not considered unusual enough to include here.

Background. Like earthquakes, tornadoes and waterspouts were widely thought to be manifestations of electricity two centuries ago. Today, the role of electricity in generating tornadoes is generally denied. Even the existence of tornado lights, which seem rather reasonable phenomena in the vicinity of powerful tornadoes, are not recognized as legitimate phenomena by many scientists.

Data Evaluation. Several modern reports by experienced observers plus some provocative photographs lend credence to tornado lights. Rating: 1.

Anomaly Evaluation. Although ordinary lightning is normally associated with tornadoes, the glowing columns and other luminous structures---all suggestive of strong electrical discharges---are not part of prevailing tornado theory. Even less likely, according to current thinking, is the possibility that tornadoes are actually caused by electricity. Rating: 2.

Possible Explanation. The intense electrical fields generated in the neighborhood of the tornado funnel are strong enough to cause glow discharge.

Similar and Related Phenomena. Earthquake lights (GLD8), volcano lights (GLD9), the burning and dehydration effects of tornadoes (GWT), and low-level auroras (GLA4).

Examples of Tornado Lights

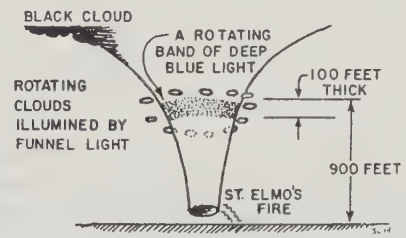
X1. December 12, 1846. St. Just, England. During the passage of four powerful whirlwinds. "At the distance of about a mile SW. of the mine, in the direction of Cape Cornwall, there suddenly rose from the sea, or the land near to it, to a vast height, a pillar of fire, exceedingly vivid, and apparently of the thickness of a man's arm. On reaching its highest elevation, it spread itself from the top in all directions, with splendid coruscations, followed by a terrific peal of thunder. This form of the luminous appearance renders it probable that the electric fluid passed at that moment from the earth into the clouds, along the axis of the fourth or most western whirlwind, which must at the time have been near the Cape." (R1)

X2. June 22, 1928. Greensburg, Kansas. "Steadily the tornado came on, the end gradually rising above the ground. I could have stood there only a few seconds but so impressed was I with what was going on that it seemed a long time. At last the great shaggy end of the funnel hung directly overhead. Everything was as still as death. There was a strong gassy odor and it seemed that I could not breathe. There was a screaming hissing sound coming directly from the end of the funnel. I looked up and to my astonishment I saw right up into the heart of the tornado. There was a circular opening in the center of the funnel, about 50 or 100 feet in diameter, and extending straight upward for a distance of at least one half mile, as best I could judge under the circumstances. The walls of this opening were of rotating clouds and the whole was made brilliantly visible by constant flashes of lightning which zigzagged from side to side." (R2)

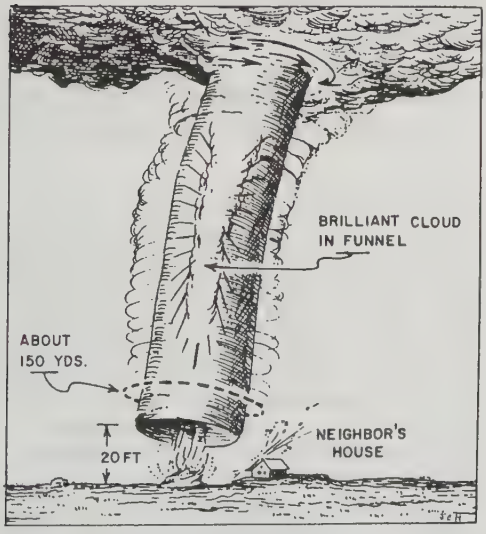
X3. Summer 1942. Champaign, Illinois. "I was looking....up at the clouds when I saw something that looked like a searchlight beam extend out of the cloud and reach to the skyline. It seemed a bit brighter than the cloud background. Edges were sharp, overall intensity even, sides parallel. Width

about a degree of arc. No movement or turbulence evident..... abruptly the ray was instantly replaced by a normal tornado funnel. No transition stage was noted. The funnel did not descend from the cloud layer. It appeared over all, in situ." (R3)

X4. May 25, 1955. Blackwell, Oklahoma. "Eyewitnesses to the tornado in Blackwell also have reported evidence of intense electrical activity. Montgomery, who viewed the tornado from a distance of about 3000 ft, reports: 'As the storm was directly east of me, the fire up near the top of the funnel looked like a child's Fourth of July pin wheel.' 'There were rapidly rotating clouds passing in front of the top of the funnel. These clouds were illuminated only by the luminous band of light. The light would grow dim when these clouds were in front, and then it would grow bright again as I could see between the clouds. As near as I can explain, I would say that the light was the same as an electric arc welder but very much brighter. The light was so intense that I had to look away when there were no clouds in front of it. The light and the clouds seemed to be turning to the right like a beacon in a lighthouse. Montgomery also tells of other eyewitnesses who had different views of the phenomenon, such as Mrs. Carl Sjoberg whose house in the direct path was completely demolished: 'She saw lightning coming up from the ground two or three feet high and about half as wide as adding machine tape. It was a deep blue and forked on the end like a Y or like a snake's tongue.' According to Montgomery, Lee Hunter, who was 4 mi north of Blackwell, described the tornado as follows: 'The funnel from the cloud to the ground was lit up. It was a steady, deep blue light ---very bright. It had an orange color fire in the center from the cloud to the ground. As it came along my field, it took a swath about 100 yards wide. As it swung from left to right, it looked like a giant neon tube in the air, or a flagman at a railroad crossing. As it swung along the ground level, the orange fire or electricity would gush out from the bottom of the funnel, and the updraft would take it up in the air causing a terrific light---and it was gone! As it swung to the other side, the orange fire would flare up and do the same.'" (R4-R5)

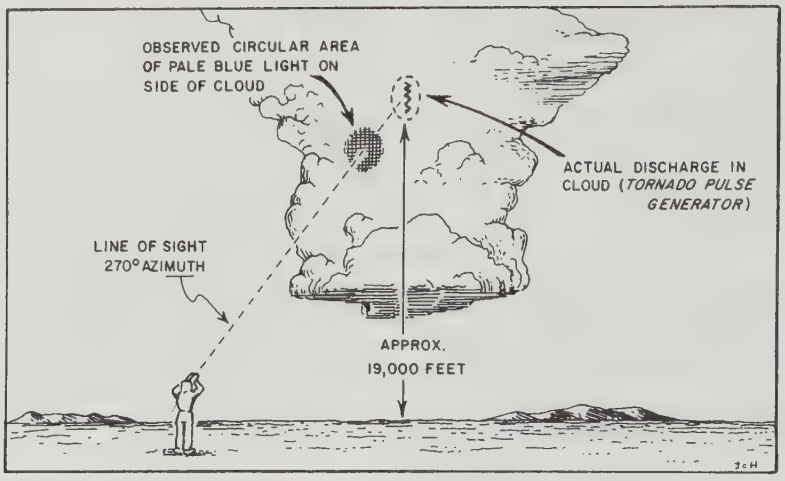


Other luminous phenomena observed during the 1955 Blackwell tornado. (X4)



The famous Blackwell, Oklahoma, tornado of 1955 seemed to contain a bright, self-luminous cloud inside the funnel. (X4)

X5. May 31, 1956. No place given. Double tornado pulse generator in a thundercloud. "...there was no apparent electrical activity whatsoever except for an odd flashing patch of illumination in the top section of the thundercloud, as shown in figure 1, a flashing that appeared as a circular patch of light on the side of the cloud structure between the observer and the center of action where the electrical activity appeared to be. At that time these patches of light



Tornado-spawning clouds near Blackwell, Oklahoma, in 1955, contained a pulse-generator. (X5)

appeared as circular patches of pale blue illumination for an estimated time of two seconds; this circular area would then become dark for another estimated period of two seconds, and again would reappear. The on-and-off flashing continued for the entire time of visual observation. It was definitely obvious that there was absolutely no cloud-to-ground or cloud-to-cloud lightning visible or even any lighting of the sky in that particular region." (R6)

X6. June 17, 1959. Miami, Florida. The "lower extremity was continuously illuminated with a blue-green light flashing like an electric welding torch. A part of this was no doubt produced by the tornado disrupting...power lines...However, the tornado was associated with a thunderstorm which had an extreme amount of electrical activity with almost continuous cloud to cloud and cloud to ground lightning strokes." (R3)

X7. April 11, 1965. Toledo, Ohio. "The beautiful electric blue light that was around the tornado was something to see, and balls of orange and lightning came from the cone point of the tornado." "The most interesting thing I remember is a surface glow---some three or four feet deep---rolling noise etc....there was sort of a general brightness for a few seconds..." "We thought we saw searchlights all around us, but there were no light beams shooting up to the clouds from the ground. The lights darting around in the clouds were sort of luminous and appeared to be more round in shape than anything else, also they were quite large. The lights were not as bright as a stroke of lightning, but they were above a dense layer of clouds, and bluish white in color...they were shooting around." Photographs accompanying this article show vertical beams of light associated with the funnel. (R3, R7)

X8. April 3, 1974. Huntsville, Alabama. "What we first saw was a green spike of light...The spike would move along and there would be a burst of light and it looked like some bombing taking place...The green light looked very much like the kind of light you would get from a laser made to lase in the green, very fluorescent in nature." "...I noticed...a brilliant blue flash like an electric arc, off on the horizon...many miles away. It appeared to be a gigantic electric arc, and I thought at the time it was a power transmission line shorting out, but I've never found where the line was, if that's the case. That was followed about 5 to 10 seconds later by another gigantic flash of bright blue light in essentially the same lo-

cation. There were just two flashes, nothing in between. At that time and after that, the entire sky in this area was just constant blue lightning flashes. " "It appeared.... that in the lower impact areas there was a light blue discharge present---roughly that associated with the ionization of molecular oxygen. In the high impact area.... we saw a slightly green glow, which would be very typical of the ozone discharges I have seen in plasma physics. These were very faint glows from my point of observation. They were not a strong or intense glow. After the tornado had passed through.... there remained, for a few minutes, a purplish glow which would be very typical of ionized air.... This glow was more intense up near the clouds and tended to fade out as it worked toward the surface." (R8)

X9. General observations, no times or places given. Speaking of a tornado funnel. "...suddenly it turned white outside. This whiteness definitely was not fog. I would say it appeared to be giving off a light of its own." "The beautiful electric blue light that was around the tornado was something to see, and the balls of orange and lightning came from the cone point of the tornado." "The most interesting thing I remember is a surface glow---some three or four feet deep---rolling noise, etc." (R9) Obviously some of these observations are derived from the preceeding examples.

X10. 1885. Greene County, Alabama. Tornado preceded by a phosphorescent glow resembling a sunrise. (R10)

X11. October 17, 1909. Mediterranean Sea. A streak of light was seen along the axis of a waterspout accompanied by vivid lightning. (R11)

X12. March 23, 1913. Omaha, Nebraska. The lower end of the tornado was a lurid, fiery mass. (R12)

X13. August 21, 1933. the Orkneys, England. Strange bright object seen in the sky after the passage of a tornado. (R13)

X14. February 10, 1959. St. Louis, Missouri. Blue flash of light, a big ball of fire in the sky, strong glow of light. (R14)

X15. March 26, 1968. Monroe, Michigan. A beautiful blue light associated with the tornado. (R15)

X16. May 15, 1968. Tuckerman, Arkansas. Pale-green, neon-like light inside the funnel. (R15)

X17. July 1890. Fort Bowie, Arizona. A curious tornado anecdote from long ago.

"The funnel of the cloud, which passed near them, revolved from right to left, and threw off immense volumes of white vapor, which seemed like steam. Within the funnel there was a terrible roaring unlike anything they had ever heard. The lightning was incessant and blinding, and the thunder was one constant roar, with loud crashes now and then that were deafening. The mules were terribly frightened, and were prevented from running away by the utmost efforts of the driver. During the height of the storm the lightning seemed to play around the tires of the wheels in blue flames, while jagging blue flames darted over the prairie." (R16)

X18. August 30, 1971. No place given. While watching a funnel cloud 2 miles distant. "I saw that the funnel had a very narrow core and that it extended to a great height. At that point I also observed a discharge of lightning throughout the length of this core." (R16)

X19. June 21, 1972. Tempe, Arizona. Electrical discharges were observed at the base of a nearby tornado. (R16)

X20. August 18, 1890. Brittany, France. A tornado devastated a strip of countryside 16 kilometers long and 600-800 meters wide. It was accompanied by incessant lightning. At Reinon, a woman was suddenly surrounded by violet flames that burst out of the ground. Others saw lightning flashes streaking low over the ground in front of the tornado. (R17)

X21. May 3, 1943. McKinney, Texas. People rarely get the chance to look up into the funnel of a tornado and live to tell about it. R.S. Hall did, and what he saw is very strange.

"The bottom of the rim was about 20

feet off the ground, and had doubtless a few moments before destroyed our house as it passed. The interior of the funnel was hollow; the rim itself appearing to be not over 10 feet in thickness and, owing possibly to the light within the funnel, appeared perfectly opaque. Its inside was so slick and even that it resembled the interior of a glazed standpipe. The rim had another motion which I was, for a moment, too dazzled to grasp. Presently I did. The whole thing was rotating, shooting past from right to left with incredible velocity.

"I lay back on my left elbow, to afford the baby better protection, and looked up. It is possible that in that upward glance my stricken eyes beheld something few have ever seen before and lived to tell about it. I was looking far up the interior of a great tornado funnel! It extended upward for over a thousand feet, and was swaying gently, and bending slowly toward the southeast. Down at the bottom, judging from the circle in front of me, the funnel was about 150 yards across. Higher up it was larger, and seemed to be partly filled with a bright cloud, which shimmered like a fluorescent light. This brilliant cloud was in the middle of the funnel, not touching the sides, as I recall having seen the walls extending on up outside the cloud.

"Up there, too, where I could observe both the front and back of the funnel, the terrific whirling could be plainly seen. As the upper portion of the huge pipe swayed over, another phenomenon took place. It looked as if the whole column were composed of rings or layers, and when a higher ring moved on toward the southeast, the ring immediately below slipped over to get back under it. This rippling motion continued on down toward the lower tip." (R18)

Hall also reported a peculiar bluish light and blue streamers that appeared to consist of vapor.

X22. July 21, 1992. Hill Deverill, Wiltshire, England. A couple driving home in their car saw what might have been luminous whirlwinds. Luminous whirlwinds would be a surprising development because whirlwinds are much less energetic than tornados and would seem to be unlikely light sources.

"We saw what looked like the reflection of the moon from the driver's window (i.e. we were looking in a westerly to southwesterly direction), and, as we travelled on, it then looked like four beams of a high-powered torch, but, as we went still further and were more or less alongside, we could see it was in fact four swirling shapes, shining white (not very bright, but bright against the night sky). We turned off the car engine and could hear a whooshing noise (like a car a distance away, going fast on a motorway---but the sound did not come any closer)...These four spinning shapes (like the top of a cotton bud---not dense and solid) went round and round in a clockwise direction. They came together in the middle, out and round and round. They did this several times (once, one went off to the right but came back into 'formation'), and then they came back together and just disappeared." There were no electrical storms in the area. (R19)

Wiltshire is prime crop-circle country; and crop circles have sometimes been associated with both whirlwinds and luminous phenomena. Of course, the mainstream consensus holds that <u>all</u> crop circles are of human manufacture; that is, hoaxes.

X23. January 21, 1992. Near Cripple Creek, Colorado. Shortly after 2 PM, while fishing at Skagway Reservoir, D. McGown spotted an ominous cloud formation developing in the west. A horizontal, black cloud rolled toward him. Suddenly, it lifted to reveal a huge, twisting funnel advancing directly at him. He threw himself to the ground, but got a good look up into the interior of the funnel.

"The outside of the tornado was spinning so fast my eye couldn't follow it, but the inside was rotating almost lazily. I could see a thousand feet up inside it. Tiny fingers of lightning lined the hollow tube." (R20)

Passing over him, the funnel bounced across the lake, ripped up some trees, and was gone. Although not as impressive as the inside of the Texas tornado (X21), luminous electrical activity was also present in this case.

X24. January 10, 1994. Farnham, Surrey, England. At 0448 GMT, following a sudden cessation of rainfall, M.D. Smith became aware of an orange glow outside his window. Accompanying it was a roar like that of a military jet. The phenomenon occurred a total of four times; the second of which is the most interesting in the present context.

"A second illumination was observed twenty seconds later, but this time it reappeared away from the tree so a clear view was possible. The illumination was in the form of a narrow column and of the classic gentle 'S' tornado shape in the 'roping out' stage; it was silvery in colour towards the top and golden-orange lower down. Additionally, Mr. Smith saw the illumination move from the sky towards the ground, but at a speed slower than lightning. The sound of rushing wind was heard again, while this illumination lasted five to six seconds. Mr. Smith also noted a very low cloud base with a second layer of cloud only slightly higher." (R21)

X25. Possible explanation. Electrical discharges inside tornado funnels are the most popular explanations for tornado luminosities. Another possibility is simple chemical combustion. J. Abrahamson hypothesizes that a tornado might suck up combustible material from the ground and levitate it within its funnel. If ignited by lightning, the suspended fuel would appear to be a fireball and could account for some instances of tornado luminosity. Abrahamson speculates that this mechanism might also spawn some ball lightning reports. (R22)

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GLD11 Whirlwinds of Fire and Smoke

Description. Revolving columns or wheels of fire and smoke that sweep destructively along the surface of the ground or water. Much smaller than tornadoes and considerably larger than ball lightning, these fiery pillars often leave behind sulfurous odors and burnt vegetation.

Background. This phenomenon is difficult-to-classify. It resembles ball lightning in some respects, the tornado in others, and even some low-level meteors. The characteristic explosive onset and sulfurous odor suggest that it be placed here along with electrical discharge phenomena.

Data Evaluation. The observations of whirlwinds of fire and smoke are generally old and the product of untrained observers; but they are rather consistent. Rating: 3.

Anomaly Evaluation. The flames, smoke, odor, and burning effects make this a most puzzling phenomenon. If electricity is the basis of these strange whirlwinds, current theories are deficient. Rating: 2.

Possible Explanations. Some whirlwinds are so powerful that they can account for the physical destruction noted in the examples below. The fire and smoke might result if the whirlwinds picked up materials already ignited. Electrical heating is another possible mechanism.

Similar and Related Phenomena. Ball lightning (GLB), tornado lights (GLD10), the burning and dehydration effects of tornadoes (GWT), the explosive onsets of whirlwinds (GWW). Low-level meteors (GLM1).

Examples of Whirlwinds of Fire

X1. August 26, 1823. Boncourt, France. "A waterspout was seen not far from the village of Boncourt, having its broad base resting on the ground, and its summit lost in the clouds. It consisted of a thick and blackish vapour, in the middle of which were often seen flames in several directions. Advancing along with the storm, it broke or tore up by the roots, in the space of a league, seven or eight hundred trees of different sizes, and at last burst with great violence in the village of Marchepoy, one half of the houses of which were instantly destroyed." (R1)

X2. August 26, 1826. Carcassone, France. "Fiery whirl....great heat in the morning. At noon massing clouds in the west. Then a thick black cloud suspended over a field. Crackling and hissing and air rushing toward the cloud. A loud detonation and an enormous column of fire hovered over the field---throwing down walls and picking up and killing sheep. A strong sulfurous odor. Nobody said it burned anything." (R2)

X3. Circa 1868. Lancashire, England. "I myself, about fifteen years ago, whilst driving one evening in the country district a few miles north of Bolton, in Lancashire, saw three pillars of fire rise out of the earth within a few yards from my phaeton. The first pillar rose on my left-hand side, then, after I had proceeded about a quarter of a mile, a second pillar rose on the right-hand side; and the third one appeared at the junction of two roads a few hundred yards further on. These fiery pillars seemed to be, as far as I can recollect, about twelve feet high, and in circumference about the same as the funnel of a large steamer." (R3)

X4. 1869. Ashland, Tennessee. "...a remarkably hot day....a sort of whirlwind came along over the neighboring woods, taking up small branches and leaves of trees and burning them in a sort of flaming cylinder that travelled at the rate of about five miles an hour, developing size as it travelled. It passed directly over the spot where a team of horses were feeding and singed their manes and tails up to the the roots; it then swept towards the house, taking a stack of hay in its course. It seemed to increase in heat as it went, and by the time it reached the house it immediately fired the shingles from end to end of the building, so that in ten minutes the whole dwelling was wrapped in flames. The tall column of travelling caloric then continued its course over a wheat field that had been recently cradled, setting fire to all the stacks that happened to be in its course. Passing from the field, its path lay over a stretch of woods which reached the river. The green leaves on the trees were crisped to a cinder for a breadth of 20 yards, in a straight line to the Cumberland. When the 'pillar of fire' reached the water, it suddenly changed its route down the river, raising a column of steam which went up to the clouds for about half-a-mile, when it finally died out. Not less than 200 people witnessed this strangest of phenomena, and all of them tell substantially the same story about it." (R4)

X5. April 1869. Carlisle, England. "On Saturday morning, between four and five o'clock, a ball---or more properly speaking, a pillar of fire---passed from east to west over the City of Carlisle, and was plainly visible for fully a score of miles around. It resembled an ordinary gate-post in size and shape, and seemed as though it were prevented from falling by some invisible connecting cord. It travelled in a westerly direction, and was plainly visible at Cummerdale, and at Glasson, 10 miles distant from Carlisle. At Glasson, a respectable yeoman watched the pillar intently, and he says that it caused great heat, while another person in the same locality says that the fiery substance seemed to pass within a score of yards of him, and that the heat was almost overpowering. It exploded in the air, and immediately after the report, resembling the sound of the discharge of cannon, a singular brightness lit up the heavens." (R5, R6)

X6. November 30, 1872. Banbury, England. "About 12 o'clock we had a heavy storm of rain and hail, in the middle of which there was a very vivid flash of lightning, with almost instantaneous thunder of a very peculiar rattling sound. About five minutes afterwards, as I was leaving the house, my gardner called me to come quickly and see the ball of fire. I was unfortunately half a minute too late, but I have seen four persons who saw it from different points, and who all agree they heard a whizzing, roaring sound like a passing train, which attracted their attention, and then saw a huge revolving ball of fire travelling from six to ten feet off the ground. The smoke was whizzing round and rising high in the air, and a blast of wind accompanied it, carrying a cloud of branches along and destroying everything in its way....Where it first began the breadth of ground travelled over was very narrow, but increased as it proceeded, till in the last field the debris covered a space quite 150 yards wide, and here it seems to have exhausted itself, as all witnesses agree that the ball of fire seemed

to vanish at this spot without any explosion. Here the ground had been cut in places as if by a cannon ball, but I could find no cause for this, and I saw no signs of fire on its route."....."William Marshall, gardner at Newbottle Manor, was returning from the stables to the house. He heard a noise like a long railway train crossing a bridge, and saw leaves and branches whirled into the air above the Spinney, and immediately afterwards 'a dark ball, as big as a carriage, and sending up 'a cloud of smoke,' come out of the trees with a shower of branches, and roll 'over and over' down the hill in the direction of the bridle road; the cloud of smoke at the same time whirling 'round and round' with a 'buzzing noise.' He distinctly saw sparks of a red colour emitted from the ball about six feet from the ground, and this is confirmed by another man, William Jilson, of Astrop, who, from a field on the west, saw fire and ran away affrighted." (R7-R9, R13)

X7. July 18, 1881. Americus, Georgia. "...at some distance from the town a small whirlwind, about 5 feet in diameter and sometimes 100 feet high, formed over a cornfield where it tore up the stalks by the roots and carried them with sand and other loose materials high into the air. The body of the whirling mass was of vapourous formation and perfectly black, the centre apparently illuminated by fire and emitting a strange 'sulphurous vapor' that could be distinguished a distance of about 300 yards, burning and sickening all who approached close enough to breath it. Occasionally the cloud would divide into three minor ones, and as they came together again there would be a loud crash, accompanied by crackling sounds, when the whole mass would shoot upwards into the heavens." (R10)

X8. June 1928. Travancore, India. "The account describes the passage of 'a cylindrical column of water 20 to 30 feet high' across a paddy-field, the column 'emitting fire and making a dreadful noise,' and the ground is said to have been torn up so as to leave a deep well-like hole." (R11)

X9. February 22, 1934. La Rinconada, Spain. "Suddenly I heard a strange noise. My son thought it was an airplane flying low and went out of the hut. Almost immediately I heard him say 'Papa, look!' I went out of the hut, and found myself within a black cloud. I was overcome and fell to the ground. My cap was violently torn from me and lost. The dust cloud made a black column which extended, strange to say, in a direction against the strong wind which was then blowing. It seemed to rapidly take fire. Of the hut only the posts remained. The furnishings were totally destroyed by the fire. The cup of a charcoal brazier, recently bought, was melted into several pieces and mixed with other material. The beam of a plow fifty meters from the hut was scorched, as were also some olive trees around the hut." (R12)

References

R1. "Remarkable Water-Spout in France, in 1823," American Journal of Science, 1: 10:183, 1826. (X1)
R2. Fortean Society Magazine, 1:12, Spring 1944. (X2)
R3. M., G.; "A Curious Phenomenon," Knowledge, 4:293, 1883. (X3)
R4. "A Fiery Wind," Symons's Monthly Meteorological Magazine, 4:123, 1869. (X4)
R5. "A Pillar of Fire," Symons's Monthly Meteorological Magazine, 4:37, 1869. (X5)
R6. "Singular Atmospheric Phenomenon," Eclectic Magazine, 9:765, 1869. (X5)
R7. Nature, 7:112, 1872. (X6)
R8. Cartwright, T. L. M.; "An Extraordinary Phenomenon," English Mechanic, 16:309, 1872. (X6)
R9. Beesley, T.; "The Newbottle Whirlwind of Nov. 30th, 1872," Symons's Monthly Meteorological Magazine, 8: 149, 1873. (X6)
R10. Monthly Weather Review, 9:19, 1881. (X7)
R11. Nature, 122:214, 1928. (X8)
R12. Wylie, C.C.; "Meteorite or Whirlwind in Spain," Popular Astronomy, 42: 277, 1934. (X9)
R13. Preece, W.H.; "Lightning and Lightning Conductors," Society of Telegraph Engineers, Journal, 1:362, 1873. (X6)

GLD12 Anomalous Flashes Detected by Satellite

Description. Satellite-observed light flashes of very short duration distributed randomly over the earth's surface. See details in X1.

Data Evaluation. The data are from satellite photometers. Although the experimenters believe they have eliminated instrumental errors, that possibility always exists. Rating: 3.

Anomaly Evaluation. No known natural process generates these flashes. Rating: 2.

Possible Explanations. None, assuming instrument errors are eliminated.

Similar and Related Phenomena. Many short-duration light flashes illuminating much of the visible hemisphere have been observed from the ground (GLA14).

Examples of Satellite-Detected Flashes

X1. General observation. From the OSO-2 and OSO-5 satellite observations. "On some occasions apparent 'lightning strokes' were detected that could not be assigned as such because at the time the fields of view of the telescopes were well above the earth. Some of these were detected by as many as three photometers simultaneously when the photometers were looking above the satellite.... The distribution of these signals over the earth's surface is approximately random, suggesting that the source is not lightning. Single occurrences are seen about once every ten orbits. No acceptable mechanism has yet been found to explain these anomalous spikes. These increases, which seem to be due to short duration (less than 0.1 sec) 'light' flashes, arise from processes other than lightning and must be eliminated from the data before any discussion of lightning distribution can be entered into." (R1

References

R1. Sparrow, J.G., and Ney, E.P.; "Lightning Observations by Satellite," Nature, 232:540, 1971. (X1)

GLD13 Enhanced Luminosity of Rocks and Other Solids

Description. The enhanced luminosity of rocks (especially chalk) and other solids during earthquakes, electrical storms, and other natural stimuli. The effect is reputed to be the strongest over buried ore bodies.

Background. The few simple experiments conducted on this phenomenon aimed at finding the cause of earthquake lights. This phenomenon is also probably closely related to some

nocturnal lights and the so-called "mineral lights." In general, the intriguing possibility of enhanced phosphorescence has been greatly neglected, and we have little to go on.

Data Evaluation. The observational and experimental foundation for this phenomenon is rather weak. Rating: 3.

Anomaly Evaluation. The enhanced luminosity of solids due to natural causes, assuming the effect exists, probably has simple electrochemical explanations. Rating: 3.

Possible Explanation. Earth currents, often strong near ore bodies, and chemical reactions may stimulate luminosity during quakes, sharp atmospheric pressure changes, and other natural phenomena. A biological origin is also possible, perhaps enhanced by earth currents.

Similar and Related Phenomena. Earthquake lights (GLD8), nocturnal lights (GLN), especially the Brown Mountain Lights, and marine phosphorescent displays (GLW).

Examples of Luminous Rocks and Other Solid Materials

X1. General observations. "The fact that a luminous emanation of variable shape will appear in the dark at such points on the surface of the earth below which there are extensive ore deposits at more or less considerable depth, was recorded in Germany as far back as 1747. Immediately before or during a thunderstorm these phenomena are said to be especially striking. Similar observations have more recently been made in North America in the neighborhood of ore deposits. Though much should be ascribed to superstition and to errors of observation, the fact nevertheless has been confirmed by recent investigation. The electric emanation given off from the surface of the earth (see Prometheus No. 891) has in fact been repeatedly ascertained photographically by Mr. K. Zenger. Plates coated with fluorescent substances were used. It may thus be taken for granted that the emanations in question occur with an especially high intensity at those points of the ground where good conductors of electricity are found in large amounts in the neighborhood of the surface of the earth, in other words, above ore deposits, which are very good conductors of the electric current." (R1, R2)

X2. General observations. Isle of Wight. Photographic experiments on rock luminosity. "The object was to determine whether there was or not at the time of a large earthquake a practically instantaneous transmission of energy to distant regions other than that recorded by seismographs. It was observed and still is observed, by many persons that the face of a very large chalk pit at Shide exhibits, after dull damp days, a flaring luminosity. In a chamber at the end of a tunnel in this pit, a cylinder carrying photographic paper was installed. This cylinder was enclosed in a box, one end of which was a metal plate containing three holes. The plate touched a flat chalk surface. The cylinder took one week to turn; therefore parts of the paper before the holes were very slow ly exposed to a chalk surface about 3/16th of an inch distant. On certain weeks the results were nil. Other weeks, after the development of the paper, there were three dark bands corresponding to the position of the holes, suggesting that the chalk had acted like an extremely feeble light.... The conclusion was that the photographic effects were in no way connected with radio-activity, but they were probably electrical." (R3, R4)

X3. July 7, 1875. Switzerland. During a violent electrical storm. "Electrical phosphorescence was remarkably intense before and during the hail. The ground, animals, prominent objects, as well as the hailstones, were strongly phosphorescent. Immediately after the hail, ozone was greatly developed, the smell being so pronounced as to be compared by nearly all observers to garlic. The incessant electrical discharges passed from cloud to cloud over a central point from which the hail fell, but thunder was very rarely heard." (R5)

X4. No date or place given. "A peculiar light effect was observed by a party of German ski runners who had passed the day in fog and lightly falling snow at an elevation of

4,750 feet above sea level, and who had begun to experience slight symptoms of snow blindness. On entering a hut at dusk and opening the window they saw narrow, bright blue bands surrounding the lumps of snow that adhered to their gloves and shoes, and marking the boundaries between light and shade on all parts of their persons and clothing. The effect soon vanished with the fading twilight and not a trace of it was obseron the following day." (R6)

X5. General observation. Phosphorus becomes luminous during and on the approach of storms. The incidence of some diseases increases markedly during the same period. (R7)

References

R1. Scientific American, 96:90, 1907. (X1)
R2. English Mechanic, 85:10, 1907. (X1)
R3. Milne, John, "Earthquakes and Luminous Phenomena," Nature, 87:16, 1911. (X2)
R4. Turner, H.H., et al; "On Seismological Investigations," Report of the British Association, 1907, p. 87. (X2)
R5. Nature, 12:447, 1875. (X3)
R6. "A Singular Effect," Scientific American, 104:103, 1911. (X4)
R7. "Phosphorescence in Connection with Storms and Disease," English Mechanic, 2:21, 1865. (X5)

GLD14 Luminous Phenomena in Water and Ice

Description. Phosphorescence, sparks, and flashes of light in waterfalls, about reefs and rocky shores, and in breaking or deforming ice. This type of light production is separate and distinct from marine bioluminescence (GLW).

Background. There may actually be several different phenomena lumped together here. Only further study can separate them.

Data Evaluation. Generally poor. No systematic observation of the phenomenon. Rating: 3.

Anomaly Evaluation. Since several reasonable mechanisms of light generation have been proposed to explain this phenomenon, it has low anomaly content. No one, however, has gone much beyond merely suggesting ideas. Rating: 3.

Possible Explanations. (1) Charge separation followed by luminous electrical discharges; (2) Triboluminescence (as in crushing sugar cubes); (3) Sonoluminescence, in which trapped gases become incandescent due to sudden, violent pressure changes; (4) The release and ignition of contained gases (especially in glacier ice).

Similar and Related Phenomena. Marine phosphorescence (GLW), earthquake lights (GLD8).

Examples of Luminous Phenomena in Water and Ice

X1. General observation. Giant rollers breaking over obstructions are often accompanied by blinding white flashes. (R1, R2) Given a bright moon, such flashes might be produced by simple reflection by white spray. (WRC)

X2. General observation. Strange flashes of light are sometimes seen at the bases of waterfalls. (R3, R4)

X3. General observation. Phosphorescence, sparks, and light flashes are occasionally observed in sea ice when it is broken up by ships. Cracking and deforming glacier ice will sometimes seem to give off sparks. (R5, R6)

References

R1. "The White Flash," English Mechanic, 99:14, 1914. (X1)

R2. "The White Flash," English Mechanic, 99:37, 1914. (X1)

R3. "Electricity of Waterfalls,: American Journal of Science, 3:44:423, 1892. (X2)

R4. "An Explanation for Those Flashes of Light from Waterfalls,: New Scientist, 19:399, 1963. (X2)

R5. Allen, J. Allen; "Luminous Phenomena on Rupture of Sea-Ice," Nature, 24:459, 1881. (X3)

R6. "Sparks in Glacier Ice?" New Scientist, 18:738, 1963. (X3)

GLD15 Dazzling Lights in and on Clouds

Description. Brilliant, stationary, greenish-white lights seen on and near cloud surfaces. The light source is usually spherical and blindingly intense. Lifetime: a few minutes.

Data Evaluation. Very few observations exist. Rating: 3.

Anomaly Evaluation. Observers of this phenomenon are quite sure it is electrical in nature, perhaps a form of St. Elmo's Fire. But St. Elmo's Fire is not nearly as intense as the data indicate for this phenomenon. We must assume that these brilliant spheres are some sort of unrecognized electrical discharge. Rating: 2.

Possible Explanations. A particularly energetic form of ball lightning; some rare and undescribed form of electrical discharge from cloud to atmosphere.

Similar and Related Phenomena. Ball lightning (GLB), the tornado pulse generator (GLD10).

Examples of Dazzling Lights on Clouds

X1. February 29, 1936. New Zealand. While observing a distant electrical storm, a faintly glowing light was seen among the clouds. The light was stationary for about 5 minutes. "At 10.15, as stated, I realised the glowing light was proceeding from a cloud. Before I had time to conjecture what that could mean, I witnessed one of the most weird and uncanny sights I have ever seen. It suddenly seemed to pulsate, it took definite shape as a molten ball of soft light, but although in itself not dazzling to the eyes, threw off an indescribably bright, greenish white light, or rather radiance. This radiance lit up the

whole of the upper surface of the cloud bank and showed the ball of light balanced on a finger of cloud. On either side of this finger were ugly looking black peaks, and all these

A brilliant sphere of light appeared atop a cloud deck in New Zealand. (X1) See also the mobile luminous spheres above thunderclouds in GLN2-X24 and X25.

were silhouetted against the radiance. From being a small ball of light, it instantly became larger, until it was the size of a half crown seen from a distance of 18 ft. The radiance became brighter and lit up all the landscape and countryside. The ball itself although molten in appearance, did not hurt or dazzle the eyes. It held this size for about 15 seconds (I was far too interested in watching it to take the time). Then it pulsated again (seeming to slightly contract and expand once or twice) and almost immediately became much enlarged....This time the radiance was terrific. Thousands of searchlights would not have equalled the intensity. But still the focal point or ball was not blinding." In about 15 seconds, the ball contracted and later disappeared. (R1)

X2. September 5, 1936. Leiden, Holland. Cloudy sky. "In the west-north-west at a height of about 30^{o} an intense light was seen. At first I thought it was a mock sun (there was actually a slight part of a halo visible above the sun), but it was too high for it and the light was of one colour and of great intensity. As far as I can state it, the colour was greenish white. The light did not pulsate, but I did not see its development.... There remained no question about its being an electrical phenomenon. The light was so intense that it was unpleasant for the eye." (R2)

References

R1. Laurenson, M.D.; "Phenomenon Witnessed in New Zealand on February 29th, 1936," Meteorological Magazine, 71:134, 1936. (X1)

R2. van der Heyden, K.; "Again: St. Elmo's Fire on a Cloud," Meteorological Magazine, 71:231, 1936. (X2)

GLD16 Luminous Patches Moving on Cloud Surfaces

Description. Patches of light on the bottoms of clouds that move as if they were caused by searchlight beams playing on the clouds. The phenomenon is silent.

Data Evaluation. Only a single observation of good quality. Rating: 3.

Anomaly Evaluation. If the moving patches of light are simply manifestations of electrical discharges within the clouds, the major problem seems to be in accounting for the curious motion of the patches. In any event, this phenomenon presents only minor problems to the meteorologist. Rating: 3.

Possible Explanation. Intra- and inter-cloud electrical discharges, or possibly cloud-level ball lightning in motion.

Similar and Related Phenomena. Heat lightning is also silent and confined to the clouds, but it is characterized by rapid flickering on a large scale. The moving surface patches of luminosity described in GLD4 may be related.

Examples of Luminous Patches Moving on Clouds

X1. April 12, 1939. Wellington, New Zealand. "...the writer and two friends came out of a house on Kelburn Parade, Wellington, New Zealand, altitude about 130 metres, and were immediately arrested by what appeared to be a searchlight laying on the undersurface of broken clouds lying over the Wellington Harbour. The clouds were very low fracto-cumulus, at about 200 metres, as judged by their level on the hills. As no searchlight beam was visible, one observer said that he thought that the phenomenon was due to 'lightning'....It was seen that the clouds were moving very slowly from the south, were about six-tenths in amount (mostly overhead and towards the east) and were illuminated almost continuously by silent discharges which passed comparatively slowly, like 'blushes' (though the light was whitish) over their surfaces. The slower discharges were estimated to take as long as half a second to pass over the surface of a cloud. Others were much quicker and seemed to be brighter. Occasionally a bright but silent flash passed very rapidly from one cloud to the next. Although now and then several clouds discharged simultaneously, for the most part the 'blushes' affected first one cloud and then another." (R1)

Reference

R1. Palmer, C.E.; "An Unusual Electrical Discharge at Wellington," Meteorological Magazine, 74:185, 1939. (X1)

GLD17 Ground-Level Light Flashes

Description. Quick, bright flashes of blue-green light occurring in midair a few feet from the ground. The phenomenon is silent and narrowly localized.

Data Evaluation. A single, unpublished, but careful and thoughtful account of four separate flashes. Rating: 3.

Anomaly Evaluation. This phenomenon is more than usually significant because no electrical storms were in the area and there were so other pertinent phenomena, such as earthquakes. There seems to be no mechanism for charge separation followed by a discharge emitting light. Rating: 2.

Possible Explanation. None.

Similar and Related Phenomena. Many cases of general sky flashes have been reported (GLA). Similar flashes sometimes accompany earthquakes (GLD8) and dust and snowstorms. (GLD5)

Examples of Ground-Level Flashes

X1. October 21, 1953. Alliance, Ohio. "On the evening of October 21, 1953, my brother David and I were returning home after a twilight jaunt. The full moon had risen about two hours before and was brilliantly illuminating a clear, star-filled sky. As we walked north down the east side of our street (South Seneca Avenue), we suddenly saw an instantaneous green-blue flash of light seven or eight houses down the opposite side of the street. Although most of the flash appeared to be hidden between two houses, the top of the flash and the brightly illuminated side of one of the dwellings could be seen. Assuming the light was perhaps a television tube exploding or a flashgun popping, we continued walking. After a short interval, we approached the house owned by a Mr. and Mrs. Mather. All at once another huge silent green-blue flash occurred almost opposite us to our right between the Mather house and a tall apple tree. Lasting but a split second, the flash seemed to have its center perhaps one to two meters (3 to 6 feet) above the yard. There were no wires or other objects from which the flash could have originated. The distance separating us from this second flash was, to the best of my recollection, no more than nine or 12 meters (30 or 40 feet). Needless to say, we stood there completely astonished. Seconds later a third flash exactly like the first two appeared across the street, again almost opposite our position. It occurred in mid-air on the north side of a house. This was followed almost immediately by the fourth and final flash which took place in mid-air on the south side of the same house. Again, there was no sound. We were the only ones on the street, and no one came out to investigate." Weather: very dry and unseasonably warm. (R1)

References

R1. Webb, Walter N.; Personal communication, February 12, 1979. (X1)

GLL LIGHTNING ANOMALIES

Key to Phenomena

GLL0	Introduction
GLL1	Luminous Phenomena Occurring above Thunderclouds (Rocket Lightning)
GLL2	Bead Lightning
GLL3	Colored Lightning with Unusual Features
GLL4	Silent Lightning
GLL5	Horizontal Lightning
GLL6	Lightning from a Clear Sky
GLL7	Crown Flash
GLL8	The Preference of Lightning for Certain Trees
GLL9	Lightning Figures
GLL10	Lightning Sounds (Other than Thunder)
GLL11	Lightning's Pranks
GLL12	Hot-Air Blasts Following Lightning Strokes
GLL13	Unusual Geographical Preferences of Lightning
GLL14	Black Lightning
GLL15	Slow or Prolonged Lightning
GLL16	Correlation of Lightning and Cosmic Rays
GLL17	Lightning Superbolts
GLL18	Cyclic Flashing of Lightning
GLL19	Dual Lightning Discharges
GLL20	Abnormally Long Lightning Strokes
GLL21	Anomalous Electrical Fields and Currents during Lightning
GLL22	Lightning Shadowgraphs
GLL23	Wisps of Flame Left by Lightning Strokes
GLL24	Tubular Lightning
GLL25	Meandering Lightning
GLL26	Ribbon Lightning
GLL27	Spoked and Spider Lightning
GLL28	Bipolar Nature of Large Electrical Storms
GLL29	Gamma-Ray Flashes in Thunderstorms
GLL30	Neutron Generation in Lightning Bolts
GLL31	Unusual (Usually Deadly) Interactions between Lightning and Humans
GLL32	Effects of Lightning on Vehicle Engines

GLL0 Introduction

Ordinary lightning is the rapid, concentrated discharge of electricity through the atmosphere. The adjectives "rapid" and "concentrated" must be specified to distinguish ordinary lightning from the "slow" and "diffuse" discharges of electricity that occur in aurora-like and electric discharge phenomena (GLA, GLD). Actually, some lightning phenomena cataloged below, such as thunderless lightning, may be forms of diffuse glow discharge rather than conventional lightning.

The overwhelming majority of lightning strokes occur between clouds and between clouds and the earth. A very small fraction of these discharges, however, reach upwards from the clouds towards the ionosphere and outer space. Somewhere high above the earth there seems to exist an electrical terminal for this upward-directed "rocket lightning." (Could auroras and mountain-top glows use the same unseen terminal?)

A singular and most impressive form of lightning is pinched or bead lightning. Terrestrial experiments with strong electrical currents in gases demonstrate that an electrical current can magnetically constrict itself. Quite possibly bead lightning begins as ordinary lightning and ends up strangling itself with its own magnetic field, breaking the stroke up into many brilliant beads.

Long horizontal discharges of lightning, some of which meander close to the ground, pose a serious problem in explanation, for there seems no obvious reason for lightning to digress five miles parallel to the earth's surface when the ground is only a few hundred feet straight down, or in some instances just inches away. This apparent aimlessness of some lightning strokes is counterbalanced by lightning's strange preference for oak trees and certain areas of the terrestrial surface. Do some specific regions, perhaps because of geological conditions, have a special attraction for lightning and thus entice it from afar?

Rarely, lightning will strike without warning and without a cloud in sight. In such cases, electrical charge must accumulate in the atmosphere without the usual accompaniment of water vapor in the form of visible clouds. Little is known about these invisible concentrations of electrical charge. All we know is that "bolts out of the blue" really do occur.

Thunder is usually thought to be inseparable from lightning. This is not necessarily so! The heat lightning so common on sultry summer nights is often silent, flickering eerily for hours like a defective fluorescent bulb.. This lack of sound seems to suggest that heat lightning is really a diffuse discharge of electricity rather than distant, concentrated thunderbolts.

Sounds other than thunder sometimes precede nearby lightning strikes. The rapid buildup of electrostatic forces in the lightning's target area creates brush discharge from twigs and other sharp objects, which buzzes and hums like St. Elmo's Fire, but only for an instant until the electrical stresses are relieved suddenly by a lightning flash.

Lightning shadowgraphs have been seen on surfaces exposed to intense light. The blinding light from a lightning flash may create some temporary chemical reaction on the surface that freezes silhouettes for a few minutes. Another graphic (and rather gruesome) effect of the thunderbolt is the "lightning figure", a vein-like pattern that sometimes appears on the bodies of lightning victims. In less sophisticated times, lightning figures were said to be the images of nearby trees on the skin. Today's thinking is that they are simply the branching flow of electrical currents on the body's surface. Nevertheless, the literature contains many strange stories in this area.

Finally, lightning is an unpredictable prankster; smashing a house to bits one moment and then delicately cracking eggshells but leaving the thin membrane underneath intact. It may carefully avoid a child playing on the floor and next melt all the wiring in the house. Some of these mischievous acts try the laws of science as well as one's credulity.

GLL1 Luminous Phenomena Occurring above Thunderclouds (Rocket Lightning)

Description. The appearance above thunderclouds of a suprising variety of luminous phenomena that we classify into the five categories defined below. The first category is based upon decades of visual, anecdotal sightings; the remaining four categories are based mainly upon images taken with low-light-level cameras and related scientific instruments.

(1) Rocket lighting. Upwardly directed electrical discharges usually originating in thunderclouds and terminating in the upper atmosphere. The "bolts" sometimes resemble normal cloud-to-earth lighting, but some strokes ascend in columns, "like rockets," and burst into innumerable bright fingers thus giving a name to this category. (X1-X32)

(2) Sprites. Short-duration, reddish flashes in the ionosphere often with tendrils reaching down into the thundercloud below. (X34, X35)

(3) Blue jets. Narrowly collimated, bluish beams of light that propagate upwards. (X35) The blue jets may be the basis for some of the rocket-lightning anecdotes.

(4) Elves. Doughnut-shaped flashes observed in the outer reaches of the ionosphere. (X36)

(5) Blue starters. Bright-blue flashes just above thunderclouds; like blue jets but lower in altitude. (X37)

Undoubtedly, further research on these newly recognized apparitions will result in reclassification and in all probability the definition of new phenomena.

Background. Until about 1990, above-cloud luminous phenomena, such as our so-called "rocket lightning," were generally ignored by scientists because of the anecdotal nature of the evidence for their existence. These anecdotes were the basis for this section (GLL1) in the first edition of this volume and still constitute the bulk of this revised section. Beginning in 1989, however, low-light-level cameras caught unmistakable signs of above-cloud luminous phenomena. (X31) These recently recognized phenomena are usually too faint and too rapid to be seen visually, and they are also often quite different in appearance from what we have called "rocket lightning."

Data Evaluation. In addition to the many rocket-lightning anecdotes recorded over the decades (X1-X32), scientists have accumulated thousands of photos of sprites, blue jets, etc. (X34-X37). Rating: 1.

Anomaly Evaluation. Lightning is classically viewed as an electrical discharge between two diffuse terminals---cloud and earth---which are separated by a high potential difference. While above-cloud luminous phenomena have thunderclouds as their lower terminals, it is difficult to visualize how the ionosphere above the thundercloud can behave as the other terminal for upwardly directed electrical discharges. In addition, the peculiar geometries of the sprites, elves, etc., are hard to account for. Finally, most of the many rocket-lightning observations do not seem to fit in with the sprites, elves, etc. Separate explanations may be needed here. Therefore, in terms of our theoretical understanding, this whole class of luminous phenomena is in a state of flux and must be considered anomalous. Rating: 2.

Possible Explanations. The charge-separating mechanism of the thunderstorm may extend well above the visible clouds. Intense showers of cosmic rays or, perhaps, meteors may further ionize regions above thunderclouds and trigger the subject above-cloud luminous phenomena. (GLL27)

Similar and Related Phenomena. Lightning from a clear sky (GLL6); thunderstorms correlated with space radiation (GLL27); low-level auroras (GLA4); mountain-top glows (GLD1).

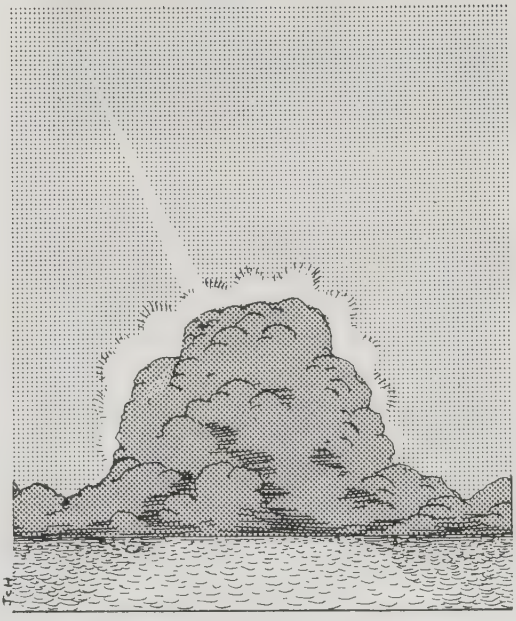
Examples

X1. August 18, 1927. West Indies. "...on running out of a heavy shower of rain, the horizon to the S.W. having been ablaze with sheet lightning all evening, again became visible and the lightning with greater play and intensity. Out of the centre of this silent confusion of light one thin streak of lightning was seen to emerge, shooting up the sky in a perfectly straight line until apparently right overhead, and then scattering at the extremity like a rocket. Unlike the usual fork lightning, it was not blinding, and gave the impression of being decidedly sluggish in its upward path." (R1, R2)

X2. February 16, 1950. Near Fiji, South Pacific Ocean. "Three or four times a remarkable phenomenon occurred. Out from the top of the cloud shot a burst of light like a firework display. The flash took several seconds to reach its maximum height at about 3,000 ft above the cloud top; it was not just a burst of light but rather a series of streamers extending from a single point at the centre of the anvil and spreading out like a water fountain. The light was so bright and so distinct that passengers and crew were entertained by the sight for several minutes." (R3)

X3. July 30, 1951. Central American Waters. "Flashes of light were observed behind a mass of Cu just above the horizon. A small sector of the sky was brilliantly illuminated and, on an average, immediately after every second flash, lines of orange-coloured flashes shot up to an altitude of 15^{o}, terminating at a layer of St. On two occasions these appeared to mushroom out at the top. The phenomenon persisted fairly regularly until 2040 A.T.S." (R4)

X4. November 19, 1951. Arabian Sea. "A brilliant greenish explosion, bearing 015^{o} (T), seemed to occur behind a large Cu, lighting it up and in particular illuminating its outer edges for about two seconds; at the same time a fiery shaft, similar to a brilliant rocket, shot up to a height of about 18^{o}. This was visible for about one second and then seemed to extinguish itself in a downward direction." (R5)



Shaft-like rocket lightning observed over the Arabian Sea in 1951. (X4)

X5. February 16, 1964. South Atlantic Ocean. "Between 0030 and 0130 GMT very vivid lightning was observed to the westward, shooting upwards from a bank of Cb cloud, as shown in the sketch." (R6)

Branching rocket lightning seen over the South Atlantic in 1964. (X5)

X6. October 13, 1967. North Atlantic Ocean. "At 0215 GMT lightning of unusual character was seen in the south-east. Instead of travelling downwards towards the sea it began at an elevation of about 35° and travelled upwards to an altitude of 45° to 50°. In some respects it resembled a firework display. No thunder was heard, nor was there any rain in the vicinity of the ship, but the radar indicated heavy rain clouds about 15 miles away and moving in a NWly direction. This unusual type of lightning was seen over a period of 3 hours." (R7)

X7. July 16, 1850. Manchester, England. Lightning travelled 6 or 7 miles, terminating in midair in a digital pattern. (R8)

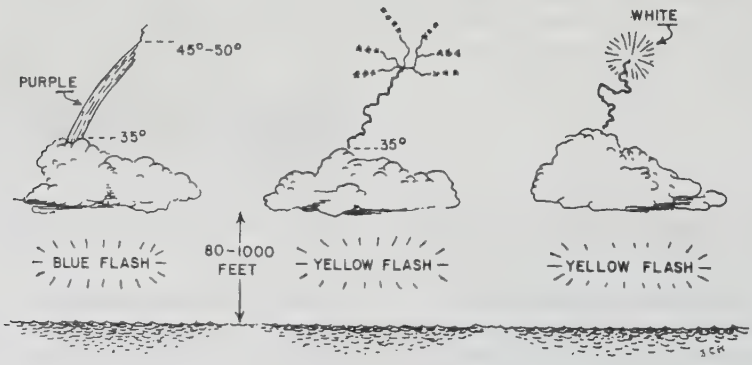
X8. Circa 1876. Wing, England. Several simultaneous flashes of rocket lightning. (R9)

X9. July 5, 1884. Duncannon, Pennsylvania. Lightning darted out into midair with digital terminations. (R10)

X10. November 23, 1885. Kingston, Jamaica. Ascending darts of lightning. (R11, R12)

X11. July 22, 1903. Calcutta, India. Rocket lightning without digital terminations. (R13, R14)

X12. General observation. Rocket lightning definitely exists. It may result when a normal bolt of lightning fails to sustain itself. (R27) This explanation would not



Three types of rocket lightning ascend from clouds over the North Atlantic. Simultaneous light flashes appeared beneath the clouds. (X6) Note that these phenomena differ in appearance from the sprites, elves, etc., introduced in X31-X37.

account or rocket lightning's upward direction and usual digital termination. (WRC)

X13. August 31, 1903. Lake Superior, Quebec, Canada. (R15)

X14. June 15, 1908. North Atlantic Ocean. The bolts burst like rockets. (R16)

X15. September 1917. Kent, England. Many reports of rocket lightning display, some from over 150 miles away. (R17)

X16. April 21, 1933. No place given. Purple flashes ending in clear sky. (R18)

X17. May 11, 1956. South Pacific Ocean. (R19)

X18. May 24, 1957. South Pacific Ocean. Up to 36 flashes per minute. (R20)

X19. May 10, 1961. Malayan waters. Thick upward flashes exploding in plumes. (R21)

X20. September 25, 1962. Mediterranean. Lightning rose from the horizon and burst into showers of sparks. (R22)

X21. March 27, 1971. Ionian Sea. Several simultaneous displays of rocket lightning. (R23)

X22. April 24, 1971. Indian Ocean. (R24)

X23. July 29, 1978. Sussex, England. The lightning branched upwards in tree-like fashion. (R25)

X24. February 7, 1945. Broome, Australia. Purple lightning like the roots of an inverted tree. (R26)

X25. 1933. Germany. (R28)

X26. No date given. Gulf of Tonkin. Pilot sees bolt of lightning shoot straight upward, like a beam of light. (R28)

X27. No date given. Near Amarillo, Texas. The following testimony came from a pilot who had a good, high-altitude view of an approaching cold front that was spawning many normal lightning discharges.

"Most of these lightning flashes were typical, occurring either inside of the clouds or with their bright channels visible. However, as I approached the front and the individual bolts could be seen in more detail, I became aware that approximately every 50th or 100th discharge would go from the top of a cloud vertically upwards through the clear air toward the ionosphere." (R29, also R28)

X28. March 17, 1992. Delta Flight 1083 from Pittsburgh to Atlanta. At approximately 8:30 PM, this flight was assumed to be flying safely high above thundercloud tops, which were situated at 20,000-22,000 feet. The pilot, W.F. Blanchard describes what he observed:

"Then, from one of these clouds, a lightning bolt appeared that changed my mind instantly. This bolt came from the top of the buildup closest to our line of flight and formed an enormous loop in the sky. It started at the top of the cloud and went well above our altitude (to at least 40,000-45,000 ft.) and then circled back down into the cloud. My impression is that it joined back into itself at the top of the cloud, but it may have returned to another of the peaks in the same cloud." (R30)

Although, we classify this as "rocket lightning," it could be just as extreme form of intercloud lightning or perhaps what we have classified as "meandering lightning" (GLL25). Most rocket lightning terminates in the upper stratosphere or ionosphere and does not loop back downwards.

X29. July 28, 1993. About 150 miles south of Panama. Time: about 0500Z. J.G. Hammerstrom was one of the pilots of a commercial flight headed north at an altitude of 33,000 feet. He wrote:

"I and another pilot in the cockpit of American Airlines Flight 912 were watching and circumnavigating a large cumulonimbus cloud. About five times, a large discharge of lightning at the top of and within the cloud was followed by a vertical shaft of blue light that propagated from the top of the cloud upward to 100,000 ft.

"The beam was very straight and the color distinctly different from the lightning. At the top of this shaft, the column fanned out just before its disappearance. All the occurrences were identical. At least one was witnessed by three other American pilots about 30 min. behind us on the same route." (R31)

X30. February 4, 1893. Queensland, Australia. The oldest account of rocket lightning that we have found comes from Down Under. J.E. Davidson was watching a thunderstorm to his south which was generating frequent lightning. He wrote:

"I was sitting on my lawn watching the distant flashes, when suddenly a patch or cloud of rosy light---5° to 6° in diameter---rose up from above the thunderstorm and mounted upwards at an elevation of from 40°-50°. There were about twenty to twenty-five of these patches in the course of half an hour, sometimes three or four in quick succession; they took from one to two seconds to mount, and were not associated with any particular flash; the rosy colour contrasted strangely with the silvery light of Nubecula Major just above. There were also occasional streamers, sometimes bifurcated, of 2° in breadth, which shot up in the same way as the auroral streamers, which I have seen both in the arctic and antarctic zones." (R32)

The rosy patches seen by Davidson were undoubtedly what are now called "red sprites."

It would be nearly a century until the reality of what we have until this point called "rocket lightning" was acknowledged by the scientific community. All of the anecdotes, even those observations of experienced pilots, were in effect cast aside as unreliable amd unlikely until the now-familiar sprites, elves, blue jets, etc. were finally captured on scientific instruments by scientists.

At this point we end our record of anecdotal observations of "rocket lightning" and turn the sprites, elves, etc., as revealed by scientific instrumentation, such as low-light video recorders. The fact that mainstream science now recognizes these apparent electrical discharges to space as legitimate phenomena does not mean there are no longer mysteries lurking high above energetic thunderstorms. Despite their fanciful new names, these discharge phenomena still pose problems of explanation.

X31. July 6, 1989. Northwestern Wisconsin. Although the anecdotes telling of upwardly directed lightning could be easily set aside by the scientific community, the following observations could not. The instrument employed was a low-light-level TC camera located some 50 kilometers northeast of Minneapolis. If one must single out an event that marks the legitimization of "rocket lightning," this is a good candidate.

"An image of an unusual luminous electrical discharge over a thunderstorm 250 kilometers from the observing site has been obtained with a low-light-level television camera. The discharge began at the cloud tops at 14 kilometers and extended into the clear air 20 kilometers higher. The image, which had a duration of less than 30 milliseconds, resembled two jets or fountains and was probably caused by two localized electric charge concentrations at the cloud tops." (R34)

The article in Science was accompanied by black-and-white photographs of what are now called "sprites." (Later color photos revealed that sprites are usually red in color.)

Note that the above discharges described above were diffuse and quite unlike most cloud-to-ground lightning discharges. They were, in fact, a bit like the mountain-top glows seen along the Andes, which may also be discharges to the upper atmosphere. (GLD1) Also, one should ask where those "localized electric charge concentrations" came from and why they did not disperse.

X32. April 28. 1990. Over Africa, as seen from the Space Shuttle. Scientific skepticism about upwardly directed electrical discharges receded as more observations accumulated. We now present a few excerpts from a report describing images of the phenomenon taken from orbit.

"Video images from space showing a single upward luminous discharge into the clear night air above a thunderstorm were recorded for the first time during the Space Shuttle STS-32 mission, and later during the STS-31 mission and other missions using the shuttle's payload-bay TV cameras.

.....

"Figure 1 [impossible to reproduce] shows the upward luminous discharge

that was seen to move out of the top of a single thunderstorm during the flight of STS-31. This video image was taken at 0335:59 UTC 28 April 1990 while the shuttle was on its 55th orbit and passing over Mauritania, northwest Africa.

.....

"The storm that had the luminous discharge was located at approximately 7.5°N, 4.0°E, and was about 2000 km from the shuttle's position. The lightning discharge was determined to be at least 31 km long.

.....

"We are now trying to understand the significance in relationship to the earth's atmosphere and the global electric circuit." (R35)

Somewhere 31 kilometers above the thundercloud, there must have been a concentration of electrical charge that acted as a "terminal" for the bolt. How did it get there? This is probably a naive question, because the electrical environment above powerful thunderstorms seems to be very complex.

X33. September 22-23, 1989. Southeastern North America. Anomalous flashes were detected above Hurricane Hugo by Minnesota-based SKYFLASH equipment. Hurricanes, of course, are accompanied by thunderstorm activity, and these flashes are assumed to be a form of upwardly directed electrical discharges.

Said apparatus consists of three photmetric telescopes using photomultiplier tubes with 19-inch parabolic mirrors. A variety of light pulses appearing in the night sky have been recorded during SKYFLASH surveys. The most puzzling types of flashes were the "long" events, which lasted about 20 milliseconds, with slow rises and falls. During the "long" flashes, no sferics (radio disturbances) are detected, whereas the more common shorter flashes are accompanied by sferics. However, during Hurricane Hugo, these mysterious "long" flashes occurred much more frequently than usual. The origin of the "long" flashes remains unknown.

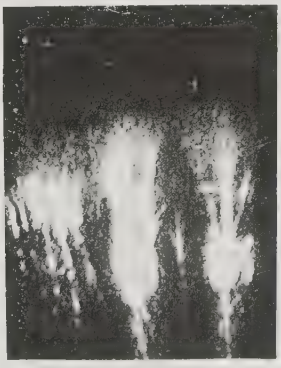
X34. 1994. General observations of the scientific status of the subject phenomenon. An overview in Eos, a publication of the American Geophysical Union, by J. Wakefield.

"Until a few years ago, the only place mysterious flashes high above thunderclouds received much respect was in the pages of the Handbook of Unusual Natural Phenomena. Although over the course of the past century there were various anecdotal accounts scattered in the scientific literature, most scientists didn't take reports of upward-shooting lightning seriously.

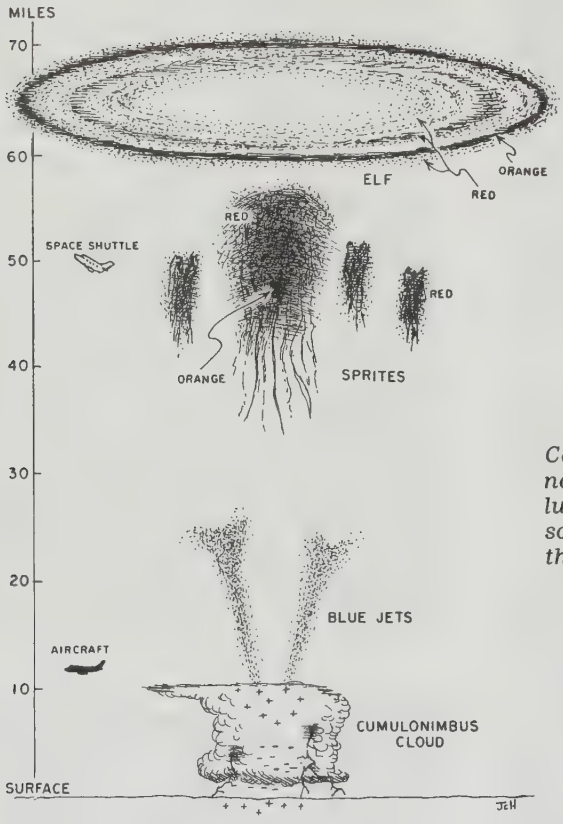
"Nowadays, all that has changed, however. In the very-hard-core atmospheric research arena, the luminous discharges are taking center stage. And scientists no longer think that the elusive flashes are rare or isolated events. In fact, in the past couple of years, scientists from four institutions have put more than 1000 sightings of the so-called "sprites" in the files." (R39)

In this overview, Wakefield defined briefly the two different types of discharges that had been identified as of 1994. The data she refers to had been collected by low-light-level cameras aboard jet aircraft flying over storm clouds in the U.S. Midwest.

"From the flight data, two distinct types of flashes seem to stand out: sprites, which are predominantly red in color and reach up to about 90 km above the storm clouds, and blue jets, which are narrowly collimated sprays or fans of light that begin at the top of the anvil and propagate upward to about 45 km at speeds of about 100 km/s." (R39)



Black-and-white photograph of three sprites rising above a thundercloud. (X35)



Composite sketch of three now-recognized types of luminous phenomena that sometimes occur above thunderstorms. (X34-X37)

X35. General observations. As outlined above, the sprites are short-duration, reddish flashes in the ionosphere. Sometimes the sprites exhibit bluish tendrils extending down into the thunderclouds. The sprites are often accompanied by "blue jets," a second class of upwardly directed discharges. The blue jets are described in more detail in a 1995 paper by E.M. Wescott et al. Here is their abstract:

"Initial observations of as newly documented type of optical emission above thunderstorms are reported. 'Blue jets,' or narrowly collimated beams of blue light that appear to propagate upwards from the tops of thunderstorms, were recorded on B/W and color video cameras for the first time during the Sprites94 aircraft campaign, June-July 1994. The jets appear to propagate upward at speeds of about 100 km/s and reach terminal altitudes of 40-50 km. Fifty-six examples were recorded during a 22-minute interval during a storm over Arkansas. We examine some possible mechanisms, but have no satisfactory theory of this phenomenon. (R44)

X36. 1995. Discovery of "elves." The name of this new phenomenon, also observed frequently above thunderstorms, is cute, but as an acronym it is a bit forced. Elves = emissions of light and very low frequency perturbations due to electromagnetic pulse sources!

R. Monastersky provided a more palatable description in Science News in the December 23/30, 1995, issue.

"Scientists have discovered a new kind of lightning that flares in the shape of a doughnut at the outer reaches of the earth's atmosphere. These fleeting flashes---too quick to be seen with the naked eye---join an ever-growing roster of electric fireworks detected in the night sky high above thunderstorms." (R45)

Elves are short-lived, flashing for

less than a millisecond at heights of 70-100 kilometers. Elves often occur in conjunction with sprites, but sometimes appear alone.

X37. 1996. Announcement of the discovery of "blue starters." Blue starters, a fourth type of luminous phenomena seen above thunderstorms (after sprites, blue jets, and elves), were reported by E.M. Wescott et al in the August 1, 1996, issue of Geophysical Research Letters.

"On the night of 30 June (UT 1 July) 1994, 30 examples of these events, which we have called 'blue starters,' were observed in a 6 m 44s interval above the very energetic Arkansas thunderstorm where blue jets were first observed. The blue starters are distinguished from blue jets by a much lower terminal altitude. They are bright and blue in color, and protrude upward from the cloud top (17-18 km) to a maximum 25.5 km (83,655 ft.) in altitude." (R51)

X38. Potential triggering phenomena. The four types of luminous phenomena outlined above (there will probably be more) might actually be triggered by external events; meteors or cosmic rays, in particular. In other words, the upper atmosphere may at times act like a triggered spark chamber.

In this view, the luminous phenomena seen in the electrically disturbed region above powerful thunderstorms occur mainly when ionization is added to the region by the passage of a small meteor or the absorption of powerful cosmic rays. The possibility that the red sprites might, for example, be triggered phenomena is suggested by the fact that they occur at a rate 200-400 times less than the normal downwardly directed lightning. (R48)

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GLL2 Bead Lightning

Description. Lightning strokes that appear to dissolve into many luminous segments, usually spherical but sometimes rectangular, as the stroke fades away. In some cases, the long lines of bright beads seem to appear without any precursor normal lightning stroke. In both cases, the beads may persist for 1 to 2 seconds. Also called pearl lightning, chain lightning, segmented lightning, punctuated lightning, pinched lightning, perlschnurblitz, eclair en chapelet, and other names.

Background. Like ball lightning, bead lightning was long doubted as a real physical phenomenon. Some scientists claimed it was simply a form of afterimage resulting from the intensity of the lightning flash.

Data Evaluation. Abundant visual observations and photographs exist. There are, in fact, so many accounts that no special effort has been made to enlarge the bibliography below, which must be considered as only representative. Rating: 1.

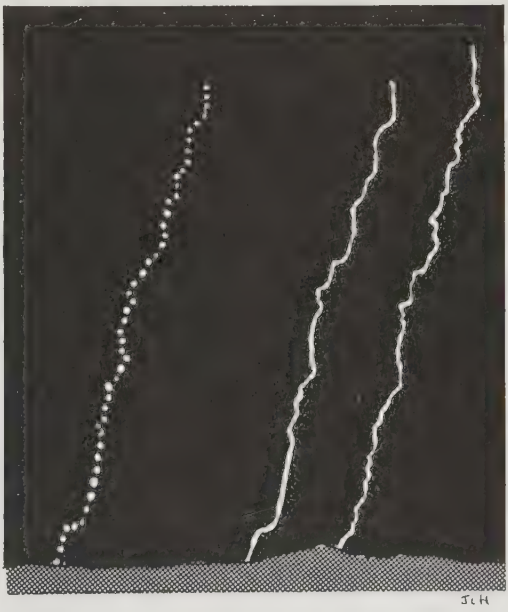
Anomaly Evaluation. While spherical segments may yield to explanations from plasma physics, the sharply defined rectangular links do not seem to have ready explanations. Rating: 2.

Possible Explanations. Spherically segmented lightning or bead lightning may result from longitudinal waves set up in an ordinary lightning stroke by some perturbation. (R16) The so-called pinch effect, well known from plasma physics, may cause some constrictions in lightning strokes. In the past, observers maintained that the string of glowing beads was formed of burning bits of matter remaining after the lightning stroke.

Similar and Related Phenomena. Ball lightning (GLB1).

Examples of Bead Lightning

X1. August 18, 1876. Paris, France. During a violent thunderstorm with a great variety of lightning strokes. "Some of the most remarkable passed from the cloud to the ground in the form of an elongated S, lasting for an appreciable instant, like a string of brilliant grains distributed along a narrow luminous string. Observed from the heights of Meudon, this lightning appeared to strike Paris in the direction of Vaugirard, where it fell. This formation of luminous beads alternating with streaks of fire---a consequence of the electric fluid passing through a ponderable medium---is altogether analogous to a string of incandescent globules presented by a long metallic wire melted by a voltaic current, the extremities of which remain suspended an instant in a state of fusion at the poles of a pile or to the swellings and knots resulting from the flowing of every liquid vein. Such agglomerations of electrised and luminous matter should naturally dissipate themselves more slowly than the bolt that develops them, which explains their persistence in this case." (R1, R8)



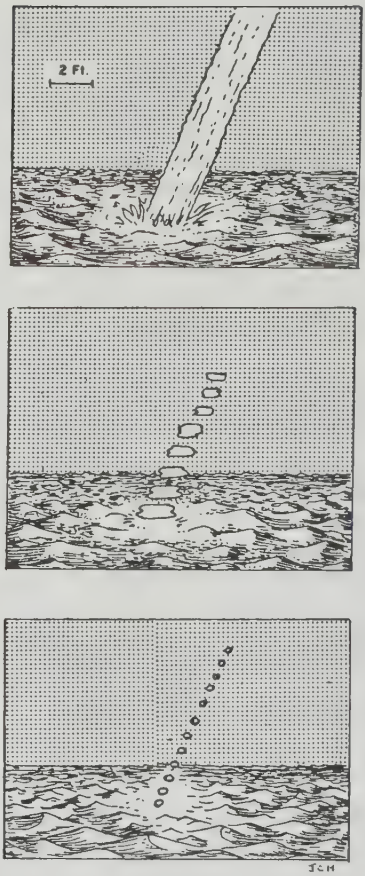
Denver, 1894. (Right) Two parallel strokes of lightning. (Left) One has disappeared while the other has broken up into a string of beads. (X2)

X2. Circa 1894. Denver, Colorado. "To-day while driving over the country midst a terrific thunderstorm, I observed many fine flashes, one instance of which deserves particular mention. Two substantially parallel simultaneous flashes, somewhat wavy, seemed to pass toward the Earth. Length about 40^{o}, distance apart about 7^{o}, both brilliant, but not blindingly so. Both, as lines of light, vanished instantly, but the one to the right broke into a multiplicity of what seemed to be spheres. This string of beads, as it seemed, appeared to be formed of material furnished by the original flash." (R2)

X3. July 26, 1929. Balboa Channel, Central America. "At 2.15 (75th Mer. Time., approx.) a flash of lightning on the port hand appeared to enter the sea about 100 yards from the vessel. It appeared as a stream of molten metal being poured from a height into the sea and of about one to two feet wide. It first made a peculiar shattering noise (as a china plate would make on a stone floor), then, as it broke up the noise was a sizzling sound (as fat being thrown on a fire), On breaking up it appeared as a disjointed spinal column and the sea as if water was being poured into it." (R3, R4)

X4. December 5, 1935. Johannesburg, South Africa. "During the height of the storm. a particularly bright flash struck the ground about a hundred yards away; the flash appeared to be approximately a foot wide and to last for at least a second. After the flash had died away, there remained a string of bright luminous beads in the path of the flash. The beads, of which there were twenty or thirty, appeared to be about a quarter of the width of the flash, that is, say, three inches in diameter. The distance between the beads, which appeared to be nearly constant, seemed about two feet. They remained visible for approximately half a second; during this time they gave no indication of any movement." (R5)

X5. General observations. Berchetesgaden, Germany; Lake Lucerne, Switzerland, and Jackson, New Hampshire. "Each of these three storms was exceptionally violent, among the most violent I have ever witnessed.



In 1929, the crew of a vessel in Central American waters saw a thick "stream" of lightning break up into brilliant segments. (X3)

The phenomenon was observed only with flashes which were comparatively close, within perhaps 2,000 feet. In each storm several flashes left beaded trails, but not every flash which struck near by exhibited that peculiar appearance. I would estimate the time during which the beads remained visible as at least one second, a time amply sufficient to observe distinctly. It appeared to me that the entire course of the flash remained luminous, with a dull red glow, but that at intervals along the path bright points like sparks appeared to remain suspended in the air. The sparks appeared to be moving horizontally as though blown along by the wind." (R6)

X6. Circa 1838. Suffolk, England. Punctuated lightning. (R7, R8)
X7. June 19, 1857. London, England. Flashes persisted, melted into granular light. (R1)
X8. Circa 1871. London, England. (R9)
X9. August 24, 1873. Hampstead Heath, England. Chain lightning, links faded away gradually. (R8, R10)
X10. August 16, 1877. Southport, England. Stroke composed of small detached fragments. (R8, R11)
X11. September 5, 1880. Vegesack, Germany. (R8)
X12. July 5, 1888. Celle, Germany. (R8)
X13. October 1, 1892. Gottingen, Germany. (R8)
X14. September 1894. Schwanden, Switzerland. Small, regular pieces of light. (R8)
X15. May 27, 1907. Calexico, California. (R6)
X16. August 15, 1907. Grenoble, France. (R6)
X17. Spring 1914. Lincoln, Nebraska. (R12)
X18. October 3, 1927. Paraguay. (R13, R14)
X19. August 1961. Los Alamos, New Mexico. Photo taken of pinched lightning. (R15)
X20. July 17, 1908. Chicago, Illinois. Analysis of a photograph of bead lightning revealed the average bead length to be 36.5 feet, with an average separation of 14.6 feet. (R17)

X21. September 9, 1895. Pitlochry, New Brunswick, Canada. Testimony of a cyclist at dusk on a very hot day.

"At ten o'clock there suddenly came on a terrific thunderstorm. Crash succeeded crash, and the lightning, of all colours, blazed almost continuously. Objects fifteen miles off could be seen plainly, if not more so, than in bright daylight. The rain soon turned the road into a torrent, and my electric lamp failed to act properly. But the chief peculiarity was the occurrence of eight strange flashes of a chain formation, with large elliptical links, and of a golden-yellow colour. These flashes were not rapid in their passage, as ordinary lightning is wont to be, but one of them took slightly over a minute to pass from the clouds to the edge of the valley opposite me. Two of these chains of living, burning gold passed between adjacent clouds, while the remaining six came to earth, one in the field just beside me." (R18)

The appearance of very slow lightning means that this anecdote could just as well have been included in GLL15. In fact, the timing of lightning bolt described above is questionable. It is just too long!

X22. February 17, 1900. Coonabarabran, Australia. Observation of an astronomer at the Siding Spring Observatory.

"I stepped outside to examine the possibility of recording lightning on video. After a short time, there was a brilliant flash behind me, and, on spinning round, I saw a 'zigzag' trail of perhaps 30 small orange balls, quite evenly spaced, outlining the path of the lightning stroke. The balls looked of uniform size, with the higher balls being fainter and of smaller angular diameter. Towards the bottom end, the balls were about half the angular diameter of the moon." (R19)

X23. February 17, 1988. Abu Dhabi, United Arab Emirates.

"On the evening of 17 February 1988, my wife and I were watching a thunderstorm from our apartment window. The storm was particularly active with lightning flashes every 10 or 15 seconds and took place during a four-day spell of exceptionally stormy weather in the area. At 10.35 pm we saw one particular lightning stroke which passed horizontally from cloud to cloud clearly visible underneath the cloud base. For a period of a couple of seconds after the stroke had stopped, a string of bright balls of light remained in the sky along the path of the lightning stroke. There were approximately 20 balls visible before they all disappeared at the same time. A colleague also saw the storm from his house 3 km away and also reported a similar phenomenon except that he thought that the line of balls was displaced slightly to one side of the path of the lightning stroke." (R20)

X24. No date or place given. B.L. Kershaw recollected a personal observation of chain lightning and suggested an explanation. First, his observation:.

"One particularly bright ground stroke appeared as a remarkably regular sinusoid curve, the x-axis roughly vertical, with many, perhaps 30 or 40 cycles between cloud and ground. This faded quite slowly, taking maybe two or three seconds, and the parts nearest the 'x-axis' faded first, leaving the curves around the maxima and minima forming a zig-zag dotted line.

"Both the original brightness and slow fading suggest this stroke conveyed a heavy and continuing current. I interpret the sinusoid as the perspective view of a helical discharge channel, suggesting electrons spiralling in a magnetic field (but what caused the field?). As this faded, sections at right angles to the line of sight, forming the parts of the curve nearest the 'x-axis', became invisible first, while light from sections along the line of sight, around the maxima and minima, still added up to visibility." (R21)

References

R1. Lake, J.J.; "Beaded Lightning," English Mechanic, 24:234, 1876. (X1, X7)

R2. Steward, J.J.; Popular Astronomy, 2:89, 1894. (X2)

R3. Morgan, W.H.; "Thunderstorm," Marine Observer, 7:146, 1930. (X3)

R4. Barlow, E.W.; "Thunderstorms at Sea," Marine Observer, 12:49, 1935. (X3)

R5. Beadle, D.G.; "A Curious After-Effect of Lightning," Nature, 137:112, 1936. (X4)

R6. Lockyer, William J.S.; "Beaded or Pearl Lightning Flashes," Knowledge, 5:53, 1908. (X5, X15, X16)

R7. Lawrence, E.J.; "Remarkable Form of Lightning," Nature, 18:278, 1878. (X6)

R8. Lockyer, William J.S.; "Beaded or Pearl Lightning Flashes," Knowledge, 4:121 and 4:145, 1907. (X6, X9-X14)

R9. "Beaded Lightning," English Mechanic, 24:291, 1876. (X8)

R10. Smith, B. Woodd; "Remarkable Form of Lightning," Nature, 18:302, 1878. (X9)

R11. Joule, B. St. J. B.; "On a Remarkable Flash of Lightning," Nature, 18: 260, 1878. (X10)

R12. Humphreys, W.J.; "Various Appearances of Lightning," English Mechanic, 108:84, 1918. (X17)

R13. Talman, C.F.; "The Strangest Lightning," American Meteorological Society, Bulletin, 12:130, 1931. (X18)

R14. "Strange Kinds of Lightning," Literary Digest, 111:22, October 10, 1931. (X18)

R15. Matthias, B.T., and Buchsbaum, S.J.; "Pinched Lightning," Nature, 194:327, 1962. (X19)

R16. Barry, James Dale; Ball Lightning and Bead Lightning, New York, 1980.

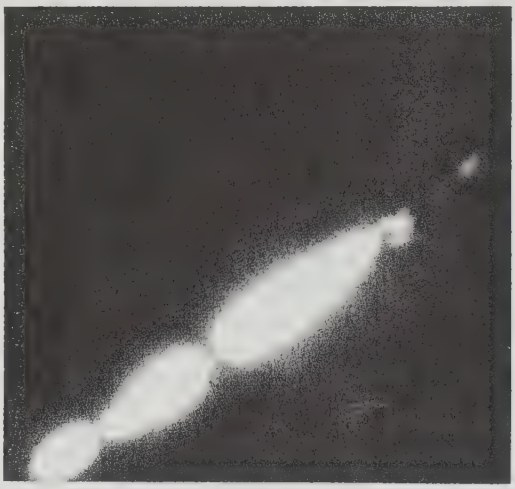
R17. Abbot, C.G.; "Remarkable Lightning Photographs," Smithsonian Miscellaneous Collections, 92:1, no. 12, 1934. (X20)

R18. Crawford, William; "Lightning--- Chain Formation," Journal of Meteorology, U.K., 17:310, 1992. Source cited: Nature, 53:5, 1895. (X21)

R19. Mcnaught, Robert H.; "Orange Sky...," Nature, 352:368, 1991. (X22)

R20. Lewis, M.P.; "Unusual Lightning Events," Weather, 43:272, 1988. (X23)

R21. Kershaw, B.L.; "Strong Theory," New Scientist, p. 53, October 14, 1995. (X24)



Still-camera photograph of pinched lightning. (R15, J.D. Barry)

GLL3 Colored Lightning with Unusual Features

Description. Yellow, red, blue, and green lightning possessing additional unusual characteristics, such as single strokes with more than one color. Red and yellow lightning are rather common, green is rare; but no colored lightning can be considered anomalous unless it possesses other puzzling features.

Data Evaluation. The unusual cases of colored lightning singled out below are one-of-a-kind. Rating: 3.

Anomaly Evaluation. The examples presented were selected for curiosity value. Rating: 3.

Possible Explanations. The color of lightning depends upon the composition of the air and the temperature of the lightning channel. Red lightning, for example, occurs when hydrogen derived from water vapor is excited electrically and emits red light. The degree of excitation along a lightning stroke may vary, creating the possibility of different colors in the same bolt of lightning.

Examples of Colored Lightning with Unusual Features

X1. August 1890. England. Red, yellow, and blue lightning in the same part of the sky, indicating local changes in atmospheric composition or lightning temperatures. One flash was yellow with a blue center. (R1)

X2. May 13, 1906. Somerset, England. Flashes of dull, "nonluminous', red lightning which was not synchronized with any of the thunder. Normal lightning occurred at the same time. (R2)

X3. October 6, 1927. Brantford, Ontario. Lightning flash began as white at the top and turned vivid green at the bottom.(R3)

X4. General observation. Red lightning seems to set very few forest fires. Since the red color is due to hydrogen from water vapor, the author concluded that red discharges occur in precipitation which would naturally suppress any fires that were started. (R4)

X5. Possible explanations of colored lightning by M.A. Uman, an authority on lightning in general.

"Reports of red, green. or blue lightning are not unusual. Although at present there is no certain explanation for these observations, we can make some educated guesses. Both the lightning source and the optical propagation path between the lightning and the viewer influence the observed color. Most lightning is perceived to be white. A typical lightning channel is hot (35,000° K) and bluish in the early microseconds of its history and with time becomes cooler and redder. Thus strokes of unusually short duration will tend to be bluer than long duration lightning which will tend to look red. Further, much of the red component in lightning is due to radiation of the H-alpha line of hydrogen.

"The amount of water vapor in the air, the source of hydrogen in the lightning channel, can, therefore, influence the color. Lightning observed through a long air propagation path looks reddish because the blue light originally radiated by the source is preferentially scattered from the line of sight. Different scattering media, e.g., various forms of precipitation and atmospheric pollutants, may yield the appearance of lightning of various colors. Additionally, corona processes in the cloud, either associated with lightning or not, can result in colored glows in localized parts of cloud. (R5)

References

R1. Pincott, Frederic; "Red, Yellow and Blue Lightning," Knowledge, 13:237, 1890. (X1)

R2. Boys, H.A.; "Red Lightning," Meteorological Magazine, 60:191, 1925. (X2)

R3. Stephenson, H.H.; "Green Lightning," Nature, 120:695, 1927. (X3)

R4. Humphreys, W.J.; "White Lightning

Versus Red as a Fire Hazard," Monthly Weather Review, 59:481, 1931. (X4)
R5. Schlatter, Thomas; "Why Is Some Lightning Colored?" Weatherwise, 36:307, 1983. (X5)

GLL4 Silent Lightning

Description. Silent, rapidly flickering, diffuse lightning, usually occurring from cloud to cloud. Silent lightning, which is also called summer or sheet lightning, resembles a large area, slow discharge of electricity as opposed to the usual highly concentrated lightning stroke. Subdued rumbling sometimes accompanies this variety of lightning, but there are no loud peals of thunder.

Data Evaluation. Silent lightning is very common. The examples offerred below have been selected because they emphasize the slow discharges of electricity on massive scales, which is evident only from good vantage points, such as mountain tops. Rating: 1.

Anomaly Evaluation. Although silent, sheet lighting is a recognized form of lightning, it is not generally appreciated that it has the characteristics of slow, large-area discharges and is not accounted for by conventional theories of lightning discharges. Rating: 2.

Possible Explanations. Slow, large-area discharges of electricity.

Similar and Related Phenomena. Mountain-top glows (GLD1), low-level auroras (GLA4), earthquake lights (GLD8), tornado lights, especially the neon-tube-like glows in funnels (GLD10). Luminous patches seen on the horizon, sometimes called weather lights (GLA16), may derive from distant sheet lightning.

Examples of Silent Lightning

X1. July 19, 1899 and August 10, 1899. Shanghai, China. The July 19 event. "The northern sky was in an almost constant blaze of light. Flashes came sometimes from two centres, as though there were an elliptical area of disturbance from whose foci were sent forth the shafts of lightning. At times these flashes would take the opposite course, and starting from the circumference make their way to the foci. Though the lightning flashes reached within twenty-five degrees of the zenith, and were vigorous enough in all conscience, yet nothing but the faintest rumbling could be heard. On August 10, the reflection of lightning was seen from the S.W. and gradually increased in brightness until at about 7.50 it had reached the zenith... the lightning played over nearly the whole of the exposed sky, sometimes six or seven streamers at a time lighting up the sky. They were different in appearance from ordinary forked lightning, having rather the appearance of a network of ribbons crossing the exposed sky in all directions, like the discharges in a vacuum tube. The most unusual circumstance was that these discharges, though most vivid, were almost noiseless, and could scarcely be heard above

the ordinary jinrickshaw traffic of the street, the only accompanying sound to the brightest display even in the zenith being a low rumbling, as of ordinary very distant thunder." (R1)

X2. August 26, 1900. Gapland, Maryland. "I saw the most beautiful display of lightning without thunder; the flashes appeared in the southwest corner of the valley known as Middletown Valley, followed the Potomac River and mountains on the Virginia side, then passed to the Blue Ridge at Weverton and followed the mountain top, making a circuit of at least 60 miles, this appeared to occur twice, when gradually the flashes spread, as it were, to the valley, in appearance resembling the discharge of a roman candle. This most beautiful phenomenon lasted from about 7 to 10:30 p.m., and when near the house the light was so vivid that at times one could easily have read a book." (R2)

X3. October 3, 1927. Paraguay. After describing an immense display of streak and bead lightning. "Dr. Knoche tells also of various anomalous phenomena seen during this display, including curious, rapidly-moving orange-colored discharges, which he says resembled cylindrical masses of glowing gas; flashes that revolved like pinwheels; and, at one period of the storm, hundreds of luminous arcs crowded together near the zenith, so dazzling in their brilliancy that he had to close his eyes. Strange to say, this spectacular display went on for hours without thunder. A ghastly quiet prevailed; not a breath of air stirred." (R3)

X4. No date given. Shanghai and Madagascar. "But the most remarkable instance occurred in May, off the south coast of Madagascar, when, from 7 to 11 p.m., I watched a glare, which left the sky dark for only a second once in an hour or so, the central point of which seemed elevated 10^{o} or 15^{o} above the horizon. As the nearer clouds cleared away, I watched for hours the unceasing flashes, tongues of fire darting out and around the distant clouds, radiating in five or six distinct streams of flame from a given point, like the thunderbolt in the hand of Jove, coursing along the sky, or dashing down into the sea at the horizon like liquid fire; yet all the while not a sound was heard." (R4)

X5. No date given. Italy. Describing the passage of two formations of clouds. "When the clouds from the south passed those from the northwest the flashes passed between the strata of cloud so rapidly and yet so silently as to produce the appearance of majestic columns of light, lasting in some cases as much as 7 seconds. Prof. Mandoj supposes that the two clouds were charged with electricity of the same kind, but as they were moving in different directions they might be compared to an immense electrical machine, of which the upper cloud was the conductor, the lower the disc, and the wind the motive force. The moisture of the air served as a conductor for a continuous silent discharge of the electricity that was induced by the motion of the clouds." (R5)

X6. No date given. Montenegrin highlands. "On these nights, the lightning was so incessant and vivid that we were able to walk about, choosing our way among the stones and shrubs as readily as by daylight, the intervals between the flashes being, I should judge, never more than a minute, while much of the time they seemed absolutely continuous, the landscape being visible in all details under a diffused violet light. Looking overhead, the movements of the lightning were easily discernable, the locality of the discharges varying from one part of the vault to another in a manner which it was impossible to confound with the reflection of lightning from a distance. Like the storm of last night, those were followed by copious rain, but not a single peal of thunder was heard during the whole night." (R6)

X7. No date or place given. No thunder heard from an intense thunderstorm seen over a town 10-11 miles away. Later, the town's residents claimed normal thunder prevailed. (R7) Anomalous sound propagation might have put the observer in a silent zone.

References

R1. Nature, 60:511, 1899. (X1)
R2. "Notable Lightning," Monthly Weather Review, 28:290, 1900. (X2)
R3. Talman, C. F.; "The Strangest Lightning," American Meteorological Society, Bulletin, 12:130, 1931. (X3)
R4. Collingwood, C.; "Silent Lightning," Knowledge, 4:381, 1883. (X4)
R5. "Columnar Lightning," Franklin Institute, Journal, 113:150, 1882. (X5)
R6. "Lightning without Audible Thunder," Popular Science Monthly, 24:575, 1884. (X6)
R7. "Silent Lightning," Knowledge, 4:308, 1883. (X7)

GLL5 Horizontal Lightning

Description. Lightning that travels horizontally many times the cloud-to-earth distance before striking the earth. Many apparently inviting targets, such as church spires and tall chimneys may be bypassed in favor of distant low-level targets located miles from the cloud-of-origin and often in bright sunlight.

Data Evaluation. Only a handful of good cases have been found. Rating: 2.

Anomaly Evaluation. The curious aspect of this phenomenon is the avoidance of what would seem to be much more attractive targets. Doubtless no laws of physics are in danger here, but horizontal lightning does hint at unusual meteorological conditions. Rating: 3.

Possible Explanations. Paths of especially low electrical conductivity may be created by air circulation well away from the visible clouds. Ionizing radiation and even meteors might be involved. Something distorts the normal cloud-to-earth electrical circuit.

Similar and Related Phenomena. Lightning from a clear sky (GLL6), rocket lightning (GLL1), meandering lightning (GLL25).

Examples of Horizontal Lightning

X1. July 16, 1873. Hereford, England. "About 10 a large cumulus rose in W.S.W., and broke into rain about 5 miles from this place, its summit at the same time, as is usual in incipient storms, assuming the cirriform appearance. The first thunderclap soon followed, and was succeeded by seven or eight others as the storm travelled to N.W. The sky overhead was quite clear, and also over Hereford, 3 miles east of this place, and the storm-cloud had a very isolated appearance, though there were other distant clouds on the horizon. I was standing in my garden watching the distant lightning, when a flash left the cloud 2 or 3 miles to W.N.W. of this place, passed almost directly overhead, but a little to N.E., and descended upon Hereford, traversing in a horizontal direction a space of about five miles of clear blue sky devoid of cloud.... Hereford lies comparatively low, and the electric fluid travelled near the earth over high ground covered with trees, buildings, &c.; avoided All Saints' and St. Peter's spires, very near which it must have passed, and singled out a house in the more eastern part of the city. The house struck is lower than the

At Hereford, England, in 1873, horizontal lightning struck a house 5 miles away from the cloud of origin, as shown in this artist's sketch. (X1)

others in the same row, and the adjoining house on the west has much higher chimneys.....As observed here, the flash appeared straight, almost resembling a rocket fired horizontally, but Mr. Isbell informs me that as seen in Hereford it was very zigzag, and seemed to come along near the ground." (R1)

X2. July 23, 1926. Near Bloomington, Indiana. After a stroke that killed two children. "They had heard no thunder previous to this stroke and heard only two or three of distant thunder afterwards. At the time of this stroke we were having frequent strokes of lightning and thunder here at Bloomington and we had 0.23 inch of rain....The lightning was severe. Witnesses near where the children were killed say the lightning travelled horizontally from north to south. It passed three buildings, missing them by about 100 feet, and struck this little house just above the top of the corner foundation post." (R2)

X3. May 14, 1965. Malacca Strait. "At 2040 GMT, a single jagged flash of lightning was seen coming from a well developed Cb cloud with anvil, several miles to the southwards. Instead of following the normal cloud-to-earth direction, this flash appeared to begin in a horizontal direction, curving to earth a considerable distance to the east and well clear of the cloud itself." (R3)

X4. July 7, 1969. Lugano, Switzerland. "Lightning strikes downward, as everybody knows, and sometimes up. But there is now at least one authenticated record of a bolt that struck sideways. Nor was this the only peculiar aspect of the freak flash. It took off upward, from a 92-meter-high television tower atop Mt. San Salvatore just south of Lugano, inscribed a complete loop in the sky and finally shot off to the west for about two kilometers. It also lasted an unusually long time---more than a tenth of a second, compared with most bolts which are measured in millionths of a second." (R4)

References

R1. Ley, W. Clement; "Extraordinary Flash of Lightning," Symons's Monthly Meteorological Magazine, 8:106, 1873.(X1)
R2. "A Lightning Stroke Far from the Thunderstorm Cloud," Monthly Weather Review, 54:344, 1926. (X2)
R3. Cook, J.W.; "Lightning," Marine Ob-

server, 36:53, 1966. (X3)
R4. "A Strange, Looping, Sideways Lightning Bolt," Science News, 104:105, 1973. (X4)

GLL6 Lightning from a Clear Sky

Description. Lightning discharges that appear to originate in clear portions of the sky. Thunder often follows such discharges, but not always. Most examples cited involve well-defined bolts, but other flashes are diffuse, like heat lightning.

Data Evaluation. Many observations. Rating: 1.

Anomaly Evaluation. Lightning usually originates in visible thunderclouds, where convection cells exist for separating electrical charge. Lightning from a clear sky implies that charge separation can occur without other visible phenomena. Rating: 3.

Possible Explanation. Invisible convection currents may be sufficiently strong so that strongly charged regions of the atmosphere are built up. Extraterrestrial radiation might conceivably contribute ionizing particles.

Similar and Related Phenomena. Horizontal lightning (GLL5), general sky flashes (GLA), rocket lightning (GLL1).

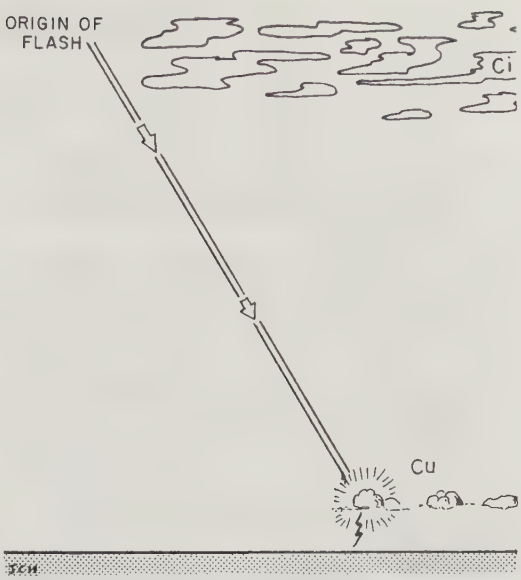
Examples of Lightning from a clear Sky

X1. September 10, 1909. Cyprus. "I was riding along the foothills to the south of Mount Troodos at an elevation of about 3000 feet about 10.30 a.m. on September 10, 1909, when straight in front of me I distinctly saw this flash. It was exactly similar to the ordinary flash usually seen against a dark thundercloud. It was followed by a very sharp crash of thunder, so that there can be no doubt it was an electric discharge. Heavy thunderclouds were then forming on the high mountains to the side, and low thunder was rumbling continuously, but the flash was quite away from these clouds and where the sky was entirely blue." (R1)

X2. July 2, 1927. Missoula National Forest, Montana. From a report of topographic mapmakers. "As they were making one of these observations toward a point southeast of Gold Peak both men saw a flash of lightning strike the ground almost on their line of alidade sight, and about 15 miles from them. This flash was followed by four others within the next few minutes. The first strike started a forest fire, the others did not. The phenomenon was most peculiar because all of these strikes descended almost vertically, apparently out of a blue sky, the nearest clouds being about 15 and 25 miles, respectively, from the area

struck.... These lightning bolts, all of which struck within a small area not over half a mile in diameter, appeared to descend vertically, and they were not between the two clouds, but in a northeasterly direction and over 15 miles from them. No thunder was heard from these flashes, and no further bolts were seen." (R2)

X3. July 21, 1952. Near the Canal Zone. Observer in a twin engine metal aircraft. "I was at 5,000 feet altitude and had 5,000 feet of very small steel cable trailing behind the aircraft with a cloth sleeve attached. I was flying on a heading of 270 degrees magnetic, and off in the distance (about 50 miles) I noticed a flash of lightning. About two minutes later the plane I was flying was struck by lightning. The plane lurched and I was blinded momentarily. The lightning struck the plane on the left side of the nose and traveled down the side to the rear. It passed on to the small cable at the rear of the plane and completely demolished it by burning it to a crisp. My ordnance man reported that we had lost all the cable. I looked back and there was a trail of smoke to the rear about 2,000 or 3,000 feet caused by the burning cable.... It is to be noted that no precipitation was encountered for more than one hour prior to the discharge and there were no clouds of any type present at my location." (R3)



In 1956, the crew of a vessel in the North Atlantic saw lightning from a clear region of the sky strike a cloud, which then generated a normal cloud-to-earth flash. (X4)

X4. October 17, 1956. North Atlantic Ocean. Two cloud layers: high cirrus (Ci) and low cumulus (Cu). "Lightning started to flash from a point slightly behind the Ci and travelled in a path about 30° from the vertical in an absolutely straight line, at what seemed to be a comparatively slow speed, towards the small Cu. It appeared to enter the Cu and then reappear, moving downwards in a different direction at normal speed. The lightning track from the Cu, which had a greenish glow when 'hit', did not seem to be so wide as the original one. Similar flashes occurred at regular intervals of between 2-3 min and each followed the same path to the Cu. The watch was relieved at 0400 but it is believed the lightning continued regularly for another 15-20 min. Neither of the observers had ever seen lightning before seeming to emerge from an almost cloudless part of the sky, and which travelled so straight and apparently slowly." (R4)

X5. General observation. Dominica. "The phenomenon of lightning from a cloudless sky seems to be regarded in the States as one of very rare occurrence, as it very likely is. I cannot remember ever observing it while in the States, but down here in the West Indies it is of very frequent occurrence, so frequent in fact that it is not regarded as remarkable by the people. .... The appearance of the flash is that of sheet lightning, generally, single flashes being seen at intervals of from two to five minutes, and again only two or three occasional flashes will be seen during an evening. They do not seem to be confined to any particular quarter of the sky for local reasons, as I have observed them in all quarters. I do not think flashes are due to falling meteors, but they may be reflected flashes of distant thunderstorms,

although a clear sky certainly does not offer so good a reflecting surface as a clouded one." (R5)

X6. August 12, 1771. Portsmouth, New Hampshire. Clear sky outside. Flash came in an open window and burned a women. (R6)
X7. May 28, 1853. Weld, Maine. Many vivid flashes from various parts of a cloudless sky. (R7)
X8. Circa 1867. South Killingly, Connecticut. Three people prostrated by lightning from a clear sky. Heavy clap of thunder followed. (R8)
X9. April 27, 1886. North Atlantic Ocean. Clear sky but thin mist about ship. Vivid flash and violent thunder. (R9)
X10. August 3, 1899. Newburg, New York. (R10)
X11. August 7, 1899. Coldharbor, Virginia. Two men struck. (R10)
X12. October 4, 1900. Detroit, Michigan. (R11)
X13. Circa 1926. England. (R12)
X14. January 20, 1931. Tatoosh Island. Several flashes. (R13)
X15. June 17, 1932. Lincolnshire, England. (R14)
X16. August 18, 1940. Asheville, North Carolina. Several flashes from a clear sky observed from two locations. (R15)

References

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R3. Baskin, Donald; "Lightning without Clouds," American Meteorological Society, Bulletin, 33:348, 1952. (X3)
R4. Smith, N.W.; "Lightning," Marine Observer, 27:208, 1957. (X4)
R5. Ashcraft, Charles E., Jr.; "Lightning from a Cloudless Sky," Monthly Weather Review, 28:489, 1900. (X5)
R6. Massachusetts Spy, September 5, 1771. (X6)
R7. Masterman, Stillman; "Observations on Thunder and Lightning," Smithsonian Institution Annual Report, 1855, p. 265. (X7)
R8. Scientific American, 17:72, 1867. (X8)
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R11. Pague, B.S.; "Lightning from a Cloudless Sky," Monthly Weather Review, 28: 429, 1900. (X12)
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R14. Reid, N.C.; "Lightning Discharge during Sunshine," Meteorological Magazine, 68:139, 1933. (X15)
R15. Jemison, George M.; "Bolts from the Blue?" American Meteorological Society, Bulletin, 21:349, 1940. (X16)

GLL7 Crown Flash

Description. The brightening of a thunderhead crown followed by the appearance of aurora-like streamers emanating into the clear atmosphere. Crown flash seems to be synchronized with lightning strokes from the cloud base to the ground.

Data Evaluation. Only a few observations have been discovered in the literature so far, but they are fairly convincing. Rating: 2.

Anomaly Evaluation. The apparent extension of the luminous display into the clear sky infers that atmospheric electric discharge phenomena may occur where no clouds are visible. The apparent cycling of the phenomenon through the cloud volume is in need of explanation. Rating: 2.

Possible Explanations. The original observers of this phenomenon speculated that it was some sort of ion discharge, perhaps occurring atop an ionized air column associated with the thundercloud. This dovetails with the occasional correlation of auroral phenomena with thunderstorms (GLA9).

Similar and Related Phenomena. Auroras correlated with thunderstorms (GLA9), tornado lights (GLD10), dazzling lights in clouds (GLD15), cyclic flashing in thunderstorms (GLL26), rocket lightning (GLL1), lightning from a clear sky (GLL6).

Examples of Crown Flash

X1. July 2, 1970. Ann Arbor, Michigan. While observing a thundercloud. "At and just above the peak of the storm cell the cloud mass seemed to be undergoing sudden changes in brightness lasting for several seconds at a time.... The phenomenon continued to occur repeatedly at intervals of 30-60 s during the next 15 or 20 min, providing the basis for the following description. The sudden brightening effect began concurrently with lightning strokes in the main cloud mass, but continued after the lightning flash was over. It had the appearance of a ripple-like upward and outward spread of radiance from the region just west of the peak of the cumulus cloud, resembling somewhat a fan-like display of aurora borealis. It lasted a substantial fraction of a second with each lightning stroke. On one or two occasions it had the appearance of a bright ring moving rapidly outward and upward above the cumulus peak. On these occasions it was clearly observed to extend beyond the cloud and into the blue sky. A linear shadow, apparently cast by one of the cumulus masses, appeared to shift its position suddenly up or down with each occurence of the event." (R1)

X2. August 18, 1950. St. Albans, England. "At 12.25 GMT a cumulo-nimbus of moderate size was passing about four miles to the south, and giving rumbles of thunder about once every minute. While observing the cloud my attention was drawn to a bright streamer, apparently of cloud, projecting northwards from the anvil top for a distance of five degrees. As I watched, the streamer suddenly 'exploded' into a rapidly widening circle of light, fading as it did so. Immediately afterwards the streamer started to reform in the same place as before, only to repeat its 'disappearing' act again after a minute or so, presumably whenever an electrical discharge took place. On some occasions the streamer shifted violently to one side, changing its form greatly, but always returning to one spot. The spectacle lasted for half an hour, becoming fainter as the cloud moved away eastward." (R2)

X3. April 30, 1885. Denison, Texas. A glowing region repeatedly travels along the tops of thunderclouds that were arranged in a long bank. (R3)

References

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R2. Hale, R. B.; "Unusual Lightning," Weather, 5:394, 1950. (X2)
R3. "Electrical Phenomena," Monthly Weather Review, 13:103, 1885. (X3)

GLL8 The Preference of Lightning for Certain Trees

Description. The marked preference of lightning for some trees over others in a mixed forest after discounting soil moisture, tree prominence, and other contributing factors. Surveys are emphatic that oaks are strongly favored and beeches the least favored.

Background. Folklore has long maintained that oaks are the most dangerous trees in the forest to take shelter under during a thunderstorm, while beeches are least often struck. Scientific surveys have borne out these popular observations.

Data Evaluation. Several scientific, but rather old, surveys of forest damage by lightning. Rating: 2.

Anomaly Evaluation. This phenomenon is primarily of curiosity value because one would expect that trees with high electrical conductivity would be struck often. However, there exists no thorough study of the electrical properties of trees that would explain the statistical data. Rating: 3.

Possible Explanations. The surveys of lightning damage are probably explained in terms of the different electrical properties of trees.

Similar and Related Phenomena. Lightning districts (GLL13), the tendency of lightning to strike repeatedly certain rock outcroppings and buildings.

Examples of Lightning's Preference for Certain Trees

X1. General observation. "Investigations made by Dr. Carl Muller, and reported in Himmel und Erde, show that lightning prefers to strike certain kinds of trees. Under the direction of the Lippe-Detmold Department of Forestry, statistics were gathered showing that in eleven years lightning struck fifty-six oaks, three or four pines, twenty firs, but not a single beech tree, although seven-tenths of the trees were beech. It would seem, then, that one is safer in a storm under a beech tree than under any other kind." (R1)

X2. General observation. The danger of taking shelter under specific trees, taking beech as 1, is 6 for spruce, 37 for Scots pine, and 60 for oak. (R2)
X3. General observation. Oaks strongly favored over beech by lightning. (R3)
X4. General observation. Oaks and, to a lesser extent, pines are favored over other trees by lightning. (R4)
X5. General observation. Oak, pine, and poplar struck more often than other species. (R5)
X6. General observation. Relative frequency of lightning hits: oak, 48; beech, 1; spruce, 5; pine, 33. (R6)

X7. 1950s. Virginia Beach, Virginia.

"In the early 1950s, my father bought a house on Lakeshore Drive (big time misnomer, as our land backed up to Rainey's Gut, a brackish tidal stream). Abounding the Gut was a marsh, and there was a big cypress tree about 25 meters behind the house. This poor tree was a natural lightning rod and it looked dead, although it wasn't. It got hit two or three times each summer, which definitely got the attention of anyone in the house. The point to be made, however, is that the tree had one long, horizontal limb about 3 meters down from the top. Ospreys liked to perch on it while watching for mullet in the Gut. And, on two separate occasions that I remember, when lightning bolts hit the top of the tree, ball lightning would form near the trunk, move outward along the limb, and fall down into the marsh. There, it would bounce along in a series of explosions of successively diminishing size, leaving circular charred spots in the marsh grass." (R7)

This cypress tree was probably favored because of its prominence and isolation. What is more interesting is the repeated occurrence of ball lightning---or perhaps St. Elmo's fire---involving the same tree.

References

R1. "Lightning and Trees," Symons's Monthly Meteorological Magazine, 31: 74, 1896. (X1)
R2. "Trees and Lightning," Royal Meteorological Society, Quarterly Journal, 33: 255, 1907. (X2)
R3. "Which Trees Attract Lightning?" Monthly Weather Review, 26:257, 1898. (X3)
R4. "Lightning and Trees," Royal Meteorological Society, Quarterly Journal, 20: 172, 1894. (X4)
R5. Nature, 68:351, 1903. (X5)
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R7. Keefe, William A.; personal communication, January 5, 1998. (X7)

GLL9 Lightning Figures

Description. Tree-like patterns or images of nearby objects appearing upon the bodies of people and animals struck or narrowly missed by lightning.

Background. The literature contains many examples of lightning figures, but only a handful have been recorded below. For many years, it was believed that the tree-like patterns on the skins of lightning victims were the true shadows of nearby foliage. Some investigators, however, could see no faithful resemblance to the surroundings; they claimed that the lightning figures were simply analogs of the dendritic patterns produced in the laboratory by electrical discharges on coated glass plates. This experimentally supported viewpoint became dominant and, probably justifiably, remains so today. Some instances of lightning figures, though, involve reproductions of nearby metallic objects on the skins of victims. There seems little room for mistaken identity here, and the laboratory dendritic patterns have no explanatory power. The evaluation that follows applies only to this type of lightning figure.

Data Evaluation. The cases of lightning figures involving nearby metallic objects are scarce, of poor quality, and rather suspect. Rating: 3.

Anomaly Evaluation. There is no known mechanism for transferring the shadow of a metal object to the skin of a lightning victim. If such a phenomenon exists, it possesses more than mere curiosity value. Rating: 2.

Possible Explanations. The most likely explanation is that the pertinent examples are just tall tales, and no amomaly exists. On the other hand, it is conceivable that the presence of a metallic object might somehow distort the lightning currents to form a rare, crude image. Lightning currents have frequently melted rings and other metal objects on people struck. For example, coins heated by lightning-induced currents might well leave circular burns on the victim's skin.

Similar and Related Phenomena. Lightning shadowgraphs (GLL22). See also GLL11 to gain an appreciation of the sometimes uncanny tricks played by lightning.

Examples of Lightning Figures

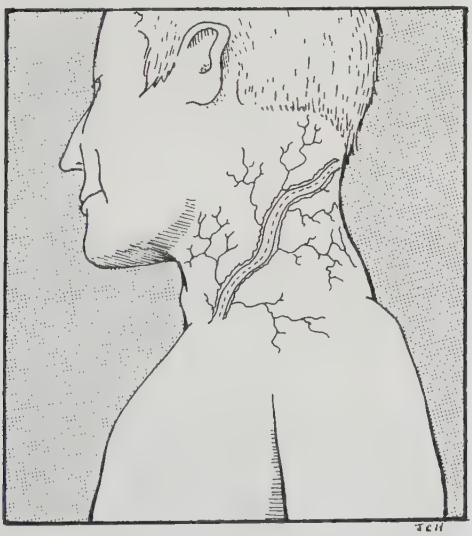
X1. September 1825. Bay of Armiro. "In September 1825, the brig Il Buon Servo, anchored in the Bay of Armiro, was struck by lightning, and a sailor who was sitting at the foot of the mizenmast was killed. Marks were found on his back, extending from the neck to the loins, including the impression of a horse-shoe, perfectly distinct, and of the same size as the one that was fixed to the mast." (R1)

X2. July 12, 1875. Americus, Georgia. After lightning had struck and severed a tree outside a house containing several people. "All these persons were rendered insensible for a time by the stroke which severed the tree, and on their recovery there were found impressed upon the bodies of them all more or less distinct images of this tree. It was most distinct in the case of the child near the center of the room. Mr. Simmons says, 'the child is impressed upon its back and exactly opposite upon its stomach. The entire tree is plain, and perfect in toto; every limb, branch, and leaf, and even the severed part, is plainly perceptible.'.... Where the leaves are, on the branch, the mark does not take the shape of the entire leaf, but only of the skeleton of the leaf." The marks on all faded away eventually.(R2)

X3. General observation. Results of a survey. "The phenomenon of lightning prints is one of which little is yet known, but which deserves attention. Prof. Poey mentions twenty-four cases of impressions like photographs made by lightning on the bodies of men and animals. Of these, eight were impressions of trees or parts of trees; one of a bird, and one of a cow; four of crosses; three of circles or of impressions of coins carried about the person; two of horseshoes;

one of a nail; one of a metal comb; one of a number or numeral; one of the words of a sentence; one of the back of an arm-chair. Many other instances of similar impressions are recorded." (R3)

X4. 1595. Wells, England. Some of the worshippers in a church struck by lightning imprinted with crosses. (R4, R14)
X5. 1812. Bath, England. Skins of six sheep killed by lightning showed images of the surrounding countryside. (R4, R5)
X6. 1828. Cuba. Image of a passing railroad engine imprinted upon the body of a man killed by lightning. (R1)
X7. July 1851. Washington County, Maryland. Image of robin on branch appeared on sheep killed by lightning beneath tree. Feather edges in great detail. (R6)
X8. August 26, 1853. No place given. (R5)
X9. November 2, 1861. Lappion, France. Tree image. (R4)
X10. June 9, 1883. Berwickshire, England. Image of nearby yew tree imprinted upon boy hurt by lightning. Image faded later. (R7, R8)
X11. June 17, 1896. Pertuis, France. Tree image. Flammarion investigated and found little resemblance to actual tree. (R4)



A typical tree-like lightning figure.

X12. September 14, 1919. London, England. Leaves and branches imprinted. (R9,R10)
X13. General observation. Tree-like figures are easily produced by electrical discharges on glass plates with conducting films. (R11)
X14. General observation. Conditions needfor image formation; i.e., lens, light-sensitive surface; are missing in all examples of lightning figures. (R12)
X15. General observation. The tree-like images are not really like the surrounding foliage. Tree-like images have appeared on people struck in the open country. (R13)
X16. No date given. Zante, Greece. Image of the number 44 appeared on the body of a sailor struck by lightning. A metallic number 44 was attached to the rigging. (R1)

References

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R2. "Images Produced by Lightning," American Journal of Science, 3:10:317, 1875. (X2)
R3. "Curious Lightning Phenomena," Popular Science Monthly, 42:422, 1893. (X3)
R4. Talman, Charles Fitzhugh; "Lightning Prints," Scientific American, 108:576. 1913. (X4, X5, X7, X11)
R5. "A 'Lightning Figure' Photographed," Symons's Monthly Meteorological Magazine, 18:81, 1883. (X5, X8)
R6. Logan, Thos. J.; "Marks Produced by Lightning Stroke," Scientific American, 21:214, 1869. (X7)
R7. Williamson, John; "Thunderstorm at Dunse...," English Mechanic, 37:364, 1883. (X10)
R8. Williamson, John; "Thunderstorm at Dunse...," Symons's Monthly Meteorological Magazine, 18:82, 1883. (X10)
R9. Newell, A.G.; "Death by Lightning---An Unusual Phenomenon," Symons's Meteorological Magazine, 54:104, 1919. (X12)
R10. "Death by Lightning," Monthly Weather Review, 47:729, 1919. (X12)
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R12. Bruce, George; "Lightning Prints on Boys," Symons's Monthly Meteorological Magazine, 18:83, 1883. (X14)

R13. Wood, James G.; "Lightning Figures," Symons's Meteorological Magazine, 54: 131, 1919. (X15)
R14. Bartlett, J. A.; "Effects of Lightning," English Mechanic, 37:504, 1883. (X4)

GLL10 Lightning Sounds (Other than Thunder)

Description. "Vits," "clicks," or ripping sounds heard just prior to and simultaneous with nearby lightning.

Data Evaluation. A large number of observations exist, many by trained personnel at scientific observatories. Only of few of these examples are reported here. Rating: 1.

Anomaly Evaluation. If the lightning sounds are only electric discharge noises (brush discharge), we have only a poorly investigated curiosity. If the perceived sound is actually due to a burst of electromagnetic energy being translated into sound physiologically, we have something demanding more attention, but still a phenomenon that poses no serious challenge to prevailing theories. Rating: 3.

Possible Explanations. The sudden discharge of electricity from exposed conductors, trees, brush, etc. Electromagnetic waves perceived as sound (electrophonic sound).

Similar and Related Phenomena. The sound of the aurora (GSD), sounds associated with meteors (GSD).

Examples of Lightning Sounds

X1. April 24, 1925. Petersfield, England. "During the storm three men were working in a field; two of them were together close to a holly tree in a hedge; there was a very bright flash of lightning, with a just perceptible interval between the flash and the thunder. At the moment of the lightning there was quite a loud swishing sound in the holly tree, as though, they said, a sudden blast of air went through the tree; the sound occurred definitely before the thunder.... The flash must have been very close as they both smelt 'sulphur'---nitrogen peroxide; and they could scarcely see anything for some moments. The third man was about 230 metres away and was close to an oak tree to which he had his back; he says that when the flash came there was a noise in the tree as though it were 'on fire.'"(R1)

X2. August 29, 1930. No place given. "I did not see the actual flash, only the illumination of the garden through the open window; it was very brilliant and was followed instantly by a noise as though a shower of large water drops had been thrown onto a hot metal plate; this was followed almost instantly by the thunder. I think there was a slight interval between the swish and the thunder, but it must have been only a frac-

tion of a second....It was also heard by two people in a cottage about 50 yards from the house; one of them likened it to a red-hot poker being plunged into cold water, the other to the sound of the arc when two electric cables are short circuited." (R2)

X3. Circa 1915. Little Shelford, England. Like a sudden rending of calico, just before the thunder. (R3)

X4. July 30, 1921. No place given. Like canvas being ripped violently, just before the flash. (R4)

X5. July 9, 1923. Kent, England. Three vits heard just before the thunder. (R5)

X6. April 28, 1934. London, England. A swishing noise accompanying the flash. (R6)

X7. March 14, 1953. Off Sardinia. Lightning strikes the water accompanied by a loud hissing noise. Thunder followed. (R7)

X8. General observation. Vits or clicks preceding lightning are commonly heard wherever electrical conductors are exposed. (R8)

X9. General observation. Siam. Vits and clicks heard often preceding the flashes. In addition, animals sometimes are disturbed just prior to a flash and have been observed to look in the direction of the impending flash. (R9)

X10. General observation. The author of this item collected many cases of vits and clicks, noting that almost all occur simultaneously with the lightning, rarely preceding it. (R10)

X11. May 13, 1989. Austin, Texas.

About 8 PM, during an intense thunderstorm, P. Gunkel heard a whistling sound, like that made by a descending firework rocket. A general pinkish brightening of the surroundings accompanied the sound. Half a second after the sound ceased, there was a tremendous clap of thunder. Discussions with neighbors within 1 hour of the event, elicited additional data: one said that it sounded like rocks falling through the air; another heard a strange humming sound from a windowpane for 2 seconds prior to the lightning; yet another spoke of a sound like that of a whistling teakettle, but with an ascending pitch; and a fourth actually saw the lightning strike the street about 500 feet away.

References

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R2. Cave, C.J.P.; "Noise Associated with Lightning," Nature, 126:401, 1930. (X2)

R3. Balls, W. Lawrence; "The Sound of Lightning," Nature, 115:912, 1925. (X3)

R4. Cave, C.J.P.; "The Sound of Lightning," Nature, 116:98, 1925. (X4)

R5. Best, Ronald L.; "Unusual Thunderstorm Phenomena," Meteorological Magazine, 63:135, 1928. (X5)

R6. Belasco, J.E.; "A Phenomenon Accompanying Lightning," Meteorological Magazine, 69:91, 1934. (X6)

R7. Cummins, K.A.H.; "Lightning," Marine Observer, 24:11, 1954. (X7)

R8. McAdie, Alexander; "Phenomena Preceding Lightning," Monthly Weather Review, 56:219, 1928. (X8)

R9. Breton, R.S.; "Unusual Thunderstorm Phenomena," Meteorological Magazine, 63:113, 1928. (X9)

R10. Ashmore, S.E.; "The Sounds Associated with Lightning," Weather, 11:269, 1956. (X10)

R11. Gunkel, Patrick; personal communication, May 13, 1989. (X11)

GLL11 Lightning's Pranks

Description. Odd, almost incomprehensible actions of lightning on people and objects. Lightning pranks range from neatly excising circles of glass from window panes to breaking every other dish in a pile.

Background. The pranks of lightning are so varied that this must be a catch-all category. Excluded are such "reasonable" actions of lightning as melting glasses frames, moving furniture about, smashing holes in dwellings, plowing up long furrows in lawns, and the well-documented propensity for killing four-footed animals rather than humans.

Data Evaluation. Lightning pranks are mostly one-of-a-kind; and few have been investigated. Rating: 3.

Anomaly Evaluation. The vagaries of lightning seem to challenge no physical law. Rather, it would seem that detailed examinations of each prank would probably result in reasonable physical explanations. Rating: 3.

Possible Explanations. Strange though lightning's pranks may be, careful studies of electrical conductivities, moisture contents, presence of metal, air currents, etc. should lead to a good understanding of each event.

Similar and Related Phenomena. Tornado pranks (GWT), the peculiar actions of ball lightning (GLB).

Examples of Lightning's Pranks

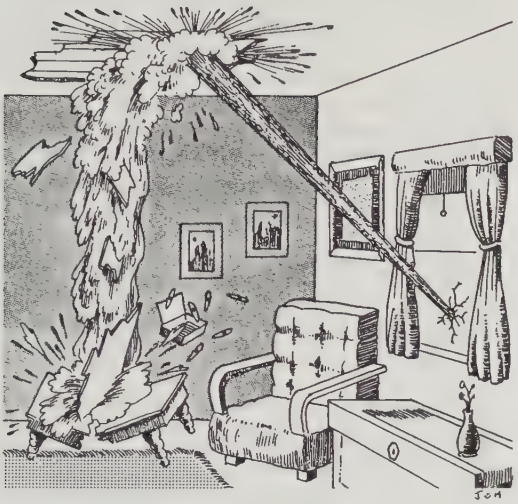
X1. Circa 1872. Vernon, France. "A curious phenomenon has been observed on a property at Vernon, in France. Five or six years ago lightning struck a garden planted with gooseberry bushes and cherry trees, making a very deep hole, the orifice of which was not 10 ctm. in diameter. Subsequently everything died round about. The death circle enlarged year by year. It is now seven metres in diameter, and has just reached a cherry tree planted twelve years ago, which has died like the rest. The gooseberry bushes which we replanted died in two years." (R1)

X2. June 15, 1873. Kansas City, Missouri. A young couple was struck by lightning. "She was killed, and he was crippled; while the shock was felt for a hundred yards from the fatal point of impact, jarring buildings, and benumbing and prostrating human beings, so as to prevent spectators for a few moments from coming to the aid of the chief sufferers. When they did so, they found, to their horror, that the body of the young lady was actually undergoing combustion, making it necessary to extinguish the flames by pailsful of water." (R2)

There may be a connection here with spontaneous human combustion (BHB).

X3. June 8, 1878. Ashford, England. A workman had taken shelter under a tree. "His companions found the tree partly denuded of its bark, and the patient's boots standing at its foot. The patient himself was lying on his back two yards off, and though he was fully clothed previously, he was now naked, with absolutely nothing on except part of the left arm of his flannel vest. He was conscious, but much burnt, and his left leg was badly broken. The field around was strewn with fragments of the clothing; the clothes were split or torn from top to bottom, the edges of the fragments being often torn into shreds or fringes; they only showed evidences of fire where they came in contact with metal, such as his watch and the buckle of his waist belt. There were no laces in the boots. The left boot was torn and twisted into fantastic shapes, but the sole was uninjured, and there were no signs of fire upon it." (R3, R4)

X4. Circa 1886. Ribnitz, Germany. "At Ribnitz, in Mecklenburg, during a violent thunderstorm, with rain and hail, about 6 a.m., the lower pane of a window on the first floor was broken by lightning, and a jet of water was thrown upwards through the aperture to



In a bizarre lighting strike at Ribnitz, Germany, lightning broke a window and hurled a jet of water at a ceiling. (X4) (Artist's interpretation)

the ceiling, where it detached part of the ceiling, and this, falling with the water, broke a small cigar-table below. Three bucketfuls of water were afterwards taken from the room. The hole in the window was like that from a bullet, and there were radial cracks. The path of the lightning is not very clear, but that it passed through the glass could not be doubted. Some cigars on the table, it may be mentioned, were carbonised." (R5, R6)

X5. January 5, 1890. Co. Mayo, Ireland. Lightning struck a house. "The most extraordinary occurrence was what happened to a basket of eggs lying on the floor of the room. The eggs were shattered, so that they fell off when the eggs were put in boiling water, but the inner membrane was not broken." (R7, R8)

X6. July 1894. Harrogate. England. "A flash of lightning passed me, which was immediately followed by another flash and a very loud peal of thunder. The second flash went in the direction of the deceased, and I saw it strike him at the back of the head.... The deceased was lifted up about 4 to 5 feet in the air in a perpendicular direction, and was then carried out against the wind for 8 or 10 yards, away from the stack, and fell to the ground like a stone." (R9)

X7. June 24, 1935. Dodge, Nebraska. A phenomenal hole was excavated by lightning. "The dirt was thrown back from all sides of the 8-inch hole at the center for a distance of about 3 feet and heaped up about 6 inches above the level of the surrounding ground. The hole extended downward 8 feet almost vertically, with an average diameter of 8 inches, then became smaller for the next 7 feet and varied somewhat from the perpendicular. At a depth of 15 feet the diameter had been reduced to about 4 inches and branched out in three directions into 2-inch holes, which were followed for 3 or 4 feet into the bank where they disappeared.... The clay showed signs of fusion at a number of points, and the inside of the hole had a corrugated appearance, as though the moist clay had been forced back by high pressure." (R10)

X8. June 8, 1972. Edinburgh, Scotland. "The damage to the window pane occurred between 1230 and 1400 BST on 8 June 1972 during which time no one was in the room but a heavy thunderstorm passed overhead. The result was an almost circular hole of dimensions 4.9 cm by 4.6 cm, and an irregular crack which ran across the pane from the bottom of the hole; the pane broke along this crack while it was being removed. The 'missing' circle of glass was found intact inside the room; the edge of this piece and also that of the glass surrounding the hole had a fused appearance, and was smooth to the touch, on the inner side of the pane." (R11)

X9. No date given. Jefferson, Iowa. After lightning had struck a house. "After the occurrence, a pile of dinner plates, twelve in number, was found to have every other

plate broken. It would seem as if the plates constituted a condenser under the intensely electrified condition of the atmosphere." (R12)

X10. July 1907. Ireland. A heavy thunderstorm leaves behind dead and withered vegetation. Sometimes only one side of a plant or tree would be affected. (R13)

X11. 1975. Walsall, West Midlands, England. N. Boynton and his mother were watching TV, when:

"In the run up to an approaching daytime thunderstorm when the air was 'heavy', and while watching television, a streak of whitish light approximately four inches (100 mm) thick came from the direction of the television straight into the body of the room at about head height between where my mother and I were sitting.

"It lasted for a fraction of a second. There was an accompanying crackling sound, with the television flickering and buzzing for a second or two. There was no evidence of damage to the television or anything else in the room. We were unaware of whether there was a lightning strike outside at the time." (R14)

The streak passed between Boynton and his mother, seated about 4 feet apart, and seemed directed toward the door of the room.

X12. July 17, 1988. Hannacroix, New York.

"On Sunday, 17 July, 1988, the usual calm and quiet on the Shelhamer property in rural Hannacroix, New York, was suddenly disrupted by a bright flash and a powerful concussion. The house shook. A picture came off the wall and crashed onto the floor. A contact lens popped out of Mrs Shelhamer's eye. The electric power went out. The kitchen clock froze at 3.30 PM. Mr Shelhamer saw three wisps of smoke rise from his parking area. He noticed a strange smell in the air. A pickup truck, parked near the house, was covered with dirt. Two of its tyres were flat, and the hubcaps were lying on the ground. Strange trenches and tracks had appeared in the surface of the parking area. These trenches led Mr Shelhamer to a hickory tree, about 20m from the house. On it a 10-cm scar had appeared, spiralling up the trunk toward the sky. A few minutes earlier it had begun to rain, and all this was the result of the lightning strike.

"Perhaps the most extraordinary aspect of this lightning strike was the way the currents flowing from the hickory tree along the surface of the ground apparently leapt out of the ground in places to pass through the automobiles parked in the parking area. Two of the trenches that radiated from the tree ended at an automobile, but reappeared at the opposite side or end of that automobile, where they either terminated in a crater, or continued tracking on. One of these trenches tracked through two automobiles that were parked side by side." (R15)

Electrical currents are supposed to follow the path of least resistance. How did all three vehicles in the parking area end up on paths of least resistance? Some of the phenomena observed can be accounted for by vaporization of moisture in the ground, but what popped those hubcaps off?

X13. March 17, 1990. Phoenix, Maryland. What follows is hardly a scientific report, but we have no reason to doubt its accuracy.

On last Saint Patrick's Day. G. Patterson, of Phoenix, Maryland, north of Baltimore, was in bed sick during a hard rainstorm, when the bulb in her bedside lamp exploded. Lightning had struck her house.

She got out of bed and rushed over to her daughter's house nearby to find a red ball of fire on the house's baseboard outlet. Her daughter's house had also been struck by lightning! Worse yet, the TV and VCR had been destroyed.

Later on the same day, Patterson's daughter in Bel Air, northeast of Baltimore, called to say that the chimney of her house had been struck by lightning, scattering fireplace bricks all over the floor! (R16)

References

R1. English Mechanic, 27:214, 1878. (X1)
R2. Hovey, Horace C.; "Death by Lightning," American Journal of Science, 3:6:157, 1873. (X2)
R3. "Singular Case of Lightning Stroke," Scientific American, 42:51, 1880. (X3)
R4. Marriott, W.; "Mortality and Accidents from Lightning," Knowledge, 12:197, 1889. (X3)
R5. Nature, 33:396, 1886. (X4)
R6. Popular Science Monthly, 29:719, 1886. (X4)
R7. Scott, Robert H.; "Note on a Lightning Stroke Presenting Some Features of Interest," Royal Meteorological Society, Quarterly Journal, 17:18, 1891. (X5)
R8. Scott, R.H.; "Note on a Lightning Stroke," American Meteorological Journal, 8:34, 1891. (X5)
R9. Marriott, William; "Thunder and Hail Storm over England....," Royal Meteorological Society Quarterly Journal, 20:31, 1894. (X6)
R10. Jensen, J.C.; "The Dodge, Nebraska, 'Fireball,'" Science, 83:574, 1936. (X7)
R11. McIntosh, D.H.; "Lightning Damage," Weather, 28:160, 1973. (X8)
R12. Nature, 66:158, 1902. (X9)
R13. Battersby, T. Preston; "Vegetation Killed by a Thunderstorm," English Mechanic, 86:195, 1907. (X10)
R14. Boynton, Neil; "White Streak from the Direction of a TV Set Prior to a Thunderstorm," Journal of Meteorology, U.K., 21:348, 1996. (X11)
R15. Jonsson, H.H., et al; "Unusual Effects of a Lightning Ground Strike," Weather, 44:366, 1989. (X12)
R16. Simon, Roger; "After Lightning Strikes a Family Thrice, Call Priest," Baltimore Sun, April 9, 1990. (X13)

GLL12 Hot-Air Blasts Following Lightning Strokes

Description. Blasts of hot air observed during thunderstorms. They are synchronized with the lightning strokes and follow the peals of thunder.

Data Evlauation. A single observation. Rating: 3.

Anomaly Evaluation. Lightning strokes possess ample energy to create blasts of hot air. At issue here is the precise accelerating mechanism. Whatever it may be, it would seem to be well within the capabilities of prevailing theories. Rating: 3.

Possible Explanation. Jets of hot air may be accelerated electrostatically and magnetically by the lightning stroke. (R4)

Similar and Related Phenomena. Powerful electrical discharges may also be involved in the production of hydrometeors (GFI) and the jets of matter seen emanating from stars, galaxies, and other astronomical objects. (R4)

Examples of Hot-Air Blasts

X1. July 1971. France. "I was standing on the summit of a mountain in central France, Puy Mary, 1786 metres, at about 3 pm in July 1971 and could see lightning below me in a band of black clouds to the north. I saw the lightning strike, heard the thunder about 5-6 seconds later and felt very few seconds afterwards a rather strong blast of hot air. This happened several times in quick succession. The blast was so forceful that I had to lean against it, and it came from the direction of the black clouds. It was a hot and sultry day, the temperature of the blast was quite a bit higher; it did not singe my hair or clothing. It was not raining on the top of the Pur Mary. The blast was associated with the lightning-thunder sequence, it travelled at a much lower speed than the thunder and made very much less noise, it was almost silent. It certainly was not just a drift of hot air up the mountain slope." (R1-R4) See also GLL10-X1.

References

R1. Worth, L.H.; "Lightning 'Blast,'" New Scientist, 57:330, 1973. (X1)
R2. Worth, L.H.; "Atmospheric Mystery," Weather, 28:86, 1973. (X1)
R3. Worth, L.H.; "Atmospheric Mystery," Nature, 236:413, 1972. (X1)
R4, Crew, E.W.; "Meteorological Flying Objects," Royal Astronomical Society, Quarterly Journal, 21:216, 1980. (X1)

GLL13 Unusual Geographical Preferences of Lightning

Description. On a global basis, the much higher incidence of lightning over land than sea. On a local scale, lightning's preference for certain areas after discounting height and other obvious factors.

Background. It is well known that lightning prefers some tall buildings and certain rocky outcrops. Farmers and sheepherders can often point out certain spots, even in treeless regions, where men and animals are in much more danger from lightning. Here, the intent is to record examples where it is not readily apparent why lightning favors specific areas.

Data Evaluation. Global-scale observations from satellites are of high quality, but the local claims of "lightning districts" are not backed by credible statistics. Rating: 2.

Anomaly Evaluation. Both global and local anomalies in the distribution of lightning strikes are probably explainable in terms of meteorology and geological conditions. However, the land-over-sea preferences of lightning are so strong that even these factors may be inadequate. Rating: 3.

Possible Explanation. Satellite maps of lightning incidence show strong concentration over tropical areas, as one would expect meteorologically from known ground temperatures, humidity, etc. Meteorologists, however, are puzzled as to why land areas are favored by a factor of ten over the oceans. (R6) Uncharted local moisture and mineral concentrations can probably account for local lightning "hot spots" that persist after obvious lightning attractors, such as trees and prominences, are taken into account.

Similar and Related Phenomena. Lightning's preference for specific trees (GLL8), tornado alleys (GWT), horizontal lightning (GLL5), meandering lightning (GLL25).

Examples of Unusual Geographic Preferences of Lightning

X1. General observation. California. "The San Francisco Chronicle says there is a tract of country in Butte County, Cal., about fifteen miles long by half a mile in width, where lightning strikes trees nearly every time a storm passes over. Outside of this strip there is no such damage. The line can be plainly traced by dead timber." (R1)

X2. General observation. Van Wert, Ohio. One small area of the city is hit more frequently by lightning. (R2)

X3. General observation. A nine-year survey along a power line proved that certain sections were hit more often by lightning and that these sections seemed to be over underground springs. (R3)

X4. General observation. From satellite observations, lightning is roughly ten times more frequent over land areas than the oceans. (R4-R6)

In 1998, data arriving from NASA's new, satellite-mounted Lightning Imaging Sensor confirmed the older estimate given in the forgoing paragraph. The first three months of observations from the new satellite showed that 85-90% of the globe's lightning strokes occurred over land, despite the fact that more than 70% of the planet is water-covered. (R7)

This strong asymmetry is not unexpected because thermal convection of the atmosphere, which helps generate electrical storms is much greater over land. Thereofre, striking though this phenomenon may be, it cannot be labeled as anomalous.

X5. North American lightning survey. North America's National Lightning Detection Network reveals that the peak electrical currents in lightning strokes very strongly with latitude. For example, in New England they measure about 25,000 amperes, whereas in northern Florida they reach 45,000 amperes. This difference is probably associated with the observation that Florida's cumulonimbus clouds are about 30% taller than those in New England; that is, there is more energy available in Florida to power thunderstorms.(R8)

References

R1. "Local Lightning," Scientific American, 45:146, 1881. (X1)

R2. "Electrical Districts," Monthly Weather Review, 25:249, 1897. (X2)

R3. Goodlet, B. L.; "Lightning," Institute of Electrical Engineers, Journal, 81:1, 1937. (X3)

R4. "Zeus Expends His Wrath More upon Land Than Sea," New Scientist, 47:512, 1970. (X4)

R5. "Thunderstorms Fall Mainly on the Land," Science News, 98:207, 1970. (X4)

R6. "Patterns of Thunderbolts," New Scientist, 92:102, 1981. (X4)

R7. Anonymous; "Lightning Hits Land Far More Than Sea,"San Francisco Chronicle, May 30, 1998. Cr. J. Covey. (X4)

R8. Anonymous; "Flashes Sizzle in the South," Science News, 137:92, 1990. (X5)

GLL14 Black Lightning

Description. Lightning strokes that appear black or dark rather than bright either to the eye or photographic film.

Background. Early photographs of lightning frequently showed dark as well as bright strokes. (R1, R2) The question naturally arose as to whether black lightning had any objective existence in nature. After all, lightning could be red, blue, and other colors (GLL3). As the Nineteenth Century drew to a close, photographic experiments proved to everyone's satisfaction that the phenomenon of film reversal accounted for all photos of dark lightning. (R3)

Data Evaluation. Rating: 1.

Anomaly Evaluation. No anomaly appears to exist here. The phenomenon is included for the record and for comparison with the similar, and apparently genuine black auroras and black ball lightning. Rating: 4.

Possible Explanations. Photographs of dark or black lightning stem from film reversal. Visual observations of black lightning are due to retina fatigue.

Similar and Related Phenomena. Black auroras, which may be due to obscuring matter (GLA22), black ball lightning, which may be no more than smoky occurrences of normal ball lightning (GLB11).

References

R1. "Ribbon and Dark Lightning, " Nature, 60:423, 1899.
R2. Wood, R.W.; "Dark Lightning," Nature, 60:460, 1899.
R3. Lockyer, William J.S.; "Dark Lightning Flashes," Nature, 60:570, 1899.

GLL15 Slow or Prolonged Lightning

Description. Lightning flashes that persist for one or more seconds.

Data Evaluation. A limited number of observations exist, and some of these may be confused with sheet lightning. Rating: 3.

Anomaly Evaluation. Lightning flashes normally last for but a small fraction of a second. Those flashes that persist for a second or more pose serious problems in explanation. Rating: 2.

Possible Explanations. None, other than possible confusion with sheet lightning or some type of eye fatigue or afterimage.

Similar and Related Phenomena. Sheet lightning (GLL4), ball lightning which usually endures for several seconds (GLB1).

Examples of Slow or Prolonged Lightning

X1. 1916. Surrey, England. Observing a sudden squall. "But instead of a flash this was more like a deluge of light, hardly varying in intensity during the three seconds or more that it lasted, lightning up a house some thirty yards distant with a curiously even glow." (R1)

X2. 1916. Somerset, England. An extremely long flash. (R1)

X3. July 12, 1931. Herts, England. Lightning flashes persisted up to one second a and were markedly different from normal flashes. No thunder heard. (R2)

X4. October 17, 1956. North Atlantic Ocean. Slow, unusually wide stroke of lightning hits a cloud, from which proceeds a normal quick, narrow flash. (See GLL6-X4) (R3)

References

R1. Clark, J.E.; "Peculiar Lightning," Symons's Meteorological Magazine, 51:152, 1916. (X1, X2)

R2. Beckett, H.E., and Dufton, A.F.; "Unusual Lightning," Nature, 128:189, 1931. (X3)

R3. Smith, N.W.; "Lightning," Marine Observer, 27:208, 1957. (X4)

GLL16 Correlation of Lightning and Cosmic Rays

Description. The correlation of increases in cosmic-ray intensity with increases in lightning (thunderstorm) frequency, suggesting a causal relationship.

Background. During the early 1930s, thunderclouds were found to produce a type of penetrating radiation. (R4). This relatively low energy radiation was shown to be produced by electron acceleration within thunderclouds and unrelated to extraterrestrial cosmic rays. However, this storm-produced radiation, while not anomalous in itself, may be related to crown flash (GLL7) and the aurora-like displays sometimes observed above thunderstorms (GLA9). In addition to the above radiation, thunderstorms by virtue of their strong electrostatic accelerating fields constitute a sort of natural atom smasher, which can generate neutrons and other nuclear radiation. The neutrons, in particular, may interact with carbon and upset carbon-dating measurements. Fortunately, lightning-produced neutrons have proven to be of minor importance. (R5) With these preliminaries out of the way, the rest of the discussion deals with the possible initiation of lightning (thunderstorms) by extraterrestrial cosmic rays.

Data Evaluation. Several modern studies suggest a causal relationship. Rating: 2.

Anomaly Evaluation: The possible initiation of thunderstorms by cosmic rays, an extraterrestrial influence, is only one element in the hotly debated subject of weather and astronomy. Generally speaking, extraterrestrial influences on weather are not yet assimilated into accepted theory. Rating: 2.

Possible Explanations. On a broad geographical scale, cosmic rays influence significantly the global electrical circuit and, by yet unknown mechanisms, may increase thunderstorm frequency. On a local scale, intense showers of cosmic rays might trigger specific storms or even specific lightning strokes, although this is sheer speculation. The ionizing ability of the cosmic rays is, of course, the probable triggering effect.

Similar and Related Phenomena. Correlation of auroras and thunderstorms (GLA9), the correlation of ball lightning with solar activity (GLB17).

Examples of Correlations between Cosmic Rays and Lightning (Thunderstorms)

X1. General observation. "An increase in the cosmic-ray component (E>500 kev) was found to accompany thunderstorms. No correlation was found between nearby individual lightning strokes and count rate, but a general count increase with a time constant of some 10 min was found for all thunderstorms that passed nearby. Flux increases were typically 5%. The nature of the count increase in not known." (R1)

X2. General observation. "A significant maximum in cosmic rays occurs one day before solar sector boundary crossings. Therefore, previous work showing a maximum in thunderstorm frequency one day after solar sector boundary crossings may result from high cosmic ray counts. This is evidenced by a maximum in thunderstorm frequency three days after high cosmic rays and, also, by a maximum in thunderstorm frequency three days after minimum K_p." (R2)

X3. General observation. Electrification of the terrestrial atmosphere is strongly affected by cosmic rays. There also seems to be a thundercloud electrical mechanism that is sensitive to atmospheric electrification, so that thunderstorms (and lightning) are influenced by cosmic rays. (R3)

X4. General observation. Cosmic-ray showers may ionize enough air to trigger lightning discharges. (R6)

References

R1. Shaw, Glenn E.; "Background Cosmic Count Increase Associated with Thunderstorms," Journal of Geophysical Research, 72:4623, 1967. (X1)

R2. Lethbridge, M.D.; "Cosmic Rays and Thunderstorm Frequency," Geophysical Research Letters, 8:521, 1981. (X2)

R3. Markson, Ralph; "Modulation of the Earth's Electric Field by Cosmic Radiation," Nature, 291:304, 1981. (X3)

R4. Schonland, B.F.J., and Viljoen, J.P.T.; "On a Penetrating Radiation from Thunderclouds," Royal Society, Proceedings, A140:314, 1933.

R5. Fleischer, Robert L., et al; "Are Neutrons Generated by Lightning?" Journal of Geophysical Research, 79: 5013, 1974.

R6. "Do Cosmic Rays Trigger Lightning Discharges?" New Scientist, 77:88, 1978. (X4)

GLL17 Lightning Superbolts

Description. Lightning bolts approximately 100 times more powerful than ordinary lightning. Most superbolts have been observed in winter storms over Japan and the northeast Pacific. They seem to originate in positively charged portions of the clouds.

Data Evaluation. Many satellite observations. Rating: 1.

Anomaly Evaluation. The much greater energy of the superbolts and their apparent origin in positively charged sections of thunderclouds may signify a different, hithertofore unrecognized, mechanism of lightning generation. Rating: 3.

Possible Explanation. None.

Examples of Lightning Superbolts

X1. General observation. "Unusually intense lightning strokes have been observed by optical sensors on the Vela satellites. These lightning flashes are over 100 times more intense than typical lightning. The lightning superbolts are characterized by optical power in the range of 10^{11} - 10^{13} W, have a duration on the order of 1 ms, and have a total radiant energy greater than 10^{9} J. In conjunction with sferics data the Vela trigger rates indicate that about two lightning flashes in 10^{3} exceed an optical power of 10^{11} W and five flashes in 10^{7} exceed an optical power of 3×10^{12} W." Winter storms over Japan and the northeast Pacific have produced most of the superbolt observations. Lightning in these storms is very powerful, infrequently hits the ground, and seems to originate in positively charged regions of the clouds. (R1, R2)

X2. General observation. Superbolts detected in Oklahoma prairie storms. (R3)

X3. December 4, 1978. Quito, Ecuador.

"9:50 P.M. local time. Weather: heavy rain for 2-3 hours earlier that evening, followed by a dense and very low overcast. Same conditions appear to have prevailed over the entire northern half of Ecuador, at least along the Andes. In Quito there had not been a single lightning flash during any part of the rainstorm.

"The light was on in the room and the drapes were drawn over the windows. Still, though I was reading a book on top of all the other impediments to vision, I noted a brilliant, rapid series of silver flashes flooding in through a crack in the drapes. I flinched, thinking lightning had struck right outside and that a tremendous crash was coming. But---nothing!...But a good 3 minutes after the flash, a low booming began, rising suddenly to deep, loud shock waves, which rattled windoes and literally shook the whole building. 'Wow,' I thought, computing the distance at about 36 miles, 'that must have been the most incredible bolt of lightning ever!' And at that my interest dropped.

"Until the next morning, that is, when a call came from my wife. Her first words were, 'The world is coming to an end,' Instantly (or nearly so) I realized she must have seen the flash in Ibarra, some 80 miles north of Quito. Not only had she seen it, she had been out driving with friends when it blinded and scared them so badly that they had to pull off the road.

"I was able to learn that the flash had been seen all the way north at least to Columbia, westward to Esmeralda (150 miles), eastward to Lago Agrio (an oil town 180 miles from Quito) and south to Latacumga (100 miles from Quito), and these were only minimal distances---I believe it may have been seen over a much wider area than this." (R4, R5)

References

R1. Turman, B.N.; "Detection of Lightning

Superbolts," Journal of Geophysical Research, 82:2566, 1977. (X1)
R2. "Super Lightning Detected by Satellite," Science News, 112:15, 1977. (X1)
R3. "NOAA Finds Lightning Superbolts in Oklahoma Storms,"American Meteorological Society, Bulletin, 62:1060, 1981. (X2)
R4. Girard, Robert G.; personal communication, September 15, 1985. (X3)
R5. Anonymous; "Chispazo Electrico en las Nubes Causo Alarma Anteanoche," Quito El Comercio, December 6, 1978. (X3)

GLL18 Cyclic Flashing of Lightning

Description. The cyclic waxing and waning of the frequency of lightning flashing in a thunderstorm. During its lifetime, a thunderstorm may go through several cycles of lightning activity with periods of roughly 10-30 minutes.

Data Evaluation. Several reinforcing studies exist. Rating: 2.

Anomaly Evaluation. It is not clear why a single thunderstorm cell would wax and wane cyclically. Usually, they grow and decay---lasting one cycle only. Rating: 3.

Possible Explanation. Rather than single cells varying in their rates of activity, a composite cyclic effect may result when individual cells in a storm grow and decay sequentially.

Examples of Cyclic Flashing of Lightning

X1. General observation. Three thunderstorms were observed with a noise meter. The average periods of flash rate varied between 17 and 31 minutes. (R1)

References

R1. Satyam, M.; "Cyclic Variation of the Rate of Flashing in Thunderstorms," Journal of the Atmospheric Sciences, 19:346, 1962. (X1)

GLL19 Dual Lightning Discharges

Description. Two or more lightning discharges that occur essentially simultaneously several miles apart. The discharge channels are not usually connected in any way. A substantial fraction of lightning discharges in a storm may be dual in nature.

Data Evaluation. Only a single study found to date. Rating: 2.

Anomaly Evaluation. No interconnecting mechanism for producing simultaneous lightning discharges has been found as yet. Electrostatic induction seems a likely prospect; and this process is well-understood. Rating: 3.

Possible Explanations. One discharge might simultaneous stimulate another, although the distances involved are admittedly large. More speculatively, cosmic ray showers might initiate two or more discharge channels.

Similar and Related Phenomena. The apparent induction of ball lightning inside enclosures (GLB10) is a good example of electrostatic induction over long distances.

Examples of Dual Lightning Discharges

X1. General observation. "30% of the intracloud lightning discharges and 35% of the cloud-to-cloud lightning discharges that occurred in the late stages of a convective thunderstorm are shown to possess two major,unconnected channel portions several kilometers apart." (R1) This is an excerpt from the abstract.

X2. Satellite observations. Later observations from satellites have shown that "sympathetic" lightning strokes may be separated by much great distances than suggested in X1.

"Video recordings made from the Space Shuttle at night show large areas of lightning activity in clouds and some flashes that appear to be sympathetic with other flashes. Nearly simultaneous appearances of lightning as far apart as 100 km suggest that widely separated discharges may somehow be related." (R2)

In fact, even the forgoing 100-kilometer figure may be much too small according to other observations from other Space Shuttle flights.

"One interesting observation from space is that lightning discharges appear to be initiated simultaneously at places as far as 1,000 miles apart, [B. Vonnegut] says. 'If you know that this has happened, for example, in 40 milliseconds, you can calculate the speed of communication' of electrical signals." (R3)

The questions are, of course, just what are these "signals" and how do they trigger sympathetic lightning strokes?

References

R1. Teer, T. L.; "Dual Lightning Discharges," American Geophysical Union, Transactions, EOS, 55:1131, 1974. (X1)

R2. Ahmadjian, Mark, et al; "Video Pictures of Lightning Discharges Taken from the Space Shuttle," Eos, 67:891, 1986. (X2)

R3. Anonymous; "Top-Side View of Lightning's Splendor," Science News, 123: 8, 1983. (X2)

GLL20 Abnormally Long Lightning Strokes

Description. Lightning strokes on the order of 100 miles long.

Data Evaluation. A single report of radar observations. Rating: 3.

Anomaly Evaluation. Current theories of lightning discharges cannot easily account for lightning strokes 100 miles long. Rating: 2.

Possible Explanations. None.

Similar and Related Phenomena. Horizontal lightning (GLL5), superlightning (GLL17), meandering lightning (GLL25).

Examples of Abnormally Long Lightning Flashes

X1. General observation. Reporting the results of radar observations of cloud-hidden flashes. "In Midwestern thunderstorms along the front separating masses of warm and cooler air, lightning strokes up to 100 miles long have been found. Theories of lightning discharge are expected to need revision because of the new observations. (R1)

References

R1. "Spot Hidden Lightning," Science News Letter, 68:359, 1955. (X1)

GLL21 Anomalous Electrical Fields and Currents during Lightning

Description. Measurements of near-zero electrical currents and fields during strong lightning strokes.

Data Evaluation. Repeated observations with one experimental setup. Rating: 3.

Anomaly Evaluation. Large electrical currents and strong fields would normally be expected during a lightning stroke. Rating: 2.

Possible Explanation. None.

Similar and Related Phenomena. None.

Examples of Anomalous Electrical Fields and Currents during Lightning Strokes

X1. General observation. Toronto, Ontario, Results from current measuring instruments placed on the CN Tower, 1815 feet high. "In the past eight months, 31 flashes and their current measurements have been recorded to the tower, he said, but some puzzling observations---such as a zero electric field in the midst of a large flash---need to be explained." (R1)

References

R1. "Flashy Research," Science News, 117: 376, 1980. (X1)

GLL22 Lightning Shadowgraphs

Description. The production of shadowgraphs of objects on exposed surfaces by bright lightning flashes. The images often fade within a few minutes.

Background. Lightning shadowgraphs resemble the lightning figures said to appear on persons struck by lightning (GLL9). Whereas lightning figures are generally dismissed as misinterpretations of the dendritic patterns normally appearing on the bodies of lightning victims, the reality of lightning shadowgraphs might signify that some lightning figures, especially those involving metallic objects, have some basis in fact.

Data Evaluation. Several reports exist; some in good detail. Rating: 2.

Anomaly Evaluation. Although the precise photochemical reactions are not known, the reproduction of images on surfaces, particularly chemically treated surfaces, does not seem unreasonable. Rating: 3.

Similar and Related Phenomena. Lightning figures (GLL9).

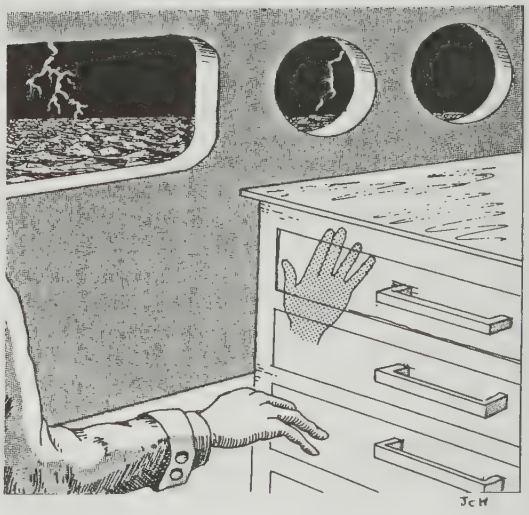
Examples of Lightning Shadowgraphs

X1. 1892. Errol, England. "A telephone wire had been broken or fused by lightning, and on an employe seeking to repair the break, he found on one of the white insulators a picture of the roof of a neighboring house. The picture had probably been flashed on the porcelain by the lightning." (R1)

X2. Circa 1904. North Atlantic Ocean. "While on a voyage recently from Hamburg to St. Thomas, the second officer of the Hamburg-America liner 'Galicia', being on the bridge during a terrific electrical display, observed the following phenomena, which he carefully noted, and which it is our privilege to present to our readers. In advance it may be remarked that all the wood and iron work about the bridge had been painted gray. In changing his position he casually removed his hand from a cabinet on the bridge immediately after a particularly brilliant flash of lightning, and what was his astonishment to notice was an exact counterpart of it in silhouette upon the cabinet, and to add to his amazement the picture remained imprinted fully five min-

utes. Such a spectacle was well calculated to inspire the officer to further observations, which he carried out with like results. Among others he placed an observation instrument upon the cabinet, and waiting his opportunity to remove it just after a vivid flash, to find the shadowgraph perfect in detail even to the cross-hairs over the objective plainly visible upon the surface." (R2)

X3. July 9, 1923. England. "During the storm of July 9th-10th a remarkable 'photograph' of a wastepaper basket was made by lightning on the floor of a Mincing Lane office, that of Messrs. Thompson Bros. & Co. The impression had been made on bare, unpolished, ordinary flooring boards, and consisted of a bleached image of the basket, which was apparently lying across the boards with its open end roughly towards south." A photograph of the shadowgraph accompanies the article. (R3)



Lightning shadowgraph created on the bridge of the Galicia in 1904. (X2)

References

R1. English Mechanic, 56:428, 1892. (X1)
R2. "Remarkable and Rare Effects of Lightning, Scientific American Supplement, 57:23679, 1904. (X2)
R3. "The Production by Lightning of a Shadow-Picture on Bare Boards," Meteorological Magazine, 58:166, 1923. (X3)

GLL23 Wisps of Flame Left by Lightning Strokes

Description. Residual wisps of flame, resembling ignited material, left in lightning discharge channels. The wisps may seem to drift with the wind.

Background. This phenomenon possesses some characteristics of bead lightning (GLL2) and may in fact be a variety of this form.

Data Evaluation. A single but well-observed example. Rating: 3.

Anomaly Evaluation. The persistence of "ignited material" (probably incandescent gases) is curious as is their tendency to drift away from the discharge channel. Rating: 2.

Possible Explanation. Packets of incandescent gases detached from the discharge channel.

Similar and Related Phenomena. Bead lightning (GLL2), which sometimes seems to be composed of burning fragments.

Examples of Residual Wisps of Flame Left by Lightning Strokes

X1. July 27, 1936. Clarendon, Virginia. "The center of the storm kept somewhat west of the writer's position at Clarendon, Virginia, and at a point in the southwest, only a few miles away, there appeared a most spectacular frequency of discharges earthward. Some appeared as mere single sparks, but the majority were of the repeating or of the stream type of discharge of exceptional size, appearing like ribbons of flame searing the darkness. One of these, which seemed almost to hang in the sky only a few miles away, appeared to ignite something high in its course, leaving wisps of flame which persisted momentarily, detaching themselves from the stream and drifting eastward from the path of the discharge as if carried by the wind. This phenomenon was observed at several points along the discharge, and was also witnessed by my son, Howard F. Allard, who was observing the lightning beside me. A portion of the path of the discharge, at and below these points, was also indicated by a train of sparks persisting momentarily after the streak had gone." (R1)

Reference

R1. Allard, H.A.; "Remarkable Lightning Bolt," Science, 84:136, 1936. (X1)

GLL24 Tubular Lightning

Description. Very broad lightning discharge channels possessing a tubular appearance. Channels up to 18 feet in diameter have been measured in photographs. These broad channels frequently meander and display a striated or broken structure.

Data Evaluation. Thick, stream-like strokes are often reported visually, but the basis of this entry is substantial photographic evidence. Rating: 2.

Anomaly Evaluation. Normal lightning channels are typically 5 inches in diameter, so that channels many feet in thickness sorely try prevailing models of lightning discharges. Rating: 2.

Possible Explanation. No physical explanation has been uncovered; however, camera motion during exposure is a possible source of error, although the examples reported below seem free of this problem. To a camera, ball lightning might appear as a tubular channel.

Similar and Related Phenomena. Bead lightning (GLL2) is sometimes thick and broken; meandering lightning (GLL25) may seem unusually broad. Rapidly moving ball lightning, which occasionally measures several feet in diameter, might be rendered photographically as tubular lightning (GLB1).

Examples of Tubular Lightning

X1. May 29, 1908. Chicago, Illinois. During lightning photography experiments. "The flash was a very bright one, but it was so sudden and vivid that I did not notice anything peculiar about it. The thunder accompanying it was sharp and sudden, like the report from a cannon. The interval between lightning and thunder cannot be given accurately; it was less than a second, and probably more than half a second. The picture of this flash is very remarkable; I have never seen any one resembling it, and would prefer to call it a tubular flash on account of its general shape and large diameter, measuring, as it does, over 3 mm at its widest part, and about 2 mm at its narrowest; this great width cannot be accounted for, to be caused by the movement of the camera; the uniformity of the width, both in the vertical and horizontal portion of it, disproves that idea....If we assume that the nearest portion of this flash took place at a distance of 1,000 feet, which in my opinion would be a conservative estimate, we are confronted by the remarkable fact that the diameter of this flash would be over 18 feet. (The angle of the lens in 43°.) I am absolutely at a loss to account for this remarkable flash; it does not appear to be a ribbon flash, which can be accounted for by the movement of the lightning path, by air currents; so will have to defer my opinion until some future time, and leave it to others who may be able to give a plausible explanation." (R1)

X2. July 21, 1937. Deer Lodge, Manitoba, Canada. Photograph taken of a meandering, broad, tubular discharge channel. (R2)

Still-camera photograph of what was believed to be meadering tubular lighting. (R2, J.D. Barry)

References.

R1. Abbot, C.G.; "Remarkable Lightning Photographs," Smithsonian Miscellaneous Collections, 92:1, no. 12, 1934. (X1)

R2. Holzer, R.E., and Workman, E.J.; "Photographs of Unusual Discharges Occurring during Thunderstorms," Journal of Applied Physics, 10:659, 1939. (X2)

GLL25 Meandering Lightning

Description. Intricate, looping, reversing, wandering lightning strokes. Such discharge channels often approach the ground closely but do not touch seemingly inviting objects. Meandering lightning is frequently broken and/or tubular.

Data Evaluation. Only a few of the many extant photos of meandering lightning are noted below. Rating: 1.

Anomaly Evaluation. It is difficult to conceive, in the framework of current thinking about the formation of lightning discharge channels, how such long, tortuous paths close to grounded objects could occur. It would seem that a multitude of paths of much lower resistance exists but are "ignored" by the lightning for some undetermined reason. Rating: 2.

Possible Explanations. Camera motion; but experienced investigators easily eliminate this. Rapidly moving ball lightning might appear as a meandering flash on film.

Similar and Related Phenomena. Ball lightning (GLB) habitually follows complicated courses. Meandering lightning is frequently striated or broken (GLL2) and tubular (GLL24). Horizontal lightning (GLL5) usually bypasses nearby, seemingly inviting targets.

Examples of Meandering Lightning

X1. July 17, 1908. Chicago, Illinois. Analyzing a lightning photograph. "It shows a meandering and very complicated flash, consisting of four distinct and separate rushes, following one another in the same path, opened up by the first discharge. It is almost incomprehensible how such a complicated flash can follow all those curves and bends which the photograph shows. The only reasonable explanation to my mind would be that the path of the flash was a partial vacuum with very low resistance, which the beaded or striated appearance of this flash would tend to confirm. How this partial vacuum can be accounted for is a difficult problem to solve. It is the first lightning photograph I have had the fortune of seeing that shows the path in broken lines, or striated." (R1)

X2. September 3, 1936. Santa Fe, New Mexico. Referring to a lightning photo. "The nost notable features of this discharge are: (1) its irregularity of path and rapid reversals in direction, (2) its proximity to ground objects with no apparent contact with the ground, (3) the beaded nature of the path, and (4) the progress of the discharge in two directions from a single point." (R2)

X3. July 21, 1937. Deer Lodge, Manitoba, Canada. A meandering, broad, tubular flash, close to but not touching ground objects. (R2)

X4. May 1, 1997. Near Patterson, New Jersey. That lightning may sometimes seem to meander in circular fashion is seen in the following observation.

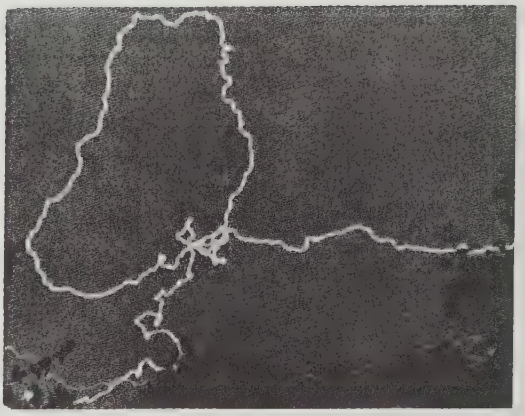
Between 3 and 4 P.M., D. Quinlan was driving along Route 80. A dark line squall was approaching from the west. Quinlan observed many horizontal strokes of lightning passing from cloud to cloud. These discharges seemed to make little noise---no loud crashes of thunder, although sounds were somewhat muffled by his vehicle. These strokes moved so slowly that their progress across the sky could be easily tracked visually. Most remarkable were three discharges that began to his right, progressed across the sky in nearly a horizontal plane, and then looped back to near their starting points, thereby completing what appeared to be a circle.

References

R1. Abbot, C.G.; "Remarkable Lightning Photographs," Smithsonian Miscellaneous Collections, 92:1, no. 12, 1934. (X1)

R2. Holzer, R.E., and Workman, E.J.; "Photographs of Unusual Discharges Occurring during Thunderstorms," Journal of Applied Physics, 10:659, 1939. (X2, X3)

R3. Quinlan, David; personal communication, May 2, 1997. (X4)



Meandering lightning photographed over Arnhem in 1958. (J.D. Barry)

GLL26 Ribbon Lightning

Description. Multiple, nearly simultaneous, parallel lightning strokes that are so close together and so arranged geometrically that they resemble a ribbon. The regions between the several parallel flashes involved may be filled with bright horizontal and curved lines. Ribbon widths have been measured in feet.

Data Evaluation. The only evidence we have found so far supporting this unusual sort of multiple lightning flashes in seen in a century-old photograph published in a science magazine. Rating: 2.

Anomaly Evaluation. It is curious that so many lightning channels should develop very close and parallel to one another, but there does not seem to be anything anomalous in ribbon lightning. Rating: 3.

Possible Explanation. None offered.

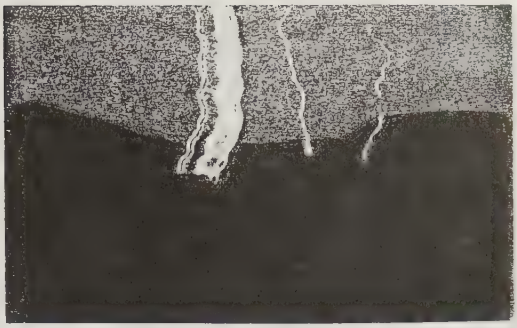
Similar and Related Phenomena. Sheet lightning; dual lightning discharges (GLL19); sympathetic lightning (GLL18).

Example

X1. Summer 1898, Chardon, Ohio.

"In the summer of 1898, W.H. Osborne, of Chardon, Ohio, an amateur photographer of some experience, secured the accompanying photograph [see sketch] of a lightning flash which seemed to us to show certain peculiarities that entitle it to a public notice and a permanent record. The picture shows three flashes, of which the distant and faint one at the right and the bright one at the left were simultaneous, while the center one occurred a few seconds earlier. Nothing about the thunder that followed the last and bright flash suggested that it was specially near, but an examination of the picture when developed and a comparison with the features of the landscape showed that it had come to earth about fifteen rods from the place where Mr. Osborne stood with his camera. Mr. Osborne and myself carefully searched the locality indicated, but failed to find even the slightest mark caused by the discharge upon any object or in the earth.

"Measurements at this place give the width of the ribbon of light, if it stood at right angles with the line of sight, about eight feet. This ribbon of light is seen to consist of six lines, approximately parallel, of unequal brightness, a pair being at each edge and a pair near the center. The space between these pairs is crossed by many nearly horizontal lines and a few oblique ones, while that between the right-hand pair is crossed by oblique lines only. The horizontal lines at the right of center become curved downward, which, with the increased brightness of the whole toward that side, suggests to us that the ribbon of light did not lie in a plane, but was concave toward a point at the observer's left." (R1)



Ribbon-like lighting was photographed at Chardon, Ohio, in 1898. (X1)

Further analysis appeared to show that the ribbon was curved and at an angle to the observer. Taking this curvature and angle into account, the actual width of the ribbon was probably fifteen or twenty feet wide.

Reference

R1. Cook, Orange; "Ribbon Lightning," Popular Science Monthly, 56:587, 1900. (X1)

GLL27 Spoked and Spider Lightning

Description. Horizontal, radial patterns of lightning discharges that emerge parallel to thundercloud bases. If the discharges are relatively straight, it is termed "spoked lightning"; if strongly branched, it is "spider lightning."

Data Evaluation. Spider lightning is formally recognized by science and has been the subject of instrumented investigation. Spoked lightning has been observed and documented, but we know little about it. Rating: 2.

Anomaly Evaluation. Although spoked and spider lightning possess similar geometrical features---radial, horizontal structure---they may not be closely related. The origins of both are obscure. Why, for example, should a thundercloud develop a wheel-like structure? Rating: 2.

Possible Explanations. Convection cells in liquids sometimes develop radial symmetry as seen, for example, in the basalt prisms of the Giants Causeway.

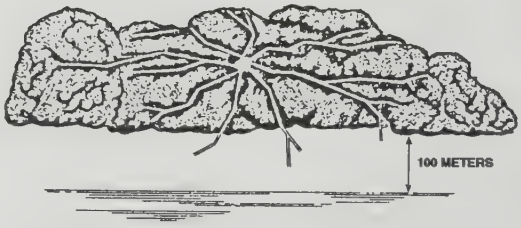
Similar and Related Phenomena. The spoked structure of some thunderclouds (GWC14 in Tornados, Dark Days..).

Examples

X1. July 21, 1985. Strait of Malacca. Spider lightning as seen from the m.v. Staffordshire.

"Between 2000 GMT and 2200 GMT whilst the vessel was transiting the Strait of Malacca in a southeasterly direction, the following phenomenon was observed.

"For several hours lightning had been seen ahead of the vessel. As we approached, it appeared to take on several forms, the most interesting of which is shown in the sketch. It had the appearance of a central point of light with ragged streaks radiating from the centre in a mainly horizontal direction. At no time did this lightning reach the sea surface. This type was observed about ten times during the period of observation." (R1)

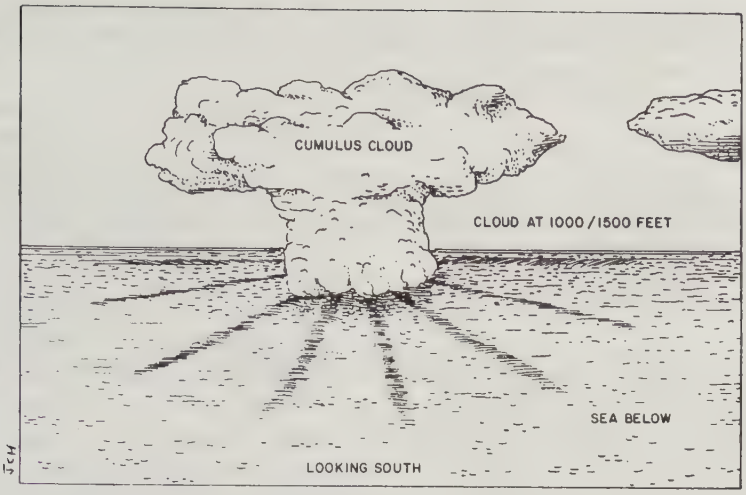


Strait of Malacca, 1985. Spider-lightning emanated from the central region of a cloud deck. No strokes reached the ground. (X1)

X2. July 1990. Fenwick Island, Delaware. Spoked lightning as observed by the compiler.

A severe thunderstorm had just passed and was moving away eastward over the ocean. Suddenly, from a very black cloud to the southeast, a very thick, very straight bolt of lightning descended from the black cloud directly to the sea surface. At this instant, about six bright spheres shot out radially from the base of the cloud where the lightning bolt emerged. The bright spheres resembled the balls produced by the old-fashioned Roman candles once used on the Fourth of July. They quickly fizzled out. (R2)

The spoke-like pattern immediately brought to mind the spoked structure of some thunderclouds, as described in GWC14 in Tornados, Dark Days. One can only surmise that the several bright spheres were examples of ball lightning.

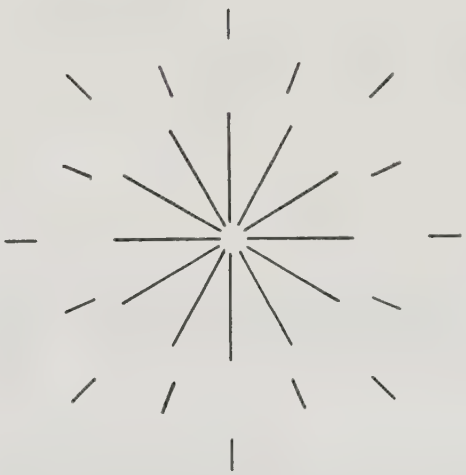


Sketch of cloud spokes radiating from a cumulus cloud over the English Channel in 1937. This phenomenon supports the possibility of a radial structure in thunderclouds that might generate spoked lightning. (See GWC14-X2 in Tornados, Dark Days...)

X3. September 6, 1997. Lac Leman, France. Spoked lightning observed by campers at 1250 meters elevation.

"We were awoken at 11 p.m. by what initially appeared to be a white light flashing at approximately one-second intervals. The flashing was caused by regions of lightning rotating within the immediate cloud sheet. The cloud-base was at least 300 metres above the ground and was incomplete because the occasional star could be seen. The clouds were misty in appearance and of low density. This lightning-effect slowly changed to provide the main observation of a slowly clockwise-rotating spoked wheel with 12 to 16 spokes and two outer rings of more diffuse bands.

"This wheel appeared immediately above us and moved across the visible sector of the sky, with a lifetime of between three and five seconds. It is difficult to estimate the size of the wheel but to all intents and purposes it practically filled our field of view. A succession of similar wheels was observed over a period of about 15 minutes. Each wheel followed essentially the same path. Some were more perfect than others, presumably because of differences or breaks in the cloud sheet. No thunder was heard nor was there any wind. Occasionally, single unrelated flashes of sheet lightning occurred." (R3)

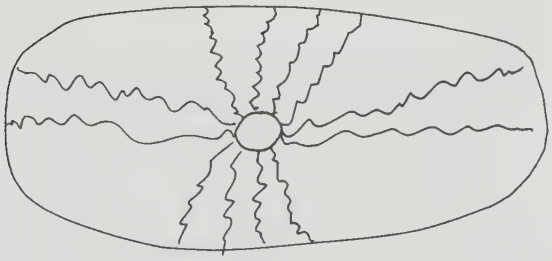


Wheel-like lightning was observed at Lac Leman, France, in 1997. (X3)

There is an eerie resemblance between the luminous wheel-like structures just described and the marine light wheels of GLW4.

X4. August 1, 2000. Tampa, Florida. L. Winton was observing a fast-moving thunderstorm a couple miles to the north of his home. The lightning was almost constant, but one event resembled that of X2.

"Suddenly, in the center of a small cloud that I was looking at directly, I could see a white, very bright ball of possibly plasma that appeared to be about 1.5 times the diameter of the sun at about two miles away. Immediately, the ball spiked and formed short, jagged lightning bolts up, down and sideways, all of about the same diameter and composition. Three or four bolts went up and the same number down, and 2-3 each from both sides. I could not see bolts that



Spoked lightning radiated from a bright ball near Tampa, Florida. (X4)

may have come toward or away from me. All bolts went to the edge of the cloud and disappeared, followed by a very loud thunderclap. From the first appearance of the ball of light to the thunderclap was probably not more than one second. I would have missed it if I had not been looking directly at it." (R4)

X5. General observations of spider lightning in Florida. The basic phenomenon was described as follows:

"Dissipating storms in Florida produce spectacular discharges that propagate over large horizontal distances near the cloud base. These discharges have come to be called 'spider' lightning because of their highly branched nature and their propensity to 'crawl' along the cloud base at a visually detectable speed. Spider-like discharges occur also within the trailing stratiform region of convective systems in the Great Plains states." (R5)

Using a VHF interferometer, a high-speed video system, and other instruments, it was concluded that spider-lightning events consist of slow, negative leaders that propagate horizontally at 2-4 x 10^5 m s^{-1}. The nature and origin of spider lightning remain poorly understood. (R5)

References

R1. Thomas, C.O.; "Lightning," Marine Observer, 56:116, 1986. (X1)
R2. Corliss, William R.; personal observation, July 1990. (X2)
R3. Hooton, Elizabeth J., and Hooton, Keith A.; "Observation of a Rare 'Spoked-Wheel' Lightning Phenomenon in the French Alps," Journal of Meteorology, U.K., 22:372, 1997. (X3)
R4. Winton, Lawson; personal communication, August 25, 2000. (X4)
R5. Mazur, Vladislav, et al; "'Spider' Lightning in Intracloud and Positive Cloud-to-Ground Flashes," Journal of Geophysical Research, 103:19811, 1998. (X5)

GLL28 Bipolar Nature of Large Electrical Storms

Description. The observation that in most large electrical storms, the rarer, positive lightning flashes are strongly concentrated at the northeastern end of the storm, which may stretch southwesterly for hundreds of kilometers.

Data Evaluation. The data are generated by a network of lightning detectors now installed over much of North America. Rating: 1.

Anomaly Evaluation. It is curious that large-scale electrical storms should be bipolar in terms of charge flow between the clouds and the ground. One would expect positive and negative strokes to be evenly distributed. Some unrecognized influence must be operating at a scale of hundreds of kilometers. Rating: 2.

Possible Explanation. Upper-level winds may blow cloud tops, which are usually positively charged, to the northeast thereby concentrating the positive flashes there. In other words, the storm structure is tilted by the wind.

Examples

X1. Observations of storm systems in the southern United States. Ground-based observers see only a few of the anvil-shaped clouds that comprise a big electrical storm. The entire storm may stretch for hundreds of kilometers---and it may not be a simple structure.

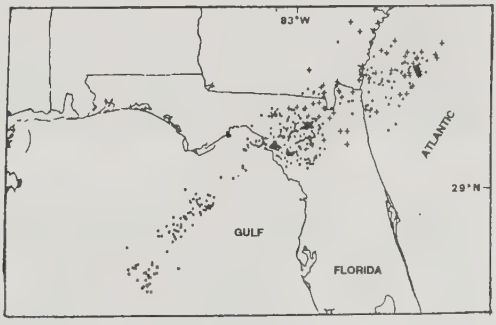
The latest surprise is that all large electrical storms are bipolar; that is, the rare positive lightning strokes are concentrated at the northeast end of the storm complex, while the negative strokes are everywhere else along a northeast-southwest line. This bipolar structure persists for several hours, and it has been found in all North American storms analyzed so far. This insight into the structure of large electrical storms was provided by magnetic lightning detectors that have now been installed over nearly 75% of the United States.

The positive lightning strokes are of longer duration and more liable to start fires than the common negative strokes. But why are they concentrated at one end of the storm complex? R. Orville ventures that in a big mesoscale electrical storm, the prevailing winds blow the positively charged upper portions of the clouds to the northeast, thus establishing bipolarity. (R1, R2)

References

R1. Orville, Richard E., et al; "Bipole Pattern Revealed by Lightning Locations in Mesoscale Storm Systems," Geophysical Research Letters, 15:129, 1988. (X1)

R2. Anonymous; "New Lightning Theory Strikes," Eos, 69:57, 1988. (X1)



Lightning distribution across Florida on February 22, 1987, 8:00-9:00 P.M. The plus signs designate the positive lightning strokes. (X1)

GLL29 Gamma-Ray Flashes in Thunderstorms

Description. The detection of bursts of gamma rays in thunderstorms.

Data Evaluation. Beginning in the 1990s, the scientific study of thunderstorm gamma-ray flashes accelerated, and the literature on the subject proliferated accordingly. Our references represent only a small portion of the relevant literature. Rating: 1.

Anomaly Evaluation. It was realized back in the 1920s that electrical conditions in the region of thunderstorms could conceivably generate gamma rays. However, none was detected until the 1990s, according to the literature examined so far. After the demonstration that thunderstorm gamma rays really existed, it was quickly determined that a runaway mechanism was involved that created avalanches of electrons leading to Bremsstrahlung ("braking") radiation consisting of gamma rays. With a ready explanation of thunderstorm gamma rays at hand, this phenomenon cannot be considered anomalous. Rating: 4.

Possible Explanation. As above.

Similar and Related Phenomena. Neutron generation in thunderstorms (GLL30); luminous phenomena above thunderstorms (sprites, elves, etc.) (GLL1).

Examples

X1. Early reports of gamma-ray flashes associated with thunderstorms. In the early 1990s it was becoming increasingly obvious that some strange, unexplained phenomena were occurring in the upper atmosphere, particularly above thunderstorms. Mysterious light flashes had been reported above these storms for years (GLL1) but had hitherto for been been largely ignored by mainstream science. In 1994, similar, possibly intimately related flashes of energy in a different portion of the electromagnetic spectrum were detected by G.J. Fishman et al.

"Detectors aboard the Compton Gamma Ray Observatory have observed an unexplained terrestrial phenomenon: brief, intense flashes of gamma rays. These flashes must originate in the atmosphere at altitudes above at least 30 kilometers in order to escape atmospheric absorption and reach the detectors. (R2)

The energies of the gamma rays in these flashes are very high. They are typical of the braking radiation (Bremsstrahlung) from 1,000,000 electron-volt electrons. (R3) Since most of the gamma flashes originate over regions where thunderstorms are frequent, it is tempting to associate them with lightning. Ordinary lightning, however, is not energetic enough to generate the gamma flashes and, of course, ordinary lightning does not occur above 30 kilometers altitude anyway. G.J. Fishman et al, who reported on this new phenomenon in Science, speculated that some hitherto unrecognized, high altitude electrical discharges occur high above areas hosting thunderstorms. (R1, R2)

Of course, we now know that these "hitherto unrecognized," high-altitude, luminous, electrical phenomena are called spites, blue jets, elves, etc.---the same phenomena we collected under the term "rocket lightning" in the first edition of this volume. (GLL1)

X2. Identification of the mechanism that generates gamma-ray flashes. By 1996, it was widely accepted that this mechanism was runaway air breakdown, as expressed in the abstract of a 1996 paper by Y. Taranenko and R. Roussel-Dupre.

"Gamma-ray flashes of atmospheric origin as well as blue jets and red sprites are

naturally explained by high-altitude discharges produced by runaway air breakdown. We present the first detailed model of the development of upward propagating discharges and compute optical and gamma-ray emissions that are in excellent agreement with observations. According to our theory, such discharges represent the first known manifestation of runaway air breakdown, a fundamental new process in plasma physics." (R4)

X3. Gamma-ray production more common than originally supposed. Balloon-borne instruments launched into summer thunder storms in the mid-1990s by Eack et al (R8, R7) revealed three-fold increases in the gamma-ray flux when the balloons descended through thunderstorm anvils. The implication is that gamma-ray production in thunderstorms is much more common and intense than originally believed.

References

R1. Kerr, Richard A,; "Atmospheric Scientists Puzzle over High-Altitude Flashes," Science, 264:1250, 1994. (X1)

R2. Fishman, G.J., et al; "Discovery of Intense Gamma-Ray Flashes of Atmospheric Origin," Science, 264:1313, 1994. (X1)

R3. Chang, Britton, and Price, Colin; "Can Gamma Radiation Be Produced in the Electrical Environment above Thunderstorms?" Geophysical Research Letters, 22:1117, 1995. (X2)

R4. Taranenko, Yuri, and Roussel-Dupre, Robert; "High Altitude Discharges and Gamma-Ray Flashes: A Manifestation of Runaway Air Breakdown," Geophysical Research Letters, 23:571, 1996. (X2)

R5. Inan, Umran S., et al; "On the Association of Terrestrial Gamma-Ray Bursts with Lightning and Implications for Sprites," Geophysical Research Letters, 23:1017, 1996. (X2)

R6. Milikh, G., and Valdivia, J.A.; "Model of Gamma Ray Flashes Due to Fractal Lightning," Geophysical Research Letters, 26:525, 1999. (X2)

R7. Anonymous; "Gamma-Ray Cloud Burst," Science, 287:549, 2000. (X3)

R8. Eack, Kenneth B., et al; "Gamma-Ray EMissions Observed in a Thunderstorm Anvil," Geophysical Research Letters, 27:185, 2000. (X3)

GLL30 Neutron Generation in Lightning Bolts

Description. The detection of neutrons generated in thunderstorms.

Data Evaluation. We have found only one experiment relevant to this phenomenon in the literature examined to date. Our library research may be inadequate here. Rating: 3.

Anomaly Evaluation. The source of these neutrons seems to be unknown. Conceivably, they could come from thermonuclear reactions in the lightning bolts or perhaps from nuclear reactions created by thunderstorm gamma rays. Rating: 2.

Possible Explanations. See above.

Similar and Related Phenomena. Thunderstorm gamma rays (GLL29).

Example

X1. 1980s. India. At a high-altitude, cosmic-ray research station. Statement in the abstract of a paper in Nature.

"Here we present the first experimental evidence that neutrons are generated in lightning discharges, with 10^7-10^{10} neutrons per lightning stroke. Whether these neutrons are thermonuclear in origin, or are generated by non-thermal processes, remains to be determined." (R1)

We have not come across further information on this or other experiments relating to thunderstorm neutrons.

Reference

R1. Shah, G.N., et al; "Neutron Generation in Lightning Bolts," Nature, 316:173, 1985. (X1)

GLL31 Unusual (Usually Deadly) Interactions between Lightning and Humans

Description. A collection of diverse, often rather bizarre involvements of humans with lightning.

Data Evaluation. Anecdotes, surveys, general observations, and newspaper items, which in general are not backed by thorough scientific study and analysis. Rating: 3.

Anomaly Evaluation. These bizarre incidents primarily offer curiosity value. Rating: 3.

Similar and Related Phenomena. Lightning pranks (GLL11).

Examples

X1. July 1969. Lawson, Missouri. Lightning is unpredictable and produces many weird effects, but the following case pushes the weirdness envelope.

An electrician was driving home through an intense rainstorm that was accompanied by severe lightning. He parked his truck outside his house. Then it happened:

"As I started up the drive, I took about three or four steps, and then it was as though I had stepped into a very soft cotton ball. My whole body felt as if my head was behind my shoulders and being pulled down between my shoulder blades. (R1)

When he awoke, he was about 50 feet away on the other side of a fence and on his neighbor's property. His boots had been knocked off. The coins in his pocket and his belt buckle had melted. A visit to a doctor proved that he had been struck by lightning, and that his spine had been severely damaged.

Much stranger was his reaction to the ambient temperature. He was now impervious to cold. He was most comfortable between -10° and 0°F. His normal body temperature was low, just 95.2°, not terribly far from normal. He just didn't feel the cold. He never wore a coat and was comfortable working that way even at -23°F!

The electrician is far from being disabled. He even poses for photographs in the snow wearing just shorts and a T-shirt. He is now Publicity Director for a group called Lightning Strike and Electrical Shock Survivors International. (R1)

X2. Mountainous regions worldwide.

Occasionally, young, healthy hikers are discovered lying dead in the mountains without a mark on them. The answer to this mystery may be in the magnetic pulses created by close lightning strikes.

Most deaths from lightning are from direct strikes, side flashes, or ground currents. The ground currents kill by passing up one leg and down the other. Cows sheltering under trees are even more susceptible than humans because they contact the ground in four places! People and animals electrocuted by these phenomena bear burn marks and other clues pointing to the cause of death.

As for those "mysterious mountain deaths," M. Cherington and colleagues at the Lightning Data Center, Denver, suggest that these unlucky individuals may have been zapped magnetically. Lightning strikes can create electrical currents as high as 100,000 amperes in rocks and soil. These, in turn, create intense magnetic pulses that induce small electrical currents in nearby objects, such as hikers. Although small, these internal currents are sufficient to stop heart action---without leaving tell-tale signs. (R2)

X3. General observations. From section GLL8 we know of lightning's preference for oaks over other trees in mixed forests; now it seems that a search of death records show that men are far more often killed by lightning than women. P.E. Brown checked the figures for England and Wales for the years 1974-1989, when 56 people were listed as killed by lightning. Of these 48 were male, 8 female. Brown supposes that the preponderance of male deaths is due to males being more likely to be outside in exposed areas. (R3)

X4. September 22, 1999, London England.

"Two women were killed by lightning when the metal in one of their underwire bras acted like a conductor, a London inquest was told Wednesday. Sunee Whitworth, 39, and her friend Anuban Bell, 24, were killed Sept. 22 in a city park. Iain West, a pathologist, said the metal had melted. 'They were enveloped in a massive amount of energy,' he said." (R4)

References

R1. Sunlin, Mark; "An Unusual Case of Lightning 'Victimisation," Journal of Meteorology, U.K., 23:309, 1998. (X1)
R2. Anonymous; "Mystery Mountain Deaths and Lightning," Journal of Meteorology, U.K., 23:230, 1998. (X2)
R3. Brown, Paul R.; "Lightning Deaths and Sex," Journal of Meteorology, U.K., 16:244, 1991. (X3)
R4. Anonymous; "Bra Conducts Lightning; 2 Women Killed," Chicago Sun-Times, October 28, 1999. Cr. J. Cieciel. (X4)

GLL32 Effects of Lightning on Vehicle Engines

Description. Incidents in which the engines of automobiles or aircraft stalled in the vicinity of thunderstorms. Cause and effect are implied.

Data Evaluation. Two anecdotes from usually reliable sources are at hand. No scientific studies of the purported phenomenon have been located. It must be pointed out that vehicles often operate in close proximity to electrical storms without experiencing stalling. The phenomenon, if it exists, is extremely rare. Rating: 3.

Anomaly Evaluation. From an engineering standpoint, it is conceivable that very strong electrostatic fields might temporarily shut down the electrical ignition systems of internal combustion engines. Certainly no physical principles would be violated in such an event. Therefore, there is little that is anomalous even if thunderstorm fields do cause engines to stall on rare occasions. What makes the stalling claim significant to many is its similarity to the many claimed instances where vehicles are said to have stalled during UFO encounters. Rating: 3.

Possible Explanation. The association between vehicle stalling and electrical storms is purely coincidental.

Examples

X1. July 20, 1992. Near Valognes, France. Some UFO reports aver that the presence of luminous phenomena (interpreted as alien vehicles) have stalled automobile engines. Here follows an unsensational report, sans UFOs, but with identical consequences.

A. Lunt and O. Whalley were driving a Citroen 2CV in heavy rain. Lightning in the distance only.

"While the car was four to five metres from the approaching halt sign with the gears still engaged, the engine cut out. The car was brought to a stop at the halt sign and when the puzzled men found that the car would not restart they spent some 10-15 seconds wondering what to do. Then suddenly there was a huge flash, described as an 'explosion', only two metres behind and to their right as lightning went to ground in a triangular, gravelled area which formed part of the road junction system. The inside of the car and the surrounding countryside lit up brightly and, simultaneously, there was a terrific crash of thunder. Startled, the occupants stayed in the car for a minute longer without trying to restart the engine before stepping outside to raise the bonnet of the car. The engine appeared dry and there was no discernible reason for its failure. Then, upon getting back into the car, the engine started at once, since then the vehicle has given no further trouble. (R1, R2)

Of course this single incident cannot prove that the powerful electrical field preceding a lightning stroke interfered with the car's ignition system. This report is suggestive only.

X2. July 9, 1945. An aircraft enroute from Maine to the Santa Marie Islands. As related by First Officer N.A. Pierson:

"We had just taken off from Presque Isle, Maine, and had been in cruise power for 50 minutes, when a large thunderhead cumulus was observed directly on course. Lightning could be seen around the edges and inside the thunderhead. All cockpit lights were on and the instrument spotlight was full on, with the door open. I had just finished setting the power and fuel flows for each engine. As the ship approached the thunderhead, there was a noticeable drop in horsepower and the airplane lost from 180 mph airspeed to 168 mph, and continued to lose airspeed due to power loss as we approached the thunderhead ...A few seconds before the lightning bolt hit the airplane all four engines were silent and the propellers were windmilling. Simultaneous with the flash of lightning, the engines surged with the original power...The Captain and I discussed the reason for all four engines cutting simultaneously prior to the lightning flash and could not explain it, except for the possibility of a magnetic potential around the cumulus affecting the primary or secondary circuits of all eight magnetos at the same time." (R3)

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GLM LOW-LEVEL METEOR-LIKE LUMINOUS PHENOMENA

Key to Phenomena

GLM0 Introduction

Most meteor anomalies occur at very high altitudes and belong, therefore, to the field of astronomy. As such, they are covered in another volume of this catalog (AYO). There remain, however, varieties of meteor-like luminous phenomena that apparently transpire at very low altitudes and can legitimately be included with other geophysical anomalies.

Predominant among these meteor-like phenomena are: (1) Luminous and nonluminous objects moving at very low altitudes that do not follow usual meteor protocol by disintegrating or burying themselves in the earth; and (2) Very fast, seemingly very near streaks of light that look a bit like meteors but may be auroral or electrical discharge in origin. Both phenomena are most perplexing because they do not obey the laws of meteoritics.

GLM1 Low-Level Meteor-Like Objects

Description. Luminous objects, travelling below cloud level, often trailing fire and smoke and emitting considerable noise. Most such objects disintegrate or hit the earth, but others gain altitude and disappear from sight. Frequent accompanying phenomena are: a sensation of great heat, a smell of sulfur, the appearance of black clouds before the meteor proper, and a phenomenon time span of several minutes.

Data Evaluation. Most of the observations are rather old but presented with good detail. Rating: 2.

Anomaly Evaluation. All of the examples described below are unusual in some way, but the most anomalous features are: (1) The appearance of clouds minutes before the actual object is observed; and (2) the long lifetimes of the phenomena---lifetimes much longer than those

of normal meteors. Other curious attributes, perhaps indicating that we actually have several causes acting, are: absence of sound, long horizontal paths close to the ground, and descent followed by regaining of altitude. Rating: 2.

Possible Explanations. Some of the examples recorded are undoubtedly true meteors, perhaps with the accounts garbled in some respects. Ball lightning and other electrical phenomena may be confused with meteoric objects in some cases. Some meteors may be accompanied by dust and gases that develop into clouds in the lower reaches of the atmosphere.

Similar and Related Phenomena. Some ball lightning manifestations (GLB) clearly resemble some of the phenomena cited here. The same is true for some of the electric discharge phenomena, especially GLD11. See AYO for long-duration high-altitude meteors. The similarity between low-level meteor-like objects and the classic thunderbolt (GFT) and UFO must be mentioned.

Examples of Low-Level Meteor-Like Objects

X1. March 4, 1822. Canajoharie, New York. About 10 p.m. "He first observed a sudden flash of light which appeared to extend from the heavens to the earth, and was followed by a momentary darkness, as if a cloud had passed over and intercepted the light. This darkness was soon dispelled, and the blazing meteor was in full view over his head, appearing to be twenty or thirty feet in diameter, and soon began to extend itself to the northeast and southwest, increasing in extension, and decreasing in its flaming appearance, until nothing was to be seen but two detached parts of it rapidly moving in different directions towards the northeast and southwest. Mr. Doty calculates that it was five or six minutes from the first appearance of the meteor until it finally vanished, and from six to ten minutes from its first appearance before the report of its explosion reached him, which resembled the noise of a distant cannon, and was followed by a strong sulphurous smell, that lasted fifteen or twenty minutes." (R1)

X2. January 2, 1825. Arezzo, Italy. "About a hundred paces off, at a height of ten fathoms, or less, from the ground, appeared, on a sudden, a luminous meteor, of the form of a truncated cone. This meteor appeared to be formed by a globe of fire situated in its fore part, which was the narrower, and which by its rapid motion, left behind a track of light, which gave it the appearance of a cone..... The whole length of the meteor appeared to be about two fathoms, and the diameter of the base half a fathom.... Its motion was very rapid, for in less than five seconds it traversed a space of about 350 paces. During this passage it shed a most brilliant light, so that a certain extent of land was illuminated, as in full day-light. The emanations of this luminous body were lost in the air, instead of being extinguished in the ground; it left behind no smell; produced no explosion or noise of any kind, not even that hissing made by artificial fireworks. The night in which this phenomenon occurred was calm, but very cold, and the sky clear. A great number of shooting stars were seen before and after the appearance of the meteor." (R2)

X3. 1846. Rangoon River, Burma. "It was about half-past seven in the evening, and then quite dark, when suddenly, without any warning, a tremendous sheet of light appeared to rush across the bows of the vessel in a horizontal direction. The light was not like lightning, but appeared to pass swiftly along, and had the aspect of a thick red flame, occupying the whole space left visible between the awning and the ship. The suddenness and terrific nature of the glare was such that she fell down upon the deck, believing, as she expresses it, that the world had come to an end, while the child screamed aloud with terror. As this frightful luminous appearance rushed by the ship a considerable accession of heat was felt by both the adult persons, and a strong sulphurous smell also accompanied it, though how long this feature lasted cannot now be stated with any certainty. But the phenomenon was unaccompanied by any sound, and sped noiselessly on; nor could

they see where it went, or what finally became of it. The whole affair lasted but some seconds, the light having dashed past them with a speed only inferior to lightning." (R3)

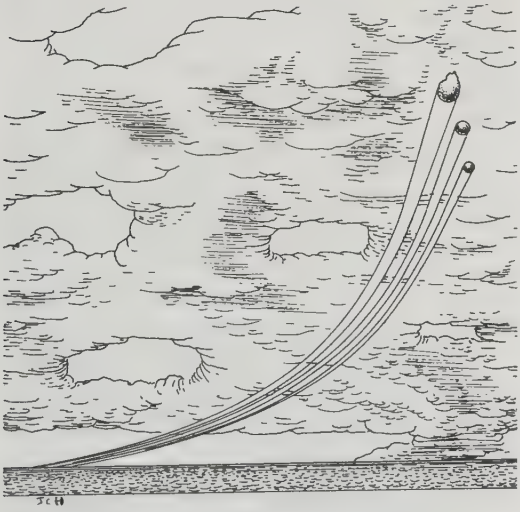
X4. December 8, 1847. Forest Hill, Arkansas. "...the sky was perfectly clear, and had been so through the day; but at quarter past 3 P. M., it became suddenly very dark. The clouds, or what appeared to be such, whirled in the strangest contortions, and appeared like a solid black fleece lighted from above by a red glare as of many torches, but scarcely penetrating the masses of clouds below. In the presence of hundreds of spectators there was a deafening explosion, and the concussion shook the houses and caused the bell of the village church to toll several times. At the moment of the explosion an ignited body ---compared in size to a hogshead---'descended like lightning,' and struck the earth about twenty feet east of a cotton gin which stands near the village. Within twenty minutes, the sky was clear and the sun shone as brightly as ever." A hot aerolite was found in the hole. (R4) The cloud preceeding the fall of the meteor is curious here.

X5. December 17, 1852. Dover, England. Squalls and red sheet lightning. "At about 4^h50^m A. M., however, these flashes constantly emerging from a dense, triangular and very remarkable cloud in the S. E., which perceptibly increased in size with great rapidity, he was induced to observe it with minute attention. At 4^h55^m A. M., Greenwich mean time, the cloud had assumed the form of a right-angled triangle, its hypotenuse, or longest side, trending east and west. At this instant he first heard a singular and extraordinary hissing sound in the air, not unlike that of a passing shot, which, although at first not very loud, was yet clearly distinguishable above the howling of the gale. At 5 A. M. the cloud had nearly doubled its original size, advancing steadily from the S. E. in a N. W. direction, or from nearly dead to leeward, towards the wind's eye; whilst the scintillations spoken of were emitted with increased rapidity. He also then first perceived in the centre of the cloud, a dull, red, obscure nucleus, or fireball, apparently about half the diameter of the moon, having a tail five or six times that length, from which the flashes mentioned were sent forth, of surpassing brilliancy, as the meteor clearly descended with great velocity through the air, accompanied by a detonating, hurtling hissing sound, impossible to describe, yet resembling that which precedes the shock of an earthquake. At three minutes past five o'clock A. M., the meteor having apparently spanned the Channel from S. E. to N. W., upon approaching the land---evidently throwing off portions of its substance as it passed through the atmosphere---the nucleus suddenly exploded with a report similar to a very heavy clap of thunder, giving out an intensely brilliant light, which rendered the minutest objects distinctly visible, although it rained violently and the sky was obscured by dark and threatening clouds. The dense body of the meteorite seemed to fall in the water about half a mile from the land, as indicated by a great volume of spray, which rose foaming in the distance." (R5) The clouds and duration of this phenomenon make the 'meteor' anomalous indeed. The observation resembles many thunderbolt tales.

X6. November 13, 1872. Scilly Islands, England. "...at 2 A. M., a meteor burst against the 'Seven Stones' light-vessel belonging to this corporation, and moored about 9 1/2 miles E. by N. of the Scilly Islands; and that it has been reported that the watch were struck senseless for a short period, seeing nothing before the shock, but that, on recovery, balls of fire like large stars were falling in the water like splendid fireworks, and that the decks were covered with cinders, which crushed under the sailors' feet as they walked. It appeared, the men said, as if something was passing swiftly and met with the obstruction of the vessel and burst. The superintendent reports that the men say there was a decided smell of brimstone, but adds that they did not mention that until he asked them." (R6)

X7. February 28, 1904. North Atlantic Ocean. "The meteors appeared near the horizon and below the clouds, travelling in a group from northwest by north (true) directly toward the ship. At first their angular motion was rapid and color a rather bright red. As they approached the ship

they appeared to soar, passing above the clouds at an elevation of about 45°. After rising above the clouds their angular motion became less and less until it ceased, when they appeared to be moving directly away from the earth at an elevation of about 75°and in direction west-northwest (true). It was noted that the color became less pronounced as the meteors gained in angular elevation. When sighted, the largest meteor was in the lead, followed by the second in size at a distance of less than twice the diameter of the larger, and then by the third in size at a similar distance from the second in size. They appeared to be travelling in echelon, and so continued as long as in sight. The largest meteor had an apparent area of six suns. It was egg-shaped, the sharper end forward. This end was jagged in outline. The after end was regular and full in outline.. The second and third meteors were round and showed no imperfections in shape. The second meteor was estimated to be about twice the size of the sun in appearance, and the third meteor about the size of the sun. When the meteors rose there was no change of relative position, nor was there at any time any evidence of rotation or tumbling of the larger meteor. I estimated the clouds to be not over one mile high. The near approach of these meteors to the surface and the subsequent flight away from the surface appear to be most remarkable, especially so as their actual size could not have been great. That they did come below the clouds and soar instead of continuing their southeasterly course is also equally certain, as the angular motion ceased and the color faded as they rose. The clouds in passing between the meteors and the ship completely obscured the former. Blue sky could be seen in the intervals between the clouds. The meteors were in sight over two minutes and were carefully observed by three people, whose accounts agree as to details." (R7)



In 1904, three meteors seemingly traveling in formation swooped down below the clouds over the North Atlantic and then turned upwards and sped out of sight. (X7)

X8. October 29, 1936. Oshkosh, Wisconsin. "While duck hunting on Lake Butte des Mortes, a few miles northwest of Oshkosh, Wisconsin, my two companions, Arthur Nelson of Oshkosh, and F.E. Winans of Wauwatosa, and I were witnesses to a strange phenomenon.... We were facing the north watching a large raft of duck, when from the east, seemingly low over the water, came a rocket black formation throwing sparks of various colors, which shot across our front and seemed to disintegrate in the north-west." (R8)

X9. September 1977. Solomon Islands. "A mysterious flying object has been sighted in the Santa Cruz Island on three separate nights. The object was described as a 'very bright light' or 'ball of fire' which travelled at high speed across the sky just below cloud level lightning up the ground underneath. One of the objects was said to have landed but nothing was found when people rushed to the spot." (R9)

X10. March 19, 1887. North Atlantic Ocean. Two fireballs, one bright, the other dark, fell into the sea, making large waves. Heat and a suffocating atmosphere followed. (R10, R11)

X11. June 30, 1908. Siberia, Russia. The fall of the Tunguska Meteor (or Comet) was a near-global phenomenon. The flight of this cosmic projectile was observed over an area of 1,500

square kilometers. Its passage was so blindingly bright that the daylight sky seemed black in contrast. It was accompanied by smoke, detonations, rumbling, and crackling. The sound phenomena were detected 1,000 kilometers from ground zero. Pressure waves were recorded in Western Europe. (GSW3 in Earthquakes, Tides...) For several days following the impact, the night skies of Europe were aglow. (GLA15)

Here, we add to the dossier of the Tunguska Event some remarkable effects experienced by the inhabitants in the vicinity of the fall. These are consistent with those of some of the other entries in this section and, therefore, pertinent. It should also be added that while the Tunguska Meteor wrought havoc with the forest around the point of impact, no crater commensurate with the energy of the projectile was found. (ETC3 in Carolina Bays, Mima Mounds,...) Additionally, there is controvery over the real nature of the impacting object: Was it a comet, a meteorite, a black hole, an alien spaceship in trouble (!), or something else?

Some of the terrestrial effects of the Tunguska Event were reported by S.B. Semenov. "It was in 1908 in the month of June about 8 o'clock in the morning. I lived at that time on the Podkamennaya Tunguska, at the factory Vanovara, and was occupied with work around my hut. I sat on the open porch with my face toward the north and at that time there arose, in a moment, a conflagration which gave off such heat that it was impossible to remain sitting---it almost burned the shirt off me. And it was such a flaming wonder that I noticed that it occupied a space of not less than two versts [one verst = 0.663 mile]. But to make up for that, this conflagration endured only a very short time. I had time only to cast my eyes in that direction and see how large it was, when in a moment it vanished...After this vanishing it grew dark and at the same time there was an explosion which threw me off the open porch about seven feet or more; but I did not remain unconscious for very long. I came to myself and there was such a crashing sound that all the houses shook and seemed to move from their foundations. It broke the window panes in the houses, and in the center of the square, near the huts, a strip of earth was torn out, and at the same time the so-called shore [bracing strip] of iron on the door of the barn was broken, but the lock remained whole." (R12)

X12. In the period 1956-1958. Martiniz, California. While the object described in the following personal anecdote is most likely a bolide (i.e., a brilliant, fiery meteor), the pyrotechnics, low altitude, and extremely low velocity make it a candidate for this section.

"At dusk of that particular day, we were picking pears when we noticed a bright light in the sky. Now I had seen several test-rocket launchings before and since ---usually Minuteman missiles---there is no resemblance between them and this object. Also, since this event, I have seen perhaps all known photographs and moving pictures taken of actual bolides and, again, there is little comparison. Most pictures I have seen of actual, large meteors are small, rounded, objects with white or reddish heads and tails moving at a brisk pace across the sky. The meteor that passed overhead that night in Martiniz was huge, appearing at least as large as the full moon, perfectly round and very bright. Most spectacular of all were the colors; jets of bright-colored plumes of every color of the rainbow except violet shot out from the tailing edge of the ball and straight out from the sides of it before falling back to form the tail of the object. The object itself was white and giving off these flashes and streaks of bright colors that graded into a train of white cloud about ten times as long as the diameter of the ball itself. Behind this train of white followed a bright red, yellow, and orange tail of dust in multiple spirals that, after the meteor had passed over, faded slowly to a dull orange-brown band stretching from horizon to horizon for about 15-20 minutes before dissipation. The meteor passed horizontally about 70 degrees up from the horizon at an amazingly slow pace, visible for a full 1½ to 2 minutes in all before disappearing over the opposite horizon and traveling in a southeast to northwest direction. I do not recall any sounds but my father swears that he heard a hissing-crackling sound the whole time." (R13)

Naturally, UFO reports to radio stations followed on the heels of this event.

X13. January 11, 1966. Pacific Ocean north of Marcus Island. Observed from the S.S. Morgantown Victory.

"Large glowing object approached from horizon on starboard beam, altered course to off starboard quarter, hovered 30 seconds, went to port quarter. Cigar shape with bright light at head." (R14)

The hovering of this object and its changes in direction of motion place it in the UFO cateory. However, the source seems reliable enough.

X14. November 30, 1966. Caribbean Sea off Barbados. S.S. Crofter enroute from Liverpool to Barbados.

"A bright object appeared about 8° on the port bow slightly above the horizon. It approached the ship at a high speed and dipped approximately 10° above the eastern horizon. The object passed over the ship throwing out several distinct and broken trails, a bright white trail, and was reddish in color. The trails extended almost to the horizon when the object passed over the ship. The whole effect was very vivid and of high intensity and lasted approximately 20-30 seconds." (R14)

Probably only a bolide, but a very-long-lived one.

X15. December 21, 1967. South Pacific near Loyalty Islands. m.v. Turakina enroute Auckland to Guam. A puzzling, hard-to-classify phenomenon. We assume that the "small cloud" mentioned below is the source of the light show and, therefore, a meteor of sorts.

"Beam approx. 35° long like a 'very powerful searchlight...observed extending almost vertically upwards from clouds on horizon.' Bearing 43°. Beam moved slowly & steadily down toward horizontal; briefly obscured by clouds, then visible again beneath them. Glow from rising moon then interfered with visibility near horizon; beam seemed to emanate from a small cloud a few degrees above the horizon. Lost from sight behid clouds at 1133 G.M.T." (R14)

X16. September 17, 1982. South Atlantic Ocean. 2103 GMT on a clear dark night. Aboard the m.v. Strathdee enroute Sheerness to the Falkland Islands.

A bright patch of light exploded into a orange fireball. See details in GLA31-X3.

X17. January 29, 1986. Dal'negorsk, Russia. The Russian author of this report states that it is based upon research by respected Russian scientists. The object in question was certainly no ordinary meteor!

"At 19.55 local time, a red fireball was seen over the town of Dal'negorsk, Russian Far East. It flew silently parallel to the ground surface with a speed of 15 m/s leaving no wake or trail. After the fireball had passed the town, it 'dived' into the slope of a small mountain (height: 611 m), then jumped up and down 6 times above the mountain surface. It was accompanied by a very bright light that persisted for an hour. One eyewitness said that after it, the fireball took off and flew away.

"The 'impact' site was researched 2 days after. The fireball destroyed about 2-3 cubic meters of the rock. The site was covered with singed pieces of the rock and sprinkled with small metallic spherules. At the edge of the site there was a burnt tree-stump." (R16)

X18. August 1986. Southern United States. A "light show" occurred over a wide area east of the Mississippi. The phenomenon was characterized variously as a pinpoint of light, a glowing cloud, and a big ball of fire. The anomalous feature was the event's long duration: 5-7 minutes. Astronomer D. Sabatini ventured that it could not have been a meteor because they burn up in just a few seconds. Government agencies stated that there had been no rocket launches or barium-release experiments. (R17-R18)

X19. January 25, 1990. Western North America. The event at hand becomes more significant when it is related to

very similar phenomena that took place during following nights over eastern North America. (X20)

A newspaper item described the January 25 apparition as a bright, slow-moving light in the predawn sky. Most anecdotes stated that the light was greenish, but some claimed it was turquoise or white. An orange tail was mentioned by some. (R19) There is nothing unusual in this report until we look at the next two items, because we seem to have a series of impressive, low-level meteor-like objects affecting the same geographical area. (X20)

X20. January 27, 1990. Eastern United States. On this date, two days after the event described in X19, thousands of people in the eastern United States saw a strange, bluish green light in the sky. The following two anecdotes will suffice to demonstrate the unusual nature of the phenomenon.

"In North Carolina, Jim Iodice, who was flying a Cessna 172 over Pilot Mountain Saturday night, said that he saw a 'glowing, yellowish-blue light between 7 and 7:30 p.m. that appeared to be near the plane. The object was descending in a northeast direction toward Martinsville, Va., but it leveled off at about 3,000 feet, flew at the same altitude for several hundred yards, then changed to a southward direction, Iodice said.'" (R20)

"Among the witnesses in the Washington area was Andrew Guthrie, a news editor at the Voice of America since 1983. 'It was a dramatic thing to see,' Guthrie said. 'I almost drove off the road.' He said that the object appeared to be 'three or four times treetop level' and about the size of a grapefruit was an 'incandescent bright light at the center, like a magnesium flare.'" (R20)

X21. February 1990. Northeastern North America. Americans from New Jersey to Nova Scotia witnessed a spectacular fireball that changed colors during the 10 seconds it was visible. So far, this fiery, low-level object seems merely a rather well-behaved, nonanomalous bolide. However, W. Webb, assistant director of the Hayden Planetarium reported that: "It went into a cloud and lit it up like a sunset. Then the thing went up vertical and came down again in a closed loop, leaving a glowing trail behind it." (R21)

Meteors that execute closed-loop trajectories cannot be considered normal.

X22. March 6, 1991. Northeastern North America. At about 3 A.M., a fireball streaked across the sky from West Virginia to Maine. Its superficial characteristics are unimpressive to an anomalist. Specifically, it was basically bright green with an orange tail. But, as it swooped low over Massachusetts, some more remarkable attributes were noticed.

"Attleboro Police Officer Mark Barton told radio station WARA that he and at least four other officers saw it.

"'From what I could see, it almost looked like a boomerang on its side. A cluster of lights with a big red fireball behind it,' Barton said.

"'That tail had to be as long as the Triboro Plaza (a shopping mall). It was moving so slow that I had time to get out of my cruiser, radio other officers to look in the sky and get back out and continue to watch this thing fly off,' he said." (R22)

The object's size, slow motion, and curious structure---if accurately reported ---make it sound more like a UFO!

X23. April 12, 1991. Sasovo, Russia. On this date, a peculiar explosion occurred at this town, located 300 kilometers southeast of Moscow. The explosion excavated a crater 30 meters wide and 3 meters deep. Damage to man-made structures extended 20 kilometers distant. It is difficult to decide whether the Sasovo event was basically geological in nature or the consequence of a meteor impact. The luminous phenomena accompanying the explosion would seem to indicate the latter, but then again earthquake lights (GLD8) cannot be ruled out. In some respects some of the phenomena resemble those of the 1908 Tunguska Event (X11), although in miniature, of course. For details concerning this curious event, we now turn to the report of A.Y. Ol'kho-

vatov.

"For about several hours before the 1991 explosion, in many places, people saw 'fireballs,' often accompanied by rumbles and even ground vibrations. In many houses, animals began to be anxious. Some people felt bad. Railroad radio-communication devices failed. At about 1 minute before the explosion, noise appeared in radio receivers, which soon jammed all radio stations. At a distance up to several kilometers from the epicenter, some people said that they felt a 'heat wave' and suffocation. Near the epicenter, a bright flash with a duration of several seconds took place accompanied by thunder and a ground shock. According to some reports, at first a 'glowing object' flew down to the ground." (R23)

So, which was it? A meteor impact or an earthquake? The precursor phenomena favor a seismic event, but then again the Tunguska Event also had its precursors.

X24. December 9, 1997. Greenland. We have here a spectacular object of uncertain nature, although the meteor theory is the best bet.

At 5:11 A.M., crews of three trawlers at widely separated sites off south Greenland reported "a blazing fireball that turned night into day." At a distance of 100 kilometers (62 miles), the flash was compared to that from an atmospheric nuclear explosion. Danish officials dismissed the possibility of a surreptitious nuclear test. The U.S. Air Force stated that the object was neither a reentering spacecraft nor artificial space debris. Some seismic tremors also emanated from Greenland, so the impact of a large meteorite is suspected. Based on the visual sightings and a moving object caught on a parking-lot surveillance camera in Nuuk, Greenland's capital, the probable impact point is at 61°25' N., 44°26' W. Efforts to locate the meteorite will have to wait for favorable weather.

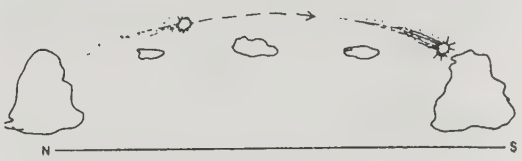
The supposed meteor was not a small object. The Niels Bohr Institute in Copenhagen compared it to the Kap York meteor that fell south of Thule, Greenland, in prehistoric times. Pieces of this iron meteorite aggregating 50 tons have been collected. (R24)

We have not seen any reports recording the discovery of this object.

X25. September 3, 1900. Mobile, Alabama. A letter from T.T. Roche to the Editor of the Scientific American Supplement described a remarkable phenomenon which we formally classify as miniature ball lightning but which could have been a meteor. See details in GLB14-X4.

X26. April 9, 1983. North Atlantic Ocean. From the n.v. Dorsetshire.

"At 2304 GMT, Mr. Haney pointed out a bright white object in the sky. It was bearing approximately 360° (T) at an elevation of about 40°. It was moving rapidly southwards across the sky, leaving a bright trail behind it, like an afterglow. Also trailing astern of the object was a light trail of sparks (possibly large solid particles). The object disappeared behind clouds, bearing about 170° (T) at an elevation of approximately 35°, and lighting the edges of the clouds. The time taken for the passage was around 20 seconds. It was obviously a very large object, judging from its apparent size as seen from sea level. The impression given was that of an object within the atmosphere, easily showing around a one-penny piece held at arm's length." (R26)



A large, very sluggish fireball trailing sparks was observed over the North Atlantic in 1983. (X26)

There is little doubt that this object is simply a large fireball, but its direction of flight (north-south) is unusual and the time of passage (20 seconds) extremely long for a meteor.

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R19. McAuliffe, Bill; "Was It Junk? Maybe So, but It Sure Lit Up the Sky," Minneapolis Star Tribune, January 26, 1990. Cr. R. PanLener via. L. Farish. (X19)
R20. Anonymous; "In the Dark," Winston-Salem Journal, January 29, 1990. Cr. G. Fawcett via L. Farish. (X20)
R21. Saltus, Richard; "Looping Fireball Dazzled Observers in Northeast," Boston Globe, February 23, 1990. Cr. B. Greenwood. (X21)
R22. Lowry, Virginia; "Strange Lights Spotted in Night Sky," Gloucester Times, March 6, 1991. Cr. Barry Greenwood via L. Farish. (X22)
R23. Ol'khovatov, A. Yu; "Strange Explosions at Sasovo, Russia," personal communication, January 1994. (X23)
R24. Sawyer, Kathy; "Fireball a Mystery till Thaw; "Charlotte Observer, December 22, 1997. Cr. G. Fawcett via L. Farish. (X24)
R25. Roche, T.T.; "Struck by a Fragment of a Meteor?" Scientific American Supplement, 49:20125, 1900. (X25)
R26. Edwards, R.A.F.; "Unidentified Flying Object," Marine Observer, 54: 82, 1984. (X26)

GLM2 Darting Gleams of Light

Description. Very swiftly moving streaks or wisps of white or bluish-white light that appear suddenly and (apparently) very close to the observer. Called "sleeks" by some, most have been reported by expert meteor observers as a rare but persistent phenomenon.

Data Evaluation. Many observations by well-qualified observers. Rating: 1.

Anomaly Evaluation. The speed, apparent closeness, lack of sound and meteoric material, all suggest that sleeks are not true meteors. Rating: 2.

Possible Explanations. Some observers have proposed electrical or auroral origins, whatever these vague suggestions mean. Cosmic-ray stimulation of visual channels in the brain is a possibility, but one would then expect everyone to see the phenomenon indoors and out, rather than meteor watchers.

Similar and Related Phenomena. Anomalous and nebulous meteors (AYO).

Examples of Darting Gleams of Light

X1. January 9, 1870. Mediterranean Sea. "14^h 50^m; mag. 3; path from $169^o + 20^o$ to $157^o - 10^o$; length 31^o; duration 0.1 second. An instantaneous flash; seemed to be in the air, quite near. Very curious." (R1)

X2. April 20, 1884. Bristol, England. "The meteor was about the third magnitude, but the singularity about it was its marvellous velocity and seeming nearness. It appeared to be in the air, a few yards distant, and I believe its path, extending (as it instantaneously impressed me) over some 16^o on the background of the sky, must have been traversed in less than the twentieth part of a second.....Now and then I have observed similar meteors before. They immediately strike one by their close proximity and enormous velocity. They are mere gleams of pale white light, which have little analogy to ordinary shooting stars, and suggest an electric origin, though I do not know whether the marvellous quickness with which they flash upon the eye is not to be held responsible for the sensation of nearness. They are somewhat rare, and one may watch through several whole nights without a single example, but, as far as my memory serves, I must have witnessed some scores of these meteoritic flashes." (R1)

X3. August 23, 1913. Bristol, England. "In late years I have not been able to pursue meteoric work to the same extent as formerly but I have occasionally caught one of these transient flashes. The last one seen here was on 1913 August 23 near the star Polaris and the meteor had a duration of less than the tenth of a second. It looked like a mere gleam of light; not a burning missile." (R2)

X4. September 13, 1913. England. (R2)
X5. December 1, 1913. England. (R2)
X6. February 1, 1914. England. (R2) Regarding these three examples. "This class of meteors is so different and distinct from ordinary ones that they are unmistakable when seen. They give one a little shock of almost fear, certainly surprise, at their seeming nearness and tremendous rapidity. They show no heads and I have never seen one with either a tail or an after streak."

X7. March 19, 1914. England. Two of them, "...appearing quite near, moving terribly rapid and suggesting little lines of light rushing close to one like a lighted wire." (R2)

X8. July 1929. In the Caribbean. Watching for shooting stars. "...and while I stood there looking for more a strange phenomenon took place. About fifty feet above the sea and say twenty feet from the ship's side a piece of incandescent matter of orange

color, or perhaps a bit brighter, came down in a straight line and then was extinguished about ten feet before it fell into the sea. I heard no hiss as it struck the water owing to the noise of the water from the propellor (sic), nor could I see anything after its luminescence stopped." (R3)

X9. 1970. London, England. "I was lying in bed, in a darkened room, when I saw a bright streak of light to my extreme right. Had I seen this streak in the sky I would undoubtedly have called it a meteor and would have described it as: colour, white; magnitude, 11.5; speed, fast; length, 20^{o} arc; width, $1/2^{o}$ arc. However, it started from just below the ceiling and disappeared before it reached the floor. It did not move with my eye, but carried on falling as I looked up at it." (R4)

X10. General observation. "From time to time I have become aware of faint wisps of light that flashed into view, and startled me into thinking, for the instant, that I had seen a meteor. These wisps were extremely faint and nebulous, as if a piece of auroral streamer had swished across the sky. At first I took these appearances to be some psychological prank of the senses caused by the patient watch for meteors, or that they were faint meteors seen at such an extreme angle of vision that their light caused a distorted impression on the senses. When I especially watched for these appearances, they seemed quite real and to be just like the ones seen when I was not thinking of them while meteor observing. After observing these phenomena for some months in a somewhat desultory manner while making meteor observations, I came to the follow-conclusions. They appeared to assume many shapes, and their flight extended up to twenty degrees in .2 second, tho some may have travelled as long as .5 second. They were from one to ten degrees long, and one-half to three degrees broad, flashing into view quite in their entirity as to shape. They appeared from very few to twenty an hour, being especially numerous on three nights of slight auroral activity. One out of ten appeared directly in my line of vision. Lastly, they were more numerous in the early hours of the night, before midnight." (R5)

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R1. Denning, W.F.; "A Peculiar Variety of Meteors," Royal Astronomical Society, Monthly Notices, 45:408, 1885. (X1, X2)

R2. Denning, W.F.; "A Curious Variety of Meteor," Popular Astronomy, 22: 404, 1914. (X3-X7)

R3. Speirs, Robert; "A Questionable and an Actual Meteorite," Popular Astronomy, 39:107, 1931. (X8)

R4. Galera, Delores J.; "Visible Cosmic Rays," New Scientist, 47:351, 1970. (X9)

R5. Anyzeski, Vincent; "Some Notes on a Possible Meteoric Phenomenon," Popular Astronomy, 54:203, 1946. (X10)

GLN NOCTURNAL LIGHTS

Key to Phenomena

GLN0 Introduction

Nocturnal lights are not associated in any obvious way with conventional meteors, electrical storms, or violent weather. The name "nocturnal light" had its origin in the UFO literature, but most nocturnal lights, such as the will-o'-the wisps, doubtless have very prosaic natural origins. The characteristics of the class are a flame-like or globular shape, a wide spectrum of colors, sizes that vary from an inch to many feet, and, most diagnostic of all, erratic motions, described as playful, elusive, inquisitive, and physically impossible.

Nocturnal lights are split here into two rather arbitrary categories: (1) low-level lights, which include will-o'-the-wisps, ghost lights, fireships, some curious natural flames, and a few UFOs; and (2) high-level lights, which seem to be predominantly UFOs.

Popular attention has long focussed on the high-level nocturnal lights because of the possibility they may have an extraterrestrial origin. This taint has prevented a concerted scientific attack on this fascinating problem. Low-level nocturnal lights, though ubiquitous today and in past centuries offer no alien overtones. Yet, they too are essentially ignored by science. The reason in this case is that it is commonly believed that the simple marsh gas theory explains all. This catalog section will demonstrate that the low-level lights pose many puzzles as to energy source, shape stability, and motion. It is a shame that such fascinating and common natural phenomena have received so little modern scientific attention.

GLN1 Low-Level Nocturnal Lights

Description. Pale flames, softly glowing globes, and other luminous apparitions hovering and drifting erratically below tree-top level. These lights range from candle-size to radiating masses several feet in diameter. Colors vary widely: white, blue, and yellow being most common. Low-level nocturnal lights frequently vanish when approached closely only to reappear nearby. Their bobbing, swooping, elusive antics seem to beckon the observer to follow. Others, though, are essentially stationary and may be approached, especially the small flame-like species seen flickering over marshy areas. All low-level nocturnal lights, in fact, seem to prefer wet and swampy areas.

Background. Low-level nocturnal lights have been documented for centuries as will-o'-the-wisps, jack-o'-lanterns, ghost lights, fireships, corpse lights, and many other names. The standard explanation attributes them to spontaneously ignited gases escaping from swampy ground. The existence of this apparently reasonable explanation seems to have shut off all scientific research in this area. As the examples below demonstrate, the marsh-gas theory will simply not do in many instances. We actually have a complex, challenging phenomenon for science that may require several explanations.

Data Evaluation. Abundant testimony exists but modern scientific observation is essentially nonexistent. Rating: 1.

Anomaly Evaluation. No satisfactory mechanism has been demonstrated whereby gases escaping from marshy areas will spontaneously ignite. Furthermore, most low-level nocturnal lights are cold---not what one would expect from burning methane. Also, no one has explained how clouds of luminous gas can maintain size and shape while engaging in erratic maneuvers over many minutes. Rating: 2.

Possible Explanations. Some low-level nocturnal lights are undoubtedly spontaneously ignited gases escaping from the earth's surface. The cold flames, though, may be due to some unidentified kind of phosphorescence. The possibility that electromagnetic fields aid in generating light and in the long-term maintenance of size and shape should not be ruled out. There might, in fact, be a spectrum of electrochemical luminous phenomena beginning with highly energetic ball lightning, progressing through luminous aerial bubbles, and terminating with the weak and diffuse nocturnal lights. All of these phenomena seem to have similar life histories.

Similar and Related Phenomena. Ball lightning (GLB), St. Elmo's Fire (GLD), luminous aerial bubbles (GLD), and high-level nocturnal lights (GLN2).

Examples of Low-Level Nocturnal Lights

X0. Introduction. Since the first edition of this catalog in 1982, we have accumulated a surprisingly large quantity of new material on nocturnal lights. This is rather surprising because will-o'-the-wisps and allied low-level luminous phenomena are certainly not hot research topics these days. In fact, the general subject is probably avoided by the scientific community because of the phenomenon's association with UFOs. Such is science's loss, because there is much to be learned from these ephemeral and elusive apparitions.

Upon surveying our new material plus that recorded in the 1982 edition, we see that the 100+ examples now at hand divide naturally into three categories:

(1) One-time, one-location, spontaneous observations. If these events recur on a regular basis at these sites, as many low-level nocturnal lights are wont to do, we do not know about it.

(2) Rare, unpredictable, but repeated observations of lights at specific sites. Many of these are well known to the local inhabitants of the area but we know little of scientific value about them. Deeper research into the literature would likely net much more information

of value. Examples: the Faro ("Lighthouse") of Maracaibo (Venezuela) (X1); the Esperanza Light (Texas) (X62); the Palatine Light (North Atlantic) (X24); and the Bay Chaleur Fireship (Canada) (X42).

(3) Well-known, often famous, lights that are seen repeatedly and frequently at some spots. This group of mysterious lights has received a lot of attention from tourists, TV-documentary producers, and, all-too-seldom, establishment scientists. We consequently have a lot anecdotal and superficial information about them. Solid, scientific investigations are exceedingly rare. Examples: the Brown Mountain Lights (North Carolina) (X54); the Tri-State, Ozark, or Hornet Light (Oklahoma) (X63); the Marfa Lights (Texas) (X69); the Min-Min Lights (Australia) (X70); the Yakima Lights (Washington State) (X71); and the Hessdalen Lights (Norway) (X72).

At many of the sites of renown, the great majority of light-sightings can be reasonably explained in terms of refracted man-made lights (automobiles, street lights, etc.). But a small residue of difficult-to-account-for sightings, mainly close encounters, often of a bizzarre nature, always seems to remain. In this respect, the problem of the low-level nocturnal lights resembles the UFO enigma and the mysteries posed by so many other paranormal phenomena in these catalogs.

Low-level nocturnal lights are hard to separate from other low-level luminous phenomena cataloged in this volume. The boundaries are fuzzy, and we must admit that overlapping occurs. In particular, it is sometimes hard to separate low-level nocturnal lights from earthquake lights (GLD8), ball lightning (GLB), St. Elmo's fire (GLD6), and luminous aerial bubbles (GLD7).

X1. Frequent occurrence. Lake Maracaibo, Venezuela. A luminous phenomenon seen frequently on the borders of the Cataumbo River near its junction with the Sulia. Can be seen 40 leagues away. Called the Faro or Taro of Maracaibo. Ascribed to ignited natural gas and electrical phenomena. (R1, R25, R30)

X2. May 26, 1821. Chapelle-aux-Planches, France. A pale red pyramid of light, 12 feet high, over marshy ground. (R2)

X3. Frequent occurrence. Along the Connecticut River. Lights often seen skipping along and sailing over the meadowlands. One observer saw at close range a solitary flame rising from the mud, flickering, waxing and waning. (R3, R4)

X4. Frequent occurrence. Newmark, Germany. "The water of the marsh is ferruginous, and covered with irridescent crust. During the day bubbles of air were seen rising from it, and in the night blue flames were observed shooting from and playing over its surface. As I suspected that there was some connexion between these flames and the bubbles of air, I marked during the day-time the place where the latter rose up most abundantly, and repaired thither during the night; to my great joy I actually observed bluish-purple flames, and did not hesitate to approach them. On reaching the spot they retired, and I pursued them in vain; all attempts to examine them closely were ineffectual.... On another day, in the twilight, I went again to the place, where I waited the approach of night; the flames became gradually visible, but redder than formerly, thus shewing that they burnt also during the day; I approached nearer, and they retired. Convinced that they would return again to the place of their origin, when the agitation of the air ceased, I remained stationary and motionless, and observed them again gradually approach. As I could easily reach them, it occurred to me to attempt to light paper by means of them, but for some time I did not succeed in this experiment, which I found was owing to my breathing. I therefore held my face from the flame, and also interposed a piece of cloth as a screen; on doing which I was able to singe paper, which became brown-coloured, and covered with a viscous moisture. I next used a narrow slip of paper, and enjoyed the pleasure of seeing it take fire. The gas was evidently flammable, and not a phosphorescent luminous one, as some have maintained. But how do these lights originate?" (R5, R6, R26, R67)

X5. Frequent occurrence. Upper Silesia, Germany. Stationary flames observed, but could not ignite paper. (R5, R6, R26)

X6. 1811. Konski Forests, Poland. Sta-

tionary flames, which did not ignite paper but covered it with a viscous moisture. (R5, R6, R26)

X7. 1812. Rubenzahl Garden, Germany. Very pale flames, which could not be approached without extinguishing them. (R5, R6)

X8. Frequent occurrence. Walkenried, Germany. Gas causing the lights was collected and found to cloud lime-water. (R5, R6)

X9. August 3, 1814. Minden, Germany. Rockets fired from the summit of a mountain caused small red flames to appear around the base of the summit. They quickly faded. (R5, R6, R26)

X10. September 19-20, 1836. Shetland Isles, Great Britain. Fishermen reported a light like a furnace on the surface of the water. It lasted two nights. Rays from it rose to great heights. (R7) This light may have been auroral.

X11. Spring 1813. Near Lincoln, England. "...a Jack-o'-lantern caught my attention, proceeding in the same direction as I was travelling. Its motion was irregular, sometimes near the surface of the ground, and then suddenly rising to the height of five or six feet. I followed very cautiously for some distance, being determined, if possible, to obtain a near view of my luminous guide. As the night was rather dark, I had everything favourable for observation. At length it rested just at an angle in the road. I dismounted, and proceeded very cautiously, in the hope of capturing it; but in this I was disappointed; for, on my near approach, whether from the noise I made, or some other cause, it suddenly rose from its resting-place, about two feet from the ground, cleared a high bank, and pursued its course in a direct line over the adjoining fields. The broad and deep dikes rendered pursuit fruitless; but my eyes followed its almost butterfly motion till the glimmering taper was lost in the distance." (R8)

X12. November 1818. Schnepfenthal, Germany. Observing a boggy meadow. "I perceived a number of reddish-yellow flames in different parts of the expanse of almost level ground. I descried, perhaps, no more than six at a time; but dying away, and appearing in other places so rapidly, that it was impossible to count them; but I should say, on a rough estimation, that there were about 20 or 25 within a second. Some were small, or burned dimly; others flashed with a bright flame, in a direction almost parallel with the ground, and coinciding with that of the wind, which was rather brisk. After having for some time looked with amazement at this brilliant scene as a whole, I tried to study its details; and soon found that the flames which were nearest originated in a quagmire, whose position I knew exactly, by a solitary cluster of willows; and I could trace a succession of flashes from that spot to a certain point of the margin of the wood, across the rivulet and meadow. The distance of the two points from each other was more than half a mile, and the flames travelled over it perhaps in less than a second. The first flash was not always observed in the immediate neighborhood of the quagmire; but the succession of flames lay always in the same straight line, and in the direction of the wind; whilst other sets were, though not with the same distinctness, observed in the more distant parts of the meadow-ground." (R8)

X13. Frequent occurrence. Bologna, Italy. Near a pool. "About 11 o'clock I saw the light appear which I was desirous to observe; and I instantly seized the stick which I always kept ready for the purpose, and which had some flax attached to its extremity, and speedily repaired to the spot indicated. When I was not more than about twenty feet from the light, I stopped a moment to observe it. It had the form and colour of an ordinary flame, with a slight discharge of smoke. Its thickness was about a decimeter; and it was moving slowly in a direction from south to north. When I approached nearer it changed its direction, retired from me, and began to rise upwards. I hurried forward with my stick, and thrust it into the flame, which kindled the flax. Soon after, the Jack-o'-lantern became extinct at a height of about two or three feet above the stature of a man. It soon reappeared of smaller size (for I was led to believe it was the same), on another pool placed at a little distance. I ran immediately towards it, but in vain, as it vanished in a few second." (R9)

X14. Circa 1840. Rome, New York. A lambent flame was seen playing on the surface of a sand bank. Digging revealed a irregular tube of fused sand nearly 50 feet long. The tube resembled a fulgerite except that it was much larger. (R10)

X15. December 2, 1845. Ryook Phyoo. A large flame appeared out on the sea, flickering 15 or 20 minutes. (R11)

X16. No date given. Liege, Belgium. A blue flame rose from a well and burned for some time. The ground in this region is calcined and hot in places. (R12)

X17. 1860. Cleveland, Ohio. A luminous phenomenon appearing like a vessel on fire out on Lake Erie. Such apparitions called frequent. (R13)

X18. June 15, 1872. Nandidroog, India. "...the plain to the east, north, and north-east of Nandidroog was covered with 'many thousands' of lights, which have been observed occasionally in former years. The correspondent compares the appearance to that of a large city brilliantly illuminated, and in one direction the scene, through a binocular glass, 'looked like a view of part of the starry heavens, each flame being like a star.' As many of the lights were from ten to fifteen miles distant from the reporter's point of view, he conjectures that each flame must have been five to six feet in length." (R14, R31)

X19. October 5, 1872. The Lizard, England. Lights seen bouncing over a marshy field reached lengths of 30 feet. (R15)

X20. February 1875. Wales. "Some few days ago we witnessed here what we have never seen before---certain lights, eight in number, extending over, I should say, a distance of 8 miles; all seemed to keep their own ground, although moving in horizontal, perpendicular, and zigzag directions. Sometimes they were of a light blue colour, then like the bright light of a carriage lamp, then almost like an electric light, and going out altogether, in a few minutes would reappear again dimly, and come up as before." (R16) See GLN1-X39 for similar lights seen during the great Welsh religious revival.

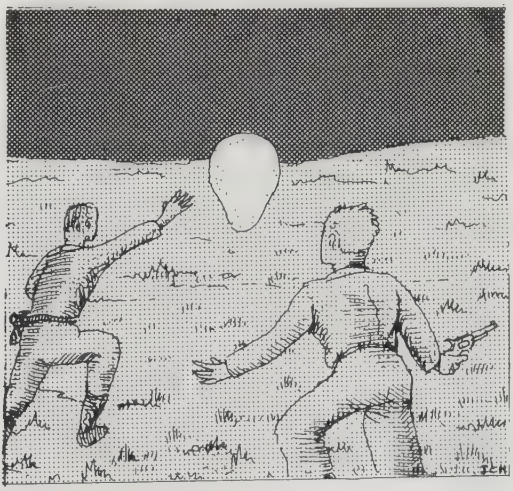
X21. 1832. Fifeshire, England. Lights seen frequently over a bog moved in straight and zigzag paths for 20-30 yards. (17)

X22. August 11, 1880. Whitby, England. Tongues of flame 15-30 feet high seen along a distant seashore. (R18)

X23. General observation. A long review of the will-o'-the-wisp in folklore and tradition indicates a persistent, world-wide phenomenon. (R19)

X24. Circa 1880. Off Montauk Point, New York. A light moved along the surface of the sea like a phantom ship. (R20) This is the general locale of the famed Palatine Light, a fireship.

X25. No date given. On the River Parana, South America. While investigating a mysterious light reported by villagers. "Only twice was it seen by me, but then very distinctly; the first time some little distance off, but the second quite close. On the first occasion the light started up from the ground with the brightness and speed of a rocket, and then again descended to the earth with equal velocity but less splendour; on the second we caught sight of it as it directly, but gently approached along the road, upon



Artist's interpretation of soldiers pursuing a mysterious, pear-shaped light in South America. (X25)

which, running to intercept it, and stumbling at every step over rough and swampy ground, we managed to arrive within three yards of the glowing vision as it slowly glided on a level of about 5 feet from the earth. It presented a globular form of bluish light, so intense that we could scarcely look at it, but emitted no rays and cast no shadows; and when about to actually grasp the incandescent nothingness, suddenly elongating into a pear-shape tapering to the ground, it instantly vanished; but on looking round up it rose again within 50 yards, but this time we could not overtake it, as it bounded over a hedge, then over trees, and finally disappeared in an inpenetrable swamp. According to the testimony of the soldiers, on another occasion, they beheld it rise from the swamp, and perch for some minutes on the top of the roof of a neighboring rancho without walls, after which it pierced the roof and subsided in the ground underneath...." (R21)

X26. No date given. England. A large will-o'-the-wisp moved up and down, back and forth in a high wind. (R21)

X27. No date given. Italy. While walking along a road surrounded by water-covered rice fields, flickering lights appeared at eye level in all directions. They always kept a fixed distance away. The observer thought he was in a faintly luminous mist, which appeared flame-like where it was most dense. (R22)

X28. No date or place given. A waving flame-like light 5 feet high, 18 inches wide, moved slowly across a graveyard against the wind. (R23)

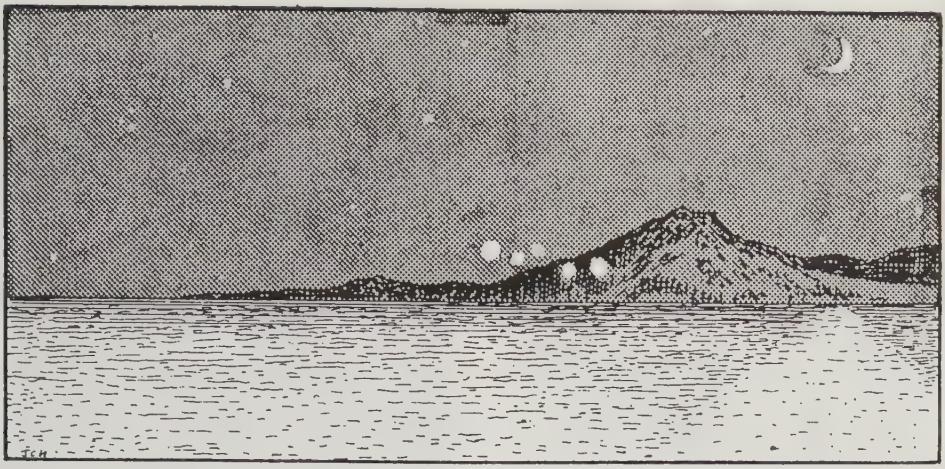
X29. July 11, 1881. At sea off Sydney, Australia. A strange red light on the sea was seen by 13 crewmen and two nearby ships. Some thought it a phantom ship. (R24)

X30. No date given. Sussex, England. Often seen in the evening hours, this light sometimes makes a graceful sweep to quite a height. Bad weather frequently follows. (R27)

X31. February 24, 1893. North Pacific Ocean. "...some unusual lights were reported by the officer of the watch between the ship and Mount Auckland, a mountain 6,000 feet high. It was a windy, cold, moonlit night. My first impression was that they were either some fires on shore, apparently higher from the horizon than a ship's masthead, or some junk's 'flare up' lights raised by mirage. To the naked eye they appeared sometimes as a mass; at others, spread in an irregular line, and, being globular in form, they resembled Chinese lanterns festooned between the masts of a lofty vessel. They bore north (magnetic), and remained on that bearing until lost sight of about midnight. As the ship was passing the land to the eastward at the rate of seven knots an hour, it soon became obvious that the lights were not on the land, though observed with the mountain behind them. On the following night, February 25, about the same time, 10 p. m., the ship having cleared Port Hamilton, was steering east, on the parallel of 34°, when these curious lights were again observed on the same bearing, at an altitude of 3° or 4° above the horizon. It was a clear, still, moonlit night, and cold. On this occasion there was no land in sight on a north bearing when the lights were first observed, but soon afterwards a small islet was passed, which for a time eclipsed the lights. As the ship steamed on at a rate of seven knots an hour, the lights maintained a constant bearing (magnetic) of N. 2°W., as if carried by some vessel travelling in the same direction and at the same speed. The globes of fire altered in their formation as on the previous night, now in a massed group, with an outlying light away to the right, then the isolated one would disappear, and the others would take the form of a crescent or diamond, or hang festoon-fashion in a curved line. A clear reflection or glare could be seen on the horizon beneath the lights. Through a telescope the globes appeared to be of a reddish colour, and to emit a thin smoke. I watched them for several hours, and could distinguish no perceptible alteration in their bearing or altitude, the changes occurring only in their relative formation, but each light maintained its oval, globular form." (R28)

X32. No date given. Bay of Islands, New Zealand. Balls of pale light floated a yard off the ground or attached themselves to pointed objects. (R29)

X33. April 1897. Lee, Michigan. A ball of



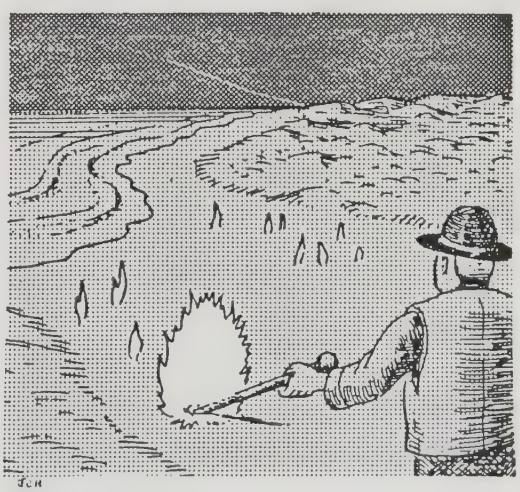
In 1893, the watch-officer on a vessel in the North Pacific reported a group of mobile, globular lights on two successive nights. (X31)

light the size of a hen's egg emerges from a river, floats through the air 10 feet above the ground with a zigzag motion and a whizzing sound. (R32) The sound hints at ball lightning.

X34. August 1897. Croisic, France. Numerous bright bubbles of light rose from the waters of the port. (R33, R34)

X35. August 1900. Scotland. Rapidly moving lights climbed a hillside and went down to a loch shore. (R35)

X36. June 5, 1902. Blundellsands, England. "The evening was dull and grey, a strong north-westerly wind was blowing in from the sea and the tide was flowing in. In the distance we first saw smoke with frequent jets of fire bursting forth from the mud of a shallow canal. Drawing near, we perceived a strong sulphurous odour, and saw little flames of fire and heard a hissing sound as though a large quantity of phosphorus was being ignited. It was impossible to detect anything which caused the fire, only the water where the flames appeared had particles of a bluish hue floating on the surface. The area over which the tiny flames kept bursting forth was about 40 yards. A gentleman present stirred up the mud with his walking stick, and immediately large yellow flames nearly 2 feet in length and breadth burst forth. The phenomenon lasted some time, until the tide covered the part and quenched the fire.. As we returned from our walk the atmosphere was impregnated with a strong odour of sulphur." (R36)



Flames erupted from an English mud flat in 1902. (X36)

X37. Circa 1900. Towyn, Wales. Four or five white lights the size of a railway lamp move across sandhills. (R37)

X38. Winter 1694. Harlech, Wales. "A pestilential vapour resembling a weak blue flame arose during a fortnight or three weeks out of a sandy, marshy tract called Morfa Byden, and crossed over a channel of 8 miles to Harlech. It set fire on that side to 16 ricks of hay and 2 barns, one filled with hay, the other with corn. It infected the grass in such a manner that cattle, etc., died, yet men eat of it with impunity. It was easily dispelled; any great noise, sounding of horns, discharging of guns, at once repelled it. Moved only by night, and appeared at times, but less frequently; after this it disappeared." (R37)

X39. Frequent occurrence during the period from December 1904 through March 1905. Wales, especially along the Welsh coast between Harlech and Barmouth. This "wave" of light-sightings coincided with a great religious revival and a period of intense transcendental fervor in Wales. We have, therefore, in this concentrated spate of observations, the fascinating possibility that some of the Egryn Lights, as they are often called, are psychogenic; that is, hallucinations. This possibility bears heavily not only upon the true origins of other low-level nocturnal lights but also UFOs and some other paranormal phenomena.

Many of the 1904-1905 Welsh lights were seen in the vicinities of the chapels at Egryn and Llanfair and, most interestingly, in direct association with the appearances of a certain Mary Jones as she conducted her ministry. The possibility of a human factor is inescapable although contrary to mainstream scientific thinking.

The Egryn Lights and the emotion-charged religious revival attracted the attention of several scientists who betook themselves to Wales for further investigation. A.T. Fryer was one of these curious scientists. He was mostly interested in the psychological aspects of the revival, but he also collected many anecdotes describing the Egryn Lights. Fryer published his findings in an 81-page report in the Proceedings of the Society for Psychical Research. (R37) From his report, we select one anecdote that not only provides some characteristics of the lights but also the states of mind of some of the observers.

"My wife and I went that night specially to see if the light accompanied Mrs. Jones from outside Egryn. We happened to reach Llanfair about 9:15 p.m. It was a rather dark and damp evening. In nearing the chapel, which can be seen from a distance, we saw balls of light, deep red, ascending from one side of the chapel, the side which is in a field. There was nothing in this field to cause this phenomenon---i.e., no houses, etc. After that we walked to and fro on the main road for nearly two hours without seeing any light except from a distance in the direction of Llanbedr. This time it appeared brilliant, ascending high into the sky from amongst the trees where lives the well-known Rev. C.E. The distance between us and the light which appeared this time was about a mile. Then, about eleven o'clock, when the service which Mrs. Jones conducted was brought to a close, two balls of light ascended from the same place and of similar appearance to those we saw first. In a few minutes afterwards Mrs. Jones was passing us home in her carriage, and in a few seconds after she passed, on the main road, and within a yard of us, there appeared a brilliant light twice, tinged with blue. In two or three seconds after this disappeared, on our right hand, within 150 or 200 yards, there appeared twice very huge balls of similar appearance as that which appeared on the road. It was so brilliant and powerful that we were dazed for a second or two. Then immediately there appeared a brilliant light ascending from the woods where the Rev. C.E. lives. It appeared twice this time. On the other side of the main road, close by, there appeared, ascending from a field high into the sky, three balls of light, deep red. Two of these appeared to split up, whilst the middle one remained unchanged. Then we left for home, having been watching these last phenomena for a quarter of any hour.

"Perhaps I ought to say that I had an intense desire to see the light this night for a special purpose; in fact, I prayed for it, not as a mere curiosity, but for a higher object, which I need not mention. Some may ridicule this idea,

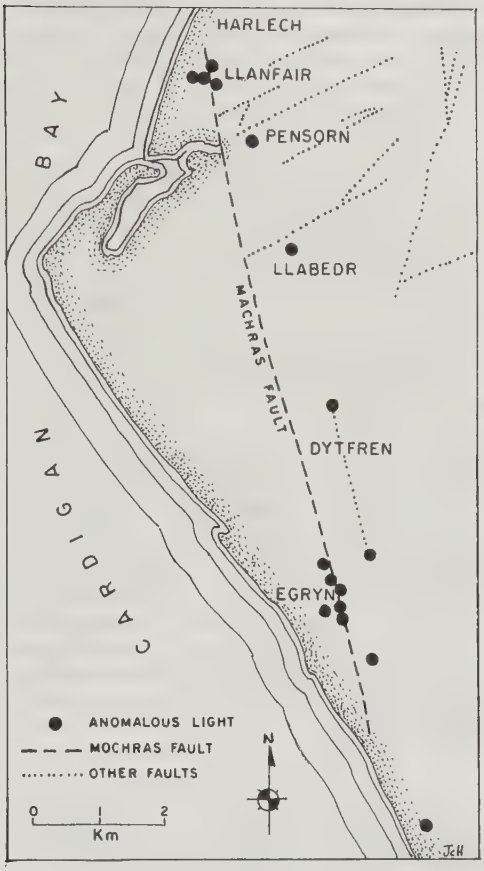
but I have great faith in prayer." (R37)

If some of the Egryn Lights really had a psychogenic origin, so might some of the other lights described in this volume, so might some UFOs. H. Evans has ventured onto these psychological waters and, in addition, has pointed out two other possible sources of the Welsh lights. He has observed:

"But if we accept the observations [of the Egryn Lights] as real and substantially accurate, it is hard to see how we can avoid the logical consequence: that the lights were somehow generated by Mary Jones herself. This is so contrary to received experience that most of us would prefer to reject the testimony, however well confirmed. We could derive some comfort from the fact that there existed a long-standing tradition of anomalous lights observed in the area, dating back over a century or so---long before Mary Jones' lifetime. Kevin and Sue McClure, in their detailed study of the phenomenon, point out that Egryn Chapel stands near marshy ground such as might generate luminous phenomena of the feu follet ["foolish fire"; i.e. will-o'-the-wisp] type. In addition, Paul Devereux has shown convincingly that many of the sightings occurred along a prominent geological fault line, which according to his hypothesis is capable of generating short-lived luminous effects." (R69)

Indeed, P. Devereux has made a good case for some of the Egryn Lights being of seismic origin. (See GLD8) In fact some other famous low-level nocturnal lights are likely of this type, such as the Yakima Lights (X71). Devereux notes that while many of the Egryn lights were observed---often by several witnesses---near the chapels of Egryn and Llanfair, virtually all of the better observations occurred within 500 meters of the Mochras Fault, a significant local geological feature. (R70)

Since luminous phenomena similar to the Egryn Lights are not uncommon in Wales (X20, X39, X40, X59), and have been seen over a long period of time, we must assume that at least some of the Egryn Lights were not associated with Mrs. Jones' comings and goings during the 1904-1905 revival. This does not mean, however, that the strong convictions of those caught up in the revival did not generate additional reports of lights. These, however, might have been psychogenic rather than geophysical.



The Mochras Fault passes close to the Egryn Chapel in Wales where many anomalous lights were observed during the 1904-1905 Welsh revival. (X39)

At least the skeptics cannot explain away the 1905-1905 Egryn Lights as mere refractions of automobile headlights, as they are accustomed to do---with good reason---at such renowned sites as Marfa (X69), Brown Mountain (X54), and Oklahoma (X63).

X40. 1877. Wales. Lights of various colors moved across the estuary of the Dysynni. (R37)

X41. September 1, 1905. Kittery Point, Maine. "On the evening of Friday, September 1, the guests at the Hotel Parkfield were startled by the appearance of flames rising from the beach and from the surface of the water, an event of so remarkable and unusual a character as to excite great curiosity and some alarm. The conflagration occurred between seven and eight o'clock in the evening, and lasted for upwards of forty-five minutes. The flames were about one foot in height. They were accompanied by a loud and continuous crackling noise which could be distinctly heard one hundred yards away, while at the same time there was a very strong liberation of sulphurous acid fumes which penetrated the hotel, drove the proprietor and his staff from the office and filled the other rooms to such an extent as to cause great inconvenience to the guests. One guest of an investigating turn of mind secured some of the sand in his hand, but was obliged to drop it on account of the heat. When some of the sand was taken into the hotel and stirred in water, bubbles of gas were liberated and produced flame as they broke at the surface in contact with the air." (R38, R40)

X42. General observations. Bay Chaleur, Canada. The summary of Ganong's study of the reputed Bay Chaleur Fireship. "After an examination of all the evidence it appears to the author plain (1) that a physical light is frequently seen over the waters of Bay Chaleur and its vicinity; (2) that it occurs at all seasons, or at least in winter and summer; (3) that it usually precedes a storm; (4) 'that its usual form is roughly hemispherical with the flat side to the water, and that at times it simply glows without much change of form, but that at other times it rises into slender moving columns, giving rise to an appearance capable of interpretation as the flaming rigging of a ship, its vibrating and dancing movements increasing the illusion. '" (R39, R41) There may be a connection between the supposed fireships and the weather lights (GLA16).

X43. General observations. Norfolk, England. The marshmen and wherrymen fire guns at the will-o'-the-wisps. The detonations usually extinguish them. (R42)

X44. No date given. Southern Nevada. The writer was tramping across a desert area that was usually dry but had just been flooded by one to several inches of water. "On this night the writer was tramping from Goodsprings, Nevada, to Ivanpah, California, and at 2 A. M. encountered a water-covered area. The flitting lights did not begin to appear until after some progress had been made through the water. The night was very dark and suddenly one of these lights appeared to float in the air about five feet above the ground. However, owing to no knowledge regarding its size, it could readily be imagined to be the light from a cabin window at some distance but for the fact that there was no habitation within twenty miles of the spot. Suddenly this light ceased to float complacently and sailed swiftly away to the left for some distance, then stopped. It was easy to imagine that it was waiting and coaxing---living true to its name in attempting to 'lure benighted travelers to destruction.' Soon others appeared, some floating apparently stationary, others shooting here and there. Little wonder that the peasantry of ancient times viewed this phenomenon with superstitious awe! When the display was at its height, hundreds of individual lights were visible simultaneously. The display was continous during the hour or more that the water-covered area was being traversed. It possibly continued for days. At first it appeared to be very chaotic, but after observing it for a time during which the writer continued walking, the individual lights seemed to progress rather jerkily or spasmodically in the same general direction." (R43)

X45. General observation. The curious motions of will-o'-the-wisps may be due to an autokinetic illusion, based on a personal experience. (R44)

X46. Frequent occurrence. Shipton, England. A peculiar light is often seen moving along a road 3-4 feet from the ground. The light may swing back and forth, emulating a hand-held lantern. (R45)

X47. No date given. Keswick, England. White lights seen near a road. One approached, slowed, stopped, quivered, and slowly went out. It was globular, white, about 6 feet in diameter and high enough to just clear a man's head. (R46)

X48. December 2, 1807. No place given. Numerous little bluish flames observed over a peat marsh. Some were stationary, but others moved horizontally in coordinated groups. (R47)

X49. No date given. Germany. In a wet area: greenish-white lights the size of a hen's egg, standing quietly amidst the grass. Waving a finger at them would usually make them disappear with a faint pop. No heat could be felt. (R47)

X50. No date given. Germany. Little flames 1 inch high in a railway cut. They were 3 inches above the ground, emitted neither smoke nor odor. (R47)

X51. No date given. Germany. Among the marsh grass, a cylindrical light 5 inches high, 1 1/2 inches in diameter. No odor or smoke. Not easily disturbed by air motion. (R47)

X52. 1921. England. Lights seen moving around inside a building attributed to will-o'-the-wisps created by the accidental release of producer gas. (R48)

X53. April 7, 1921. Cayutaville, New York. Five globules of bluish light the size of a half dollar were suspended, waveringly, 1 inch over marshy ground. (R49)

X54. Frequent occurrence. Brown Mountain, northern Burke County, North Carolina, about 15 miles northwest of Morganton. Altitude: 2725 feet. The Brown Mountain Lights have beckoned scientists and laymen alike for well over a century. They were documented in the late 1800s and are said to have been known to the local Indians as far back as 1,200 A.D. (R72), although one must wonder how this date was established.

The aura of mystery surrounding the Brown Mountain Lights has led to at least two formal, government-supported scientific studies of the phenomenon, plus additional investigations by some private research groups. Before reviewing the conclusions of these efforts, we provide two descriptions of the lights. The first appeared in the 1982 edition of this volume; the second in the Carolina Outdoor Guide in 1983.

First, a quotation from a 1925 number of the Literary Digest. "Since about 1850 there have been reports of 'lights' seen at night over the mountain. These lights have been described as varying in size, but to somewhat resemble 'toy balloons' and to be pink, orange, or reddish in color. They are said to rise into view over the mountain and to hover for periods of one to fifteen minutes duration before fading out. Sometimes, it is claimed, as many as three lights can be seen simultaneously at widely separated points. They are alleged to be bright enough to be visible from Blowing Rock, which is twenty miles away. Sightings are said to be frequent in fine weather, but also occur when the sky is overcast or the mountain hidden in mist.... On the night of 17 September I maintained a watch from the chosen position on the neighboring hill from 7.30 p.m. until 1 a.m. It had rained heavily all day. The rain stopped at about 8 p.m.,, but the sky was heavily overcast and the air exceedingly damp and misty.... from 8.30 p.m. until 11.00 p.m. I witnessed the lights which showed remarkable regularities. There were three distinct types.... Each light appeared to have its own characteristic color, frequency of occurrence, and elevation.... Light 1 was yellowish white and appeared at intervals of 8-11 seconds, having a duration of about half a second. Light 2 was reddish orange in color, and appeared at intervals of 12-15 seconds, having a duration of about half a second. Light 3 was violet in color. When it flashed the duration was only about one eighth of a second. Its occurrence was much less regular that that of the others. Sometimes there would be a series of several flashes mutually separated by time intervals of approximately 35 seconds. These bursts would be followed by lengthy pauses with no activity until the next burst. The duration of the pauses varied between 5 minutes and 30 minutes. According to my visual observation the lights seemed to be electrical in nature, and had a distinct resemblence to lightning. However, the somewhat rhythmic cycles as described above were quite unlike what is normally expected of lightning." (R50, R51, R64)

Now, the 1983 description: "An authentic Brown Mountain Light appears to rise up and hover over the mountain like a 'toy balloon.' The light may appear singly, or several lights may appear simultaneously or in succession. Average duration is 10-60 seconds although they have been known to endure as long as twenty minutes or more. The lights are usually described as being very bright and sometimes multicolored. Hunters and other people who have ob-

served the lights at close range describe them as bright spheres of moving light about the size of beach balls or car tires. Although a close encounter with the lights often is a very frightening experience, no one has reported being injured by them." (R72)

The first "official" scientific study of the Brown Mountain Lights was conducted by D.B. Sterret in 1913 under the auspices of the U.S. Geological Survey. Sterret concluded that the vaunted lights were merely locomotive headlights seen from afar. Actually, virtually all sightings of the Brown Mountain Lights are made from distant vantage points. It seems that Brown Mountain is no place to hike at night, being a maze of rocks and ravines overgrown by tangles of vines, roots, and rhododendrons. If Sterret had seen one of the lights at close range---one of those beach-ball-size bright spheres---he might not have asserted that all of the Brown Mountain Lights were merely refractions of distant locomotive headlights.

Then, too, the local inhabitants knew of the lights long before railroads penetrated into this part of North Carolina. Understandably, they scoffed at Sterret's theory as being the complete answer to the mystery. Sterret, as most scientists would have done, paid little attention to local lore and the anecdotes of hunters.

In 1922, another scientist from the U.S. Geological Survey, G.R. Mansfield, was dispatched to inquire further into the cause of the lights, which, incidentally, had refused to disappear in 1916 when floods wiped out railroad traffic in the area. Mansfield's report (R71) like that of Sterret also blamed human activity for all the lights he saw. M. Kane summarized Mansfield's findings thusly:

"Mansfield spent only two weeks in the Brown Mountain area and only two nights on the mountain itself. Despite such a small time period, he did a remarkably throrough job of pinpointing various lights on or near the mountain as seen from Blowing Rock, Gingercake Mountain, and Cold Springs. He attributed 47 percent of the lights to automobile headlights, 33 percent to locomotive headlights, 10 percent to stationary lights, and 10 percent to brush fires. He firmly believed that atmospheric refraction of these lights could account for all the 'ghost lights' on Brown Mountain." (R72)

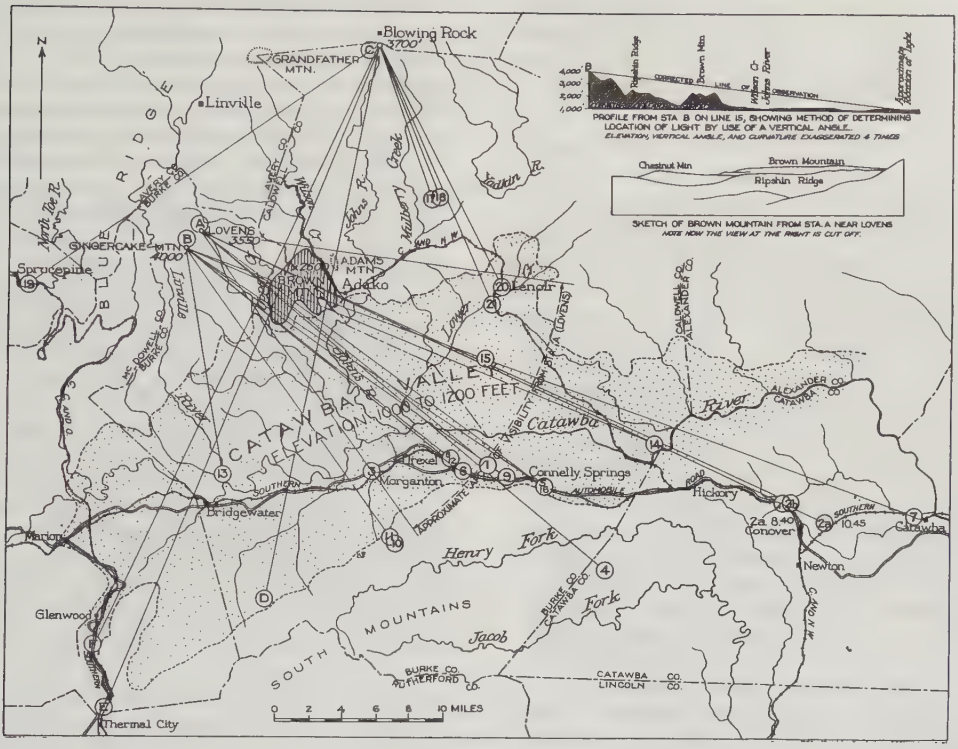
Atmospheric refraction can play many tricks with distant lights, and it seems likely that many of the Brown Mountain Lights seen today are truly man-made. But there may be natural lights in the phenomena-mix at Brown Mountain. Distant headlights cannot account for the rare close encounters nor for lights seen before intensive human settlement. Therefore, further investigations of the Brown Mountain Lights seemed reasonable to two amateur groups: the appropriately named Enigma Project and ORION (the Oak Ridge Isochronous Observation Network).

M.A. Frizzell has given us a summary description of some of the work carried out by ORION and the Enigma Project. In May 1977, ORION placed a 500,000 candlepower arc light in Lenoir, 22 miles east of Brown Mountain. Simultaneously, a group of observers gathered on an overlook on Route 181, 3.5 miles west of Brown Mountain, a favorite spot for watching for the Brown Mountain lights. Brown Mountain itself was interposed between the arc light and observers. When the arc light was switched on, the observers saw an orange-red orb hovering several degrees above the crest of Brown Mountain. Conclusion: at least some of the so-called Brown Mountain lights, particularly those seen above the crest, are refractions of distant artificial lights. Sterret and Mansfield were obviously on the right track in their explanations some of the lights.

The real Brown Mountain lights, the mysterious ones, according to Frizzell, are those that flit through the trees well below the crest. These lights are extremely rare. Typically, they commence as a brilliant blue-white or yellow light, which tapers off to dull red before disappearing, all in 2-10 seconds. Horizontal motion is often only a degree or so, although some older reports have the lights wandering greater distances at speeds faster than a human could manage in the difficult terrain.

In an experiment to determine whether the "true" Brown Mountain lights might be seismic in origin, ORION detonated small charges on Brown Mountain in July 1981. No artificially stimulated lights were recorded.

Frizzell concludes with this statement: "At the present time, no one can say with any authority what the Brown Mountain Lights are." (R73) He means, of course, the real Brown Mountain



Reproduction of G.R. Mansfield's map of the Brown Mountain region. All of Mansfield's observations were made from distant locations, such as Blowing Rock. (X54)

Lights, not those easily attributed to refraction.

We have to accept, therefore, that most of the Brown Mountain Lights seen from distant observation points are due to human activity. But, as with UFO observations and many other puzzling luminous phenomena, there appears to be a small fraction of observations that has not yet yielded to rational scientific explanations.

X55. November 1927. Bohemia, Germany. In a marshy area near an iron mine. Four small bluish flames 1 inch in diameter were constantly hopping up and down. Nearby a yellowish-green flame measured 3 feet high, 1 foot in diameter. The flames produced no heat and persisted about 15 minutes. (R52)

X56. September 1914. France. Thin, pale, greenish flames, 12-18 inches high seen shooting up and down over a marshy area. (R52)

X57. August 4, 1924. Mandeville, Louisiana. In hot, very dry weather, many marsh fires ignited spontaneously. (R53)

X58. Summer 1840. Argylshire, England. Several candle-size flames were seen flitting across the surface of a pond. They seemed to leap from place to place and disappear. The flames rose 1-2 feet above the surface of the water. (R54)

X59. September 1858. South Wales. Many bright lights swung about over a bog. (R54)

X60. No date given. Grupont, Belgium. In some marshy woods, white clouds rose from the ground and formed into luminous globes, while attaining an altitude of a dozen yards. They remained visible several minutes. (R55)

X61. Circa 1812. New London, Connecticut.

On December 2, as Commodore Decatur was planning to run the British Blockade, blue lights appeared on the shores of the harbor. They were never explained. (R55)

X62. Frequent occurrence. Esperanza Creek, Texas. "This light on the Esperanza Creek, this Will O' the Wisp, appears to be about the size of the headlight on an automobile. It travels at various speeds, and at a distance of from one to three feet above the ground. It has been seen in all kinds of weather conditions, and at all seasons of the year, and at all hours from dusk till dawn.... Only travelers on horseback or in horse-drawn vehicles see the light, which may approach the traveler from either side. It comes within twenty steps before it stops. When the traveler's horse stops, blinded by the light, the light retreats and meanders along, crossing the road back and forth in front of the traveler. Sometimes the light slowly recedes until it can scarcely be seen, but it returns at great speed. After crossing the creek, the light continues to follow for a few miles, but always returns to the river at the mouth of the creek and goes straight up and then down and disappears. (R56) There are scores of such 'ghost lights' described in the folklore and Fortean literature. (R65, R66)

X63. Frequent occurrence. Northeastern Oklahoma. The famous Tri-State or Hornet 'spooklight.' "In the northeastern corner of Oklahoma, some 14 miles from Joplin, Mo., is a lonesome stretch of country road called the 'Devil's Promenade.' Some mighty strange people have lived along this road, and some very strange things have happened there. The best of the 'haunted road' stories cannot be told at this time, but there is no longer any secret about the phenomena of the 'Indian lights,' which have been seen by thousands of tourists and discussed in newspapers as far off as St. Louis and Kansas City.... One has only to drive slowly along the road any night after dark to see the 'jack-o'-lantern' come bobbing along, always traveling in an easterly direction. Sometimes it swings from one side of the road to another, sometimes it seems to roll on the ground, sometimes it rises to the tops of the scrubby oak trees at the roadside, but it never gets more than a few feet from the road on either side. I have seen this light myself, on three occasions. It first appeared about the size of an egg, but varied until sometimes it looked as big as a washtub. It was about as powerful as an ordinary automobile headlight with the dimmer on. It is hard to judge the distance, but it seemed about a quarter of a mile off when I first saw it, and disappeared when it approached to a distance of perhaps 75 yards. I saw only a single glow, but other witnesses have seen it split into two, three and four smaller lights. It looked yellowish to me, but some observers describe it as red, green, blue or even purple in color. One man swore that it passed so close to him that he could 'plainly feel the heat,' and a woman saw it 'burst like a bubble, scattering sparks in all directions,' A fellow who drove his car straight at the dancing phantom lost sight of it, but others standing a little way off said that they saw the light hovering impishly above the pursuer's car, out of sight but plainly visible to everyone else in the neighborhood." (R57)

Several scientists, including J.A. Hynek of UFO fame, who have looked into the Tri-State Spooklight apparitions have come away convinced that everything can be explained in terms of the atmospheric refraction of automobile headlights. (R60, R61, R63, R74) If this situation sounds familiar, that is because it is.

In many respects, the history and luminous phenomena of the Tri-State Spooklight closely resemble those encountered at Brown Mountain, North Carolina (X54) and Marfa, Texas (X69). Although there do not appear to have been any "official" investigations of the Tri-State Spooklight, a few scientists, such as Hynek, have deigned to take cursory looks at the phenomenon. Like Hynek, most scientifically indoctrinated investigators opt for the refraction of automobile headlights as the sole cause of the Tri-State Spooklight. It's Brown Mountain all over again, and the same situation is seen at Marfa, Texas (X69), and elsewhere. Optical refraction is a concept that scientists feel comfortable with, and it is certainly the primary cause of many low-level nocturnal lights.

It does not seem to matter that at all three of the sites mentioned in the above paragraph there exist long histories---admittedly hard-to-verify histories---of light-sightings well before the advent of

automobiles and trains in the areas where the lights are seen. Also ignored at all three sites are the bulging files of anecdotes of observations of the lights, especially those bizarre close encounters with humans, that totally defy the headlight-refraction theory. Are we to assume that some small fraction of the Tri-State Spooklights, the Brown Mountain Lights, and the Marfa Lights are of psychogenic origin, as some of the Egryn Lights (X39) may have been? Or are there causes that we have not yet identified? It seems as if the only rational solution in such situations is to categorically deny the honesty and reliability of reports that do not to easy scientific explanations. How like the UFO enigma is that of the low-level nocturnal lights!

To conclude this entry on the Tri-State Spooklight, we add the story of one of those perplexing close encounters; one of those that headlight refraction is helpless to account for.

This anecdote was collected by D. Kaczmarek, an amateur investigator of paranormal phenomena. Based upon the testimonies of over a dozen witnesses, he wrote:

"There were between ten to fifteen people observing the light when it suddenly appeared about 30 feet away from them in the middle of the road. The light was about the size of a basketball, orange-yellow in color, throbbing and slowly rolling along the ground. They were not frightened, but awestruck and extremely quiet---because they didn't want to spook it (no pun intended). Suddenly some cars behind them began to crunch the gravel in the road, trying to get a better view. The light rose up to about ten feet above the ground, split into two sections, and shot into the woods in both directions at once. The light was apparently reacting to the sound of the gravel and, sensing that too many people were surrounding it, panicked and disappeared." (R76)

X64. No date given. England. Channels cut through a peat bog released huge quantities of marsh gas, but there was no ignition and no will-o'-the-wisps. (R58)

X65. August 7, 1957. North Atlantic Ocean. "At 2150 G.M.T. what appeared to be the loom of three lights appeared on the eastern horizon. The central loom was the most distinct and bore 098°, the others were 2° on each side of it. It was thought at first that the phenomenon was due to the reflection of moonlight from the clouds, but the source of light appeared to be below the horizon and was not steady. The moon bore 168°. No echoes showed on the radar screen on this bearing though the echo of a ship at a distance of 15 miles showed clearly, and also those of rain squalls over 30 miles away, so it would appear unlikely that the source of the lights was associated with a ship or ships. As the nearest land, Cape St. Vincent, was 200 miles distant, it was difficult to relate the lights to anything on the land. The central light persisted for 40 min, until 2230; its bearing became more N'ly and was 080° when it disappeared. The lesser lights lasted 30 min, until 2220." (R59)

X66. Frequent occurrence. Silver Cliff, Colorado. Dim, rough, spots of blue-white light glowed among the gravestones. They vanished when approached. The mention of the Silver Cliff lights in National Geographic has made them rather famous---something for the tourists! (R62)

This notoriety accruing to an apparently inexplicable phenomenon naturally attracted debunkers and believers alike. After several nights keeping vigil at the Silver Cliff Cemetery, skeptics K.J. Bunch and M.K. White had no difficulty seeing the well-advertised lights. Usually, though, they were easily proven to be simply reflections of Silver City's nearby lights off the specular surfaces of the tombstones. But spooky lights are also seen at Silver Cliff when the city is dark. Bunch and White assert further that in Colorado's clear mountain air, the stars are so bright that their light, too, is reflected off the tombstones, thereby providing a natural source for the vaunted lights. (R82)

X67. General observations. A.A. Mills, a British scientist, has had the political

courage to do research on will-o'-the-wisps, those greatly neglected luminous phenomena said to frequent marshy places. His literature search confirmed the reality of these cold flames, though he noted that they seemed to be reported only very rarely in modern times. (Research grants for the elucidation of such bizarre phenomena are doubtless hard to come by.) In truth, today's scientific establishment tends to laugh off will-o'-the-wisps as old wive's tales or as misidentifications of St. Elmo's Fire or ball lightning. But, even if their reality as a distinct phenomenon is acknowledged, will-o'-the-wisps are considered to be simply the spontaneous ignitions of marsh gas---a trivial phenomenon not worth wasting time and research dollars on.

Mills' study, however, shows this condescending attitude to be far off the mark. He experimented with marsh gases, even constructing his own controlled "swamp" in the laboratory. He has been unable to duplicate the well-established characteristics of the will-o'-the-wisps; i.e., spontaneous ignition, cold blue flames, no significant odor, etc. The marsh-gas theory does not seem to hold water. In light of Mills' research, a real mystery persists in the planet's swamplands. (R67)

X68. No date given. Caspian Sea. Subterranean disturbances release immense quantities of naptha from underground deposits. The naptha ignites and thousands of square miles of the Caspian are set afire. (R68)

X69. Frequent occurrence. Marfa, Texas. Marfa is a small ranching community in the Big Bend region of West Texas. Just to the east of Marfa on Route 90, a special "Marfa Lights Viewing Area" has been established for the many tourists who wish to see what is ballyhooed as a great natural mystery. The local populace has always known about the Marfa Lights but no longer pay much attention to them. They are there, and that's enough. But they do recognize their value in attracting tourists to the Marfa region, which is otherwise fairly barren of things to do. In fact, the city of Marfa has even held Marfa Light Festivals. In terms of tourist popularity and the number of filmers of TV-documentaries who set up shop around Marfa, the Marfa Lights now far outshine the Brown Mountain Lights and the Tri-State Spooklight as America's best-known, mysterious luminous phenomena.

The Marfa Lights are real all right. They can be seen just about every night. But, just as with most of the Brown Mountain Lights and some of the apparitions of the Tri-State Spooklight, almost all of the Marfa Lights are easily shown to be nothing more than the headlights of automobiles cresting a hill on Highway 67, 24 miles south of Marfa. Triangulation on the lights confirm this, as do high-power-telescopic observations.

Once again, though, science is restrained from "closing the book" on the Marfa Lights. Paralleling the situation at Brown Mountain, North Carolina, and in the domain of the Tri-State Spooklight on the Oklahoma border, there are two classes of data also remain unexplained at Marfa:

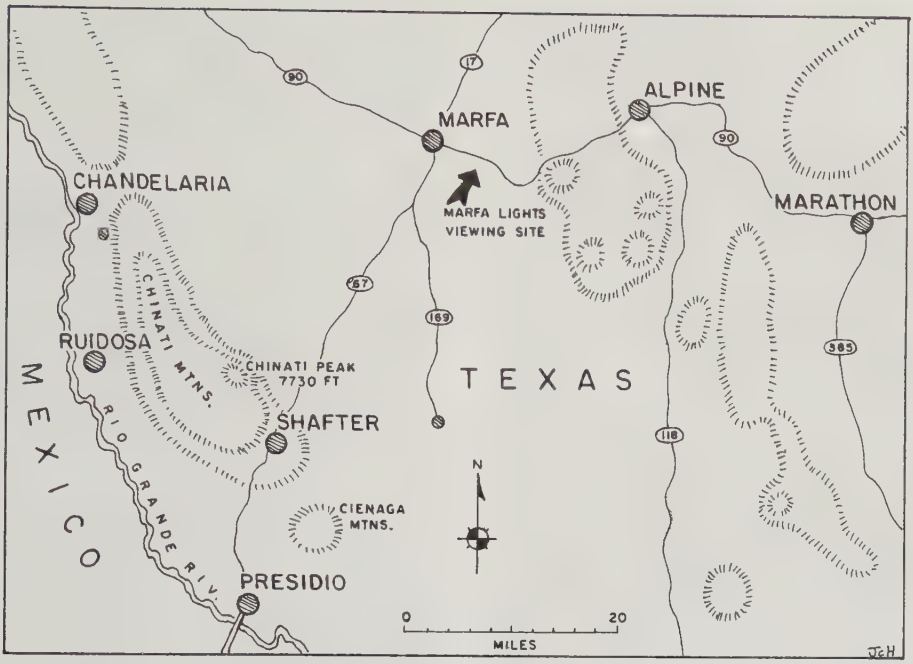
(1) The Marfa Lights were seen as early as 1883 by cattlemen---long before automobiles and Highway 67; and

(2) Anecdotes describing close encounters with the Marfa Lights, if even only partly true, suggest phenomena that cannot be ascribed to automobile headlights or man-made machinery of any kind.

As so often the case in anomalistics, we are left at Marfa with a small residue of data that come nowhere near being explained by the dominant theory espoused by the scientific establishment. The main lament of the anomalists has to be that so many of the deviant data are anecdotal and therefore unpalatable to science-in-general.

Before presenting a few examples of such indigestible fare, we require a baseline of "acceptable" Marfa Light observations. For this, we rely upon D. Stacy.

"Most observers of the phenomenon report one or more brightly twinkling lights glimpsed after dusk, either just below or slightly above the sharply outlined horizon. Some have said that there are better viewing times than others, for instance, after the passage of a patented "Blue Norther," a rapidly moving cold front, or in the wake of one of the spo-



Map of the Big Bend region of West Texas. The Marfa Lights appear quite regularly to observers in the special "viewing area" just outside of Marfa. (X69)

radic showers that settle the dust. In fact, the Lights can be glimpsed almost any time. A few old-timers will even tell you they can be seen every night of the year from the highway pullover, dancing and weaving their magic over the plain to the south.

"The most often described color seems to be a greenish-yellow or yellowish-green. Normally one or two pinpoints of light flicker into view, cavorting across the desert floor like a luminous Mexican jumping bean. These lights, so they say, may in turn divide or split into several others. They may float lazily in the air, like balloons wafted by a thermal updraft, or dart and dash through the night in fits." (R89)

One may wonder if the Light's complex antics, as described by Stacy, can really be blamed simply on distant headlights. Given the 24 or so miles to the major source of the postulated headlights and the thermal agitation of the night air by the cooling desert in between, optical refraction has the opportunity to play many tricks with headlight beams. Image-doubling, distortion, flickering, and anomalous motion are easy tasks for abnormal refraction under such conditions. (See many examples of unusual mirages and abnormal refraction in our companion catalog volume Rare Halos, Mirages...)

A close-encounter anecdote (the kind that defies the headlight theory) which involves the Marfa Lights occurred in 1974 and was reported, of all places, in the Wall Street Journal.

"About 10 years ago, Mr. Whatley was driving home a little before dawn from his night job as a computer operator when he saw what he thought were car lights speeding toward him on a road east of town. The next thing he knew, he says, a cantaloupe-sized globe of orange-red light appeared and hovered a few feet outside the rolled-down window of his pickup."

Understandably, Whatley hit the accelerator, but the light stayed with him for about two miles and then disappeared. (R84)

Mr. Whatley's Marfa Light was obviously no distant automobile headlight. Rather, it it resembled the famous foo fighters of World War II in its pacing alongside Whatley's car for two miles. (See GLB18)

A commonly reported characteristic of nocturnal lights is their seeming curiosity, even intelligence. This can be seen in the testimony of geologist E. Wright.

"Several times I had seen lights around this old hangar they had on the airbase. Well, one of these lights took off for that hangar, but the other one stayed there by the side of the road. It kept moving around a bush, kind of like it knew we were trying to get near it. It seemed to possess intelligence---it was like that thing was smarter than we were. It was making us feel pretty stupid. It was perfectly round, about the size of a cantaloupe, and it moved through that bush like it was looking for something. When the light stopped moving, it would get dimmer, but as it moved, it got brighter. Finally, it pulled out into the middle of the road about twenty yards from us and just hovered there." (R83)

It is maintained by some that, if the Marfa Lights are simply headlights, they have not and cannot be seen from aircraft, according to the laws of optical refraction. Nevertheless, a few pilots and aircraft passengers have claimed they have seen them. In February 1988, R. Weidig was flying at about 8000 feet, some 20 miles from Alpine, Texas, when he noticed white lights in motion around the Alamito Tower's red beacon light. He testified, "We noticed white lights coming up...I don't know how high, but it seemed like several hundred feet. Then the lights would just dissipate... They moved around that tower for some reason. They'd get on the right hand side of it, the left-hand side of it, and go just straight up."

In June 1988, a stranger case was reported by E. Halsell, who was a passenger on a plane flying toward the Chianti Mountains.

"'Suddenly a bright light came toward them rapidly, seemingly from a great distance. 'It came straight at us til it got to the hood of the plane....It was engulfing us, larger than the plane.' It seemed as though they were inside the light. 'We couldn't see to fly. It scared us.' According to Halsell, as they tried to turn away from it, it moved in front of them. 'Always it moved around us, like it was observing us....We made right turns and left turns and it stayed right with us, like it was playing a game.' The light was very bright, but 'It was kind of fuzzy, like a halo or aura, a ball of light without an obvious center.' The light was white in color, was constant rather than pulsating or flickering. There was no unusual sound." (R87)

Regularly appearing nocturnal lights naturally attract skeptics anxious to rid our planet of mysteries and anomalies. In this spirit, some members of the Houston Assocition for Scientific Thinking (HAST) visited the sites of the famed Marfa Lights and the less-well-publicized Saratoga Lights in East Texas. With binoculars, telescopes, and road maps, it was fairly easy for them to ascertain that the Saratoga Lights were simply the headlights of automobiles traveling along Route 787. The Saratoga display is a bit eerie but not at all mysterious, according to HAST.

The Marfa Lights turned out to be more impressive. HAST logged a total of 9 hours of observation there on three successive nights. All of the lights observed were easily attributed to cars traveling north from Presidio to Marfa. People at the viewing site who knew of the Presidio-Marfa road had no trouble identifying the lights as those of automobiles. But those unaware of the road called the lights mysterious. As for the frequent reports of Marfa lights cavorting and executing strange maneuvers, HAST thought these deviant lights were probably just low-flying aircraft in the neighborhood of the Chianti Mountains some 40 miles away. In fact, just such a plane was observed during a daylight trip to Shafter, a town near the mountains.

After having ostensibly and rudely torn away any aura of mystery surrounding the Marfa Lights, the HAST report closed with a paragraph that seems to embody second thoughts about the amply demonstratedd mundane nature of the Marfa Lights! HAST wrote:

"A reminder that caution must be taken. Because what we saw four nights in Saratoga and three nights in Marfa did not go out of the bounds of the ordinary does not mean that the extraordinary has never occurred in either place." (R90)

Obviously, the HAST members had not had any close encounters with the Marfa Lights. Nor did HAST account for those pre-automobile sightings.

To close the Marfa-Lights dossier, it is imperative to point out that some of those lights that do not yield to the headlight explanation may be related to the Yakima Lights (X71), which occur near an area where humans have pumped large quantities of fluid into the ground. Marfa is located adjacent to oil fields where thousands of gallons of water are injected into the strata to coax more oil out of the strata. The resultant increased seismicity may give rise to luminous phenomena at Marfa like those observed at Yakima. (R91) Of course, the Yakima Lights are not well-explained either and cannot possibly be headlights.

X70. Frequent occurrence. Western Queensland, Australia. Sightings of the Min-Min Light are concentrated in the desolate outback of Queensland, especially between Winton and Boulie. The Light gets its name from the old Min-Min Hotel, which once stood on the coach road connecting Winton and Boulie. Although sightings of the Min-Min Light are rather strongly focussed in the area mentioned, reports have come from all over Queensland. Indeed, this spooklight, or something very much like it, has been seen in many parts of Australia, even South Australia and Western Australia. (R97) In its wide dispersion, the Min-Min Light differs from North america's Brown Mountain Lights and Marfa Lights, which are are sharply focussed geographically. Furthermore, observations of the Min-Min Light are almost always of the close-encounter type.

On the island continent of Australia, we have an opportunity to study a luminous phenomenon in a vast land that is: (1) exceedingly dry and generally devoid of marshlands that might create will-o'-the-wisps; (2) seismically inactive and unlikely to produce earthquake lights; and (3) scantily populated in its interior (especially 50 years and more ago), thereby greatly reducing the probability of refracted man-made lights being confused with "genuine" Min-Min Lights. The dossier of Min-Min-Light observations is therefore relatively unadulterated with luminous phenomena attributable to marsh gas, seismic activity, or human activities.

These things said, the history of the Min-Min Light is much like that of other spooklights. The Australian native peoples saw it before Europeans settled the country. Said settlers recorded its existence a century ago---long before cars and locomotives penetrated into the outback in any number. In addition, the physical characteristics of the Min-Min Light are virtually indistinguishable from those recorded in close encounters with spooklights elsewhere on the planet.

Australians view the Min-Min Light much as Americans do the Marfa Lights. People go out into the outback looking for this spooklight, although there is no viewing area set aside like there is at Marfa. (Actually, the Min-Min Light is not as reliable as the nightly Marfa Lights.) Australian newspapers, like those in the States, carry articles on their national "mystery light," and TV crews have tried, usually unsuccessfully, to capture it on tape.

As indicated above, the Min-Min Light differs little from the classical spooklight. N.W. Bauer has provided us with a generic description in, rather surprisingly, an Australian science journal.

"The phenomenon usually appears as a luminous oval like a fluorescent football, sometimes stationary, sometimes moving, sometimes advancing, sometimes receding, sometimes hovering in the air, sometimes bouncing and rolling but never coming close enough to be positively identified. Its light is not constant as it floats through the air, seemingly inviting one to follow.

"On foot, on horseback and in motor vehicles, men have chased it---and some have been chased by it---but none has ever got close enough to see exactly what it was. A man of the cloth from Townsville once chased it in a car for miles but never gained on it. When going towards it, the light would recede, keeping at a constant distance. When the chaser turned to go away, the light followed, still at the same distance." (R95)

The Min-Min Light is erratic and sometimes seems to have a mind of its own, as in the testimony that follows.

"This experience I saw with my own eyes and it frightened me. I can't think of an explanation. It was in the real true home of the Min-Min Light. Near where the old Min Min shanty used to be. Very little to see now. It goes back to 1950, August. I had occasion to be travelling that road with a droving plant and we lost a few horses and had to go back to find them. I'm not the gamest guy in Australia but then again I don't frighten easily either.

"This night I was riding a very quiet horse and I was heading back towards where the camp was. Probably three or four miles away, and it was nine o'clock. This light was coming down where I reckoned the road would be. The light was so brilliant the horse started to tremble. I judged the light to be no more than three of four feet off the ground, and I put it down to being a light on a highish vehicle or some sort of truck. It came to within about 3-400 yards and then veered off to the left.

"It went around to the north of me and I lost sight of it for some minutes. When I next saw it, it was south of me and coming back towards me again and was about the same distance from me. It looked to be about the size of a bull light---a very bright spot light. It was travelling at a terrific rate of knots. Then it came up within say 150 yards and it lit the grass all around. I could distinguish which was the Mitchell and which was the Flinders grass. If a night bird had been in the grass, I'd have seen it. The light was flying dead level, not undulating or swaying, then disappeared.

"The next time I saw it, it was coming back down the road at me. This continued for about 2-3 miles and then it veered off to the south and disappeared. I didn't see it again. It lasted for about ¼ hour altogether. When it went out for the short time it would have been about a minute." (R97)

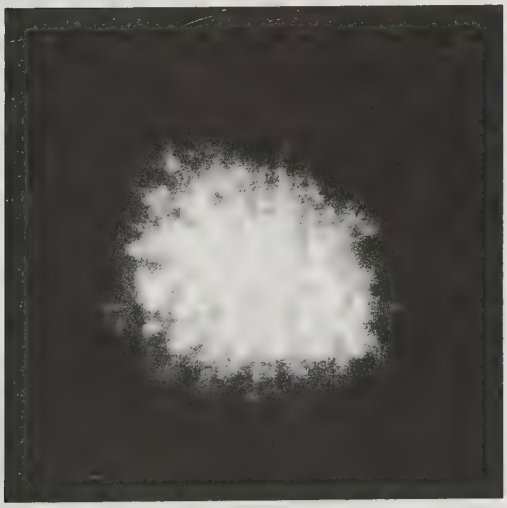
X71. Frequent occurrence. Yakima Indian Reservation, south-central Washington, in the vicinity of the Toppenish Ridge. The Yakima Lights are not casually observed luminous phenomena preserved mainly in anecdotal form---like most of the Marfa and Brown Mountain Lights. Instead, they are seen floating above and among the trees in a heavily forested area by trained fire-lookouts. Alert for forest fires, the fire-lookouts also log sightings of unusual lights. Given this network of watchtowers connected by radio, triangulation on specific lights from two or more towers provides good distance data. Photographs of the Yakima Lights taken with telescopic lenses are also available. The Yakima Lights thus offer a unique, instrumented record of a class of unexplained luminous phenomena recorded by trained observers. Unfortunately, this high-quality data is generally ignored by mainstream science. Actually, it is surprising that more adventuresome scientists have not made more of these unusually good data from Yakima. Something unusual is happening there, and apparently only two scientists have studied in depth the nature and source of the Yakima Lights.

The Yakima Lights are not rare. Over 100 observations were collected between July 1972 and July 1981. J.S. Derr and M.A. Persinger---the two scientists that have grasped the scientific importance of the fire-tower observations---employed this data base to investigate the possibility that the Yakima Lights are associated with small earthquakes and/or tectonic strain in the area. (R98-R101)

In this catalog, we are primarily interested in the physical nature of the lights. Derr and Persinger accommodate us with the following.

"Most of the observations were recorded in log books by the regular fire lookouts at their stations atop the ridges during the fire season (generally May through September). These lookouts provide regular coverage of the area during daylight and evening hours, and irregular coverage during the night. Random observations by other observers, including law-enforcement personnel from various jurisdictions, supplement the data base. Additional observations were provided by a team of scientists and engineers who came to the towers specifically to observe and photograph the LP (luminous phenomena...The observers' experience should minimize, if not eliminate, the inclusion of lightning, aurorae, and artificial light sources in this set of observations.

"The LP certainly bear a strong resemblance to ball lightning, although the weather conditions at the times of sightings would tend to rule out this explanation. The following sighting was given by the Sopelia lookout: 'A very strong white light about the size of a (baseball) was floating along just north of me down the slope from east to west, north of the trees on the deep canyon side about 6 to 10 feet below the tallest trees. I watched it as it went by between the trees. Really looked like someone could have been out for an evening stroll with a light in their hand. But nothing to stroll on but air. So this light must have been floating along. No noise at all. All quiet.' This report is evidence for the hypothesis that short-duration (less than 1 min) LP seem to behave the same way ball lightning does: once formed, the assumed plasmas seem to have lives of their own, apparently with no more energy input required. Their paths would seem to be determined by the ambient electromagnetic fields. LP of much longer duration, however, would almost certainly require a continual energy input." (R100)



Photograph of a nocturnal light seen floating near the Toppenish Ridge, Washington, in 1972. Estimated diameter of the light: 1 meter. (Photograph by D.W. Akers, courtesy of J.S. Derr, R100)

Given the distances of a specific lights and their photographs, Derr and Persinger were able to determine that some of the lights radiated tens of watts of power. A 1000-watt incandescent bulb would be needed to duplicate the observed luminous phenomenon. Any explanation of the Yakima Lights must, therefore, account for a baseball-sized sphere floating among the tree-tops charged with a surprising store of energy in some form or other. Such an entity sould be a challenge to theorists, if they only would show some interest.

Derr and Persinger correlated the appearances of the Yakima Lights with earthquake energy released within 100 kilometers of the Toppenish Ridge. "The results in that study support the hypothesis that the lights are associated with tectonic strain in active seismic areas and tend to accompany increases in earthquakes. Thus, earthquake lights and luminous phenomena [i.e., the Yakima Lights] may be related phenomena with slightly different time relationships to the associated earthquakes, or else the luminous phenomena may, in fact, be earthquake lights for very small, high stress-drop earthquakes that have not yet been detected because of a lack of instrumentation." (R101)

It seems possible that some, but not all, of the other nocturnal lights cataloged in this section might, like the Yakima Lights, derive their energies from tectonic strains. The precise mechanism employed in this energy transfer is not understood. There is obviously much left to learn here.

Perhaps more significant to the whole problem of nocturnal lights is the observation that the Yakima Lights exist for us to speculate about them only because of that network of fire lookouts. Most forests are not watched over so assiduously; nor are deserts, marshes, and croplands. One has to wonder what the totality of the nocturnal-light phenomenon really is! We really should look for them more comprehensively.

X72. Occasional occurrence. Hessdalen Valley, Norway. Hessdalen Valley is about 12 kilometers long and located in central Norway about 120 kilometers south of Trondheim.

In December 1981, the inhabitants of

Hessdalen Valley began reporting the appearance of strange lights. Sometimes there would be several appearances each day. Over the period from 1981-1985, hundreds of these unidentified lights appeared. Since then, the phenomenon has subsided to a level of about 20 sightings per year.

During the peak of the "flap" in the early 1980s, the presence of so many, rather dependable, yet highly unusual, luminous phenomena encouraged some amateur UFO-study groups in Norway and Sweden to create the Hessdalen Project. The Project's goal was to determine to nature of the Hessdalen Lights using an array of modern scientific instruments. To this commendable end, a field group of five individuals headed by E. Strand set up three observation stations around the Hessdalen Valley. Although the Hessdalen Project was not "official," it did receive assistance from the Norwegian Defense Research Establishment, the University of Oslo, and the University of Bergen. The feature of the Hessdalen Project that set it apart from other amateur investigations of nocturnal lights were the scientific instruments it deployed around the Valley. By all measures, it was the most sophisticated amateur effort aimed at unravelling the mystery of nocturnal lights. (We do not have any information on government/military efforts to solve the mystery of the Hessdalen Lights.)

The Hessdalen Project was active for just over a month (January 21 through February 26, 1984). Its task was not an easy one, because witnesses in the Valley attested to the existence of three different categories of lights:

(1) "A yellow 'bullet' with the sharp end pointing down;

(2) A strong blue-white light, sometimes flashing, always moving; and

(3) A pattern comprising many light sources with different colors that moved as if they were physically connected." (R104)

To this unexpected morphological complexity were added different types of light "behavior."

(1) "Small and strong white or blue flashes that showed up everywhere in the sky;

(2) Yellow or yellowish-white lights below the horizon. Sometimes they were just above the rooftops and even down on the ground. These would often be stationary before moving low around the valley, and sometimes they moved very quickly;

(3) Several lights together at a fixed distance from each other. Mostly these were yellow or yellowish-white lights with a red light leading them. These lights would move slowly around the mountaintops." (R103)

The Hessdalen Project's impressive complement of scientific instruments added more curious and fascinating facts to the already complex picture. During the January-February 1984 period when the Project was active, eight different kinds of instruments were in use, with the following results:

- "Camera with grating: Three pictures showed a continuous spectrum. No spectral lines were seen on any picture.
- IR-viewer: This instrument was used too little to drawn any conclusion.
- Spectrum-analyzer: Sometimes there were electromagnetic signals with harmonics of about 80 MHz.
- Seismograph: No local seismographic activity was measured.
- Magnetograph: The magnetic field did sometimes change when the lights showed up. There also seemed to be a correlation with the magnetic pulsation.
- Radar: The lights could be seen on radar. The speed varied all the way from 0 to 30,000 km/hour. Sometimes the radar saw something moving at a low speed, but no lights were seen by eye. Clearly, there was something there, but only the radar showed it.
- Laser: A laser-beam was directed toward the light, and the behavior of the light changed.
- Geiger-counter: No radioactive radiation was detected. But the source was 1 km away when this instrument

was used." (R102)

The Hessdalen Valley lights are manifestly real and cannot be discarded as automobile headlights, earthquake lights, ball lightning, or any other recognized luminous phenomena. One can only conclude that nocturnal lights are more complex and diverse than will-o'-the-wisps and earthquake lights, and that science-in-general is neglecting a group of incredible luminous phenomena.

There would probably be more establishment interest if nocturnal lights were not closely related to UFOs in the public mind!

Artist's concept of the annual rising of the Nekha Lights from the Mekong River, Thailand. (X73)

X73. Occasional possibly annual occurrence. Mekong River, Thailand. This incredible luminous phenomenon was first noticed by us when the following letter was published in the September 6, 1997, issue of the New Scientist.

"My wife and I saw a puzzling sight in October 1994, in the Mekong River near Nongkhai, Thailand, during a full moon, in the evening. Lights appeared under the water for a few hundred metres along the Mekong River. They rose from the bottom of the river and floated to the surface, then shot like missiles into the sky and out of sight. They were the size of beach balls, and many flew out of the water every few minutes, surfacing about 10 metres apart. I am told that this happens every year at the same time. Locals say it is caused by a serpent releasing her eggs. Does anyone know of this phenomenon?" (R105)

A. Pentecost, another reader of New Scientist, attempted an answer. He noted first the similarity of the Mekong phenomenon to the will-o'-the-wisp or ignis fatuus. The usual explanation of ignis fatuus blames the spontaneous combustion of marsh gas. However, the Mekong lights are initially seen under the water where there would not be enough oxygen to support combustion. Pentecost suggested instead phosphorescent bacteria or the "cold flame" of phosphorus vapor which might form through diphosphane decomposition. (R105)

More information on this most unusual phenomenon was printed in the December 20/27, 1997, number of the New Scientist.

The basketball-sized lights erupting from the Mekong River, Thailand, turn out to be a well-known annual event. Their official name is: the Nekha Lights. They have even been filmed and shown on Thai TV. These weird luminous displays occur during the October full moon and last only about 30 minutes. The lights rise out of the river and nearby rice paddies, not only near Nongkhai but also along a small stretch of the river straddling the Thailand-Laos border. (R106)

Given the annual nature of the Nekha Lights and the apparent requirement for a full moon lead one to suspect a biological origin. By way of illustration, marine Paolo worms come to the ocean surface to spawn only once a year during a full moon.

The Nekha Lights, or something much like them, may be more wide-spread geographically than indicated above. See X74.

X74. Occasional occurrence. Changkat Asah, Malaysia. Circa 1895, Sir G. Maxwell and a companion were situated on a hillside one night hoping to dispatch a troublesome tiger. Down in the valley below they remarked on the progress of

two lights apparently carried by the local people. Then began one of the most amazing displays of nocturnal lights we have come across.

"Then in an instant the two lights flew up into the air, and rushed straight at us. So fast did they fly, and so directly did they aim at us, that before we could realise that they were not the lamps of Chinese miners clamouring far below us outside the distant police station, two great balls of light sped by within fifty feet of us. To say that we were frightened is to put it lightly. I gave a gasp, and but for the support of my shoulders would have fallen backwards out of my seat. The suddenness of the assault was overwhelming. From our lonely eminence we had watched the lights making their way down the valley, my interest tempted with thoughts of the court case they might portend for the next morning; and in a second, even as we watched them, the tiny lights had turned into fiery globes the size of a man's head, and their speed had become terrifying. However, as our visitors passed us, we saw that they were natural phenomena, and either chemical gases or electric fluids ---that is to say, they were either of the nature of a Will-o'-the-Wisp or of a St. Elmo's light.

"These two lights seemed to us to have arisen from the marshes above the village. Thence they were gently borne by currents of air down to the river bank, where they were caught by the night breeze and carried up to where we sat. Soon after, several more came drifting down from both sides of the valley towards the river bank, and all, as they reached it, were seized and whirled by the wind in all directions. Before long there were over a hundred to be seen. The wind was fickle and variable and sometimes a dozen of these balls of light, which were now all around us, would fly down to the river together and meet others floating lazily by." (R107)

Maxwell soon realized that these dancing lights were the "spooks" the Malays called "penanggal." As for their scientific identity, he decided that the lights were too bright and too active to be either will-o'-the-wisps or St. Elmo's fire. (R107)

One does see, though, a similarity to the Nekha Lights (X73) and the luminous aerial bubbles cataloged in GLD7.

X75. Frequent occurrence. Nepal. On hillsides in the southern Himalayas. We have a brief reference to "amorphous glowing complexes" that move erratically over Himalayan hillsides. The children in this region are said to chase these luminous phenomena and throw rocks at them! (R108)

X76. 1895. Lake Ncovi, Western Africa. One night when M. Kingsley went out alone to swim and canoe on the Lake, she encountered nocturnal lights that seemed to be at home both in the air and under the lake waters! She wrote:

"...I saw a strange thing happen. Down through the forest on the lake bank opposite came a violet ball the size of a small orange. When it reached the sand beach it hovered along it to and fro close to the ground. In a few minutes another ball of similarly colored light came towards it from behind one of the islets, and the two wavered to and fro over the beach, sometimes circling round each other. I made off toward them in the canoe, thinking---as I still do---they were some brand new kind of luminous insect. When I got onto their beach one of them went off into the bushes and the other away over the water. I followed in the canoe, for the water here is very deep and, when I almost thought I had got it, it went down into the water and I could see it glowing as it sunk until it vanished in the depths." (R109)

An orange-size insect that can both fly and submarine! Seems unlikely.

X77. March 3, 1933. Kamaisi, Japan. A devastating tsunami followed the Sanriku earthquake on this date. K. Musya, of the Earthquake Research Institute, collected many reports of unusual luminous phenomena associated with the tsunami. Two of these apparitions seem to fit in well here. In the first, the lights are in the tsunami wave itself; in the other (X78), a bright luminous sphere was widely observed out at sea above the water.

The first type of luminosity was seen by Y. Onodera, who was located on an elevated spot overlooking Kamaisi Bay.

He submitted the following observations to K. Musya.

"While a great wave (probably the second wave) rushed in and advanced to the central part of the Bay, well-defined, round-shaped, luminous bodies as large as a "sugegasa" (sedge-sunshade) or a "tarai" (washtub), about three in number, were seen in a row in the wave, a little below the crest. Their color was bluish-purple like an electric discharge. They lighted up all around, so the curling crest and fragments of destroyed houses were clearly visible as they were tossed about by the wave. Besides him, many people who were in the neighborhood observed them." (R110)

If it were not for the very large size of the these luminous bodies, one would be tempted to identify them as bioluminescent organisms shining because of the agitation of the sea.

X78. March 3, 1933. Kamaisi Bay, Japan. Fisherman T. Harada was aboard the Koeimaru cod-fishing 4 miles from Sanganzima when the tsunami occurred. Then:

"...a large fireball suddenly appeared above the sea. It was as large as a full moon, and at a height of about 7-10 meters from the surface of the water. Believing it to be the top-lamp of a trawler, I starboarded and ported the helm, but the fireball drew nearer and nearer. I stopped our vessel, but the fireball still continued to draw near. Then I dared to advance our boat toward the fireball. Nevertheless, we did not collide with the fireball. Presently the fireball diminished in size by degrees and disappeared." Harada added that the fireball was the color of live charcoal and was not accompanied by any sound. (R110)

It should be remarked that tsunamis crest only when they approach the shore and shallow water. Where Harada was---four miles at sea---the tsunami waves may have been unremarkable.

X79. Frequent occurrence since 1930s. Gurdon, Arkansas. The Gurdon Light appears along a four-mile stretch of railroad track, 1½ miles north of Gurdon. It floats 1-3 feet above the track. Observers say it is about 12 inches high and 18 inches wide. (R111)

As usual with such spooklights---and there are many that we do not catalog---the Gurdon Light has been blamed on automobile headlights, swamp gas, and even luminous quartz deposits (?). However, "all have been dismissed after extensive scientific investigations." (R112)

"The Gurdon Light sometimes fades in and out, sometimes it changes and sometimes it appears to be revolving. Rarely visible for more than 10 seconds at a time, it will often disappear when one walks toward it, only to reappear 10 feet behind! In recent years, the Gurdon Light has been captured on film a number of times. After careful analysis of the glowing images, experts remain confused as to what is causing them. While the investigators are perplexed; the locals are convinced it is a ghost." (R112)

X80. Frequent occurrence. Argyllshire, Scotland. These nocturnal lights---apparently well known in Scotland---were described by A. Lang in the Illustrated London News. Sir G. Maxwell added Lang's account in an appendix to his book In Malay Forests (R107) because he surmised that they might be identical in origin and nature to the Changkat Asah Lights that had so strongly impressed him in Malaysia. (X74).

Here is what Lang wrote about the Argyllshire Lights:

"I am well acquainted with the set of lights which are often seen by the people of Ballachulish and Glencoe, villages on the south side of the salt water Loch Leven (not Queen Mary's fresh-water Loch Leven), on the west coast of Argyllshire. They are bright lights which disport themselves on the north side of the loch, where steep hills descend to the level, and to the road along the level, leading to the head of the loch. They rush, as it were, along the road, then up the hill, then down to the water edge, and so on, and are visible not only to the Celtic natives but to the English tourist. The ground is not marshy, even on the level, and the phe-

nomenon, though doubtless natural and normal, has not yet found a scientific explanation." (R107)

X81. Frequent observation. Screven, Georgia. Here one finds another spook-light, which, like the Gurdon Light (X79) and several other nocturnal lights on file, seems to prefer haunting railroad tracks. Records go back at least to the Civil War. The Screven Light was described in the Atlanta Journal (October 29, 1982) as a: "glowing clear-white ball that floats and swings side to side along the tracks, its light often flashing bright, then dimming." (R113)

X82. Occasional occurrence. Staffordshire, England, near Old Hannah's Cave. This spot was noted for roaring noises accompanied by bluish flames issuing from a cleft in the rocks. Obviously, the phenomenon at hand is not the usual nocturnal light and, indeed, need not be nocturnal at all. We catalog it here because of its intrinsic interest and the possibility that it might masquerade as a will-o'-the-wisp or some other form of nocturnal light. (See ESC4 in Anomalies in Geology for other "natural, rapid exothermic reactions," for example, spontaneous natural-gas explosions.

We now present the testimony of two men who were alerted to Old Hannah's remarkable activity by two explosions that sounded like rifle shots.

"Realizing that no one was shooting, they looked up the cliff and witnessed an explosion which emitted a flash from a hole or fissure in the upper part of the cliff. This had a bluish column 'not of steam or fire or smoke, but apparently of aqueous vapour,' which travelled with immense force across the valley (approximately 12 m wide). Within minutes, another discharge from higher up the cliff and then 'several ones with crackling sounds producing semi-transparent wavy streaks in the air, not smokey in appearance.' Next came a very loud explosion which 'we had the good fortune to see plainly.' Wardle describes this as 'like a gun but with crackling, a series of continuous reports, cleaving the air in a zigzag or riverlike course in a narrow band about 15 cm to 20 cm broad, of bluish colour." (R114)

The supposition is that natural gases liberated by decaying organic material and, perhaps, geochemical reactions are ignited by static electricity. A landslip now seems to have extinguished this curious phenomenon. But a rather similar phenomenon has been reported in Norway. (X83)

X83. Frequent occurrence, between Bergen and Trondheim, Norway. This phenomenon was documented over a century ago and may no longer be active.

"Another very strange phenomenon, as yet unexplained, is the appearance of those lightings which dart from time to time from certain caverns in the cliffs of the Norwegian coast. Between Bergen and Trondheim, on the shores of the Jorend Fjord, rises Mount Troldjol, or the rock of wonders; from time to time, though more often when the weather is about to change, columns of flame and smoke, followed by peals of thunder, escape from a lateral fissure of this mountain. But the cavern in which these mysterious storms are developed is so difficult of access that no one has yet entered it. Nor has an attempt been made to explore another 'laboratory of tempests,' occurring in the southern of the two cliffs at the entrance to the Lyse Fjord. This perpendicular wall is 3600 feet in height, and to reach the cavern it would be necessary to descend by means of ropes more than 1000 feet in the terrible abyss. From time to time, especially during a strong east wind, a flash of lightning is seen to shoot from the black rock, which expands and contracts alternately till it is finally lost before having reached the northern cliff. The sheet of fire revolves as it advances, and it is to this rotary movement that the apparent expansions and contractions of the lightning are due." (R115)

See for comparison some claimed examples of intermountain electric discharges. (GLD2)

X84. Occasional occurrence. Bahia Kino, Mexico. On the Gulf of California. The Kino Light is decidedly different from most nocturnal lights, for it is if immense size and stationary---not at all like the small, playful flames of the typical will-o'-the-wisp or spooklight. Rather, the Kino Light is more like the wide-area electric discharge phenomena of GLD4.

B. Mack first saw the Kino Light when camping on the desert. It manifested itself as a giant blob of blue light about 150 feet wide by 25 feet high. It was seemingly "anchored" in a spot on the desert floor that was in no way different to the eye from any other part of the surrounding desert. It is said to appear sporadically on this same spot, and it never moves.

On his first contact with the Kino Light, Mack apprehensively walked straight into the diffuse, glowing blob. Nothing adverse happened. The light was very bright inside but there were no other sensations. Nor was there any obvious source of the luminosity; it was just there.

Scientists from the University of Arizona once made some tests at the spot where the Kino Light appears. They could only venture that the glow might be due to ionization of the air under certain weather conditions. In other words, the Kino Light might be an electric-discharge phenomenon. Unfortunately, the Light chose not to appear when the scientists were there.

Mack's second visit to the site drew a blank, but on the third trip he saw it once more. It was a still, sultry night. The Light began glowing about 11 P.M., reached its maximum intensity about 11:45, and disappeared after two hours. On this visit, Mack was armed with a compass and metal detector, but they registered nothing at all. Mack's photographs turned out poorly---just a tiny glow in a field of black. The bulk of the ghostly glow was evidently too faint to register on the film. (R116)

X85. Frequent occurrence. Moravia, Czechoslovakia. Early in the 1900s, a Czech scientist described the frequent appearance of unusually large numbers of extremely active nocturnal lights.

The Kino Light is said to be a stationary blue glow that one can walk right into with impunity. (X84) This is an artist's concept.

"Prof. Wenzel Horak relates that during his boyhood he often saw will-o'-the-wisps at the Advent season over the fields and meadows of his native village of Nemcitz, in Moravia. They were, in fact, familiar to every inhabitant of the village. For eight years he served as acolyte in the parish church, and on his way to early mass, with various companions, saw sometimes two or three, sometimes as many as twenty or thirty of these lights. They appeared on calm, moonless nights, in both clear and cloudy weather. Moving with great rapidity, they would sometimes rush together, at other times scatter; spring up and down; appear and disappear; and would continue their pranks until daybreak." (R117)

Such frenetic activity would not seem possible if these Czech will-o'-the-wisps were just clouds of spontaneously ignited marsh gas.

X86. Late January 1991. Borlange, Sweden. Four observers watched what seemed to be a system of luminous rings for about 15-20 minutes. The rings were estimated to be 2-5 kilometers away and 10-30 meters in size. E. Witalis has provided a translation of their report of this phenomenon which is quite unlike our other nocturnal lights. In any case, the phenomenon is passably bizarre.

"The light phenomenon, which was strongly luminous, consisted of scintillating, rotating rings arranged as a system of plates (small rings in the centre and increasingly large ones towards the edges). The rings seemed to consist of sparks running around in a circular or slightly elliptical path with an impressive speed. Spontaneously, I associated them with electrical discharges. The plate shape was felt as being in some way static as to location, and the sparks moved in a pattern without spreading out at the edges. It seemed that strong force was controlling the event. The sparks looked like having a core and a 'tail' behind. They looked like being able to crackle but no sound was heard, perhaps because of the distance. It was interesting to note that the rings were spinning in opposite directions. The effect clearly illuminated the surrounding air space. The whole light phenomenon took place with knife-sharp edges in clear weather (temperature between -1 and -3 deg. C.)" (R118)

Of course, the author is assuming that a plasma or electrical phenomenon was observed.

X87. September 29, 1991. Winchester, England. Since the apparition described below seems to have been faintly luminous, we apparently have a strange, mobile version of the Kino Light (X84); that is, a moving, large-area, electric-discharge phenomenon, perhaps something akin to some of those found in GLD4.

To set the stage, it was a wet day, but the rain had stopped and the wind velocity dropped. The 'subject' referred to is a B. Brumpton. His actual words are in single quotes, as they were passed on to writer B. Hayes:

"A high easterly breeze was blowing along New Road which runs east-west and is about 400 yards long. The subject was 30 yards from the western end facing east. He first noticed the 'object' at approximately 150 yards, at which his reaction was that he was 'seeing things'. The object 'filled the highway', so this suggests a width of eight metres or so. It was 'on the ground' and 'round-topped', suggesting to me a hemisphere. The 'object' was a 'mass of mist' and 'looked very wet'. It seemed to 'roll' toward the subject at a speed that he estimated at 30 m.p.h. However, his estimate of half-a-minute for travelling 150 yards gives a speed of 20 m.p.h. Let us not forget that time is difficult to estimate after an event.

"The object emitted a noise 'like very heavy rain pounding on the road', except that it was not raining at the time, and the subject became concerned about 'getting soaked'. Also, the 'mist' was clearly visible in spite of the darkness. This suggests the possibility that the 'object' was luminous. The observer moved into a driveway on the south side of the road, but when a few yards away 'the object moved over' to the north side and 'just vanished'." (R119)

X88. No date given. Vale of Ewyas, Wales. On a summer night, a brilliant,

pumpkin-sized ball of light circled over a marshy tract. Suddenly, gathering speed it raced across a field, swept up and over a 10-foot hedge, dropped to ground level across the next field, then up and over another hedge. (R120)

This particular nocturnal light might very well have been an owl rendered luminous by bacteria or fungi in its nesting hole. In fact, the "luminous-owl" controversy" was discussed in several science journals and magazines about a century ago. Indeed, investigations at that time did prove that luminous owls were the source of some reports of will-o'-the-wisps. For details and other examples of luminous birds, see BBA25 in Biological Anomalies: Birds.

X89. Frequent occurrence. Green River Canyon, 30 miles southeast of Seattle, Washington. Here, there is a pool of cold salty water about 6 feet in diameter. On occasion, this pool almost sinks out of sight, but then refills charged with natural gas. This gas may at times ignite spontaneously, but often someone will toss in a lighted match. Then, the eruptions become violent, sending flames 100 feet into the air. A short distance from the geyser, bubbles of gas rise directly from the stream bed. At this spot, flames may play over the surface of the water for weeks at a time. (R121)

X90. Occasional occurrence. Almost any ocean beach. Here follows a letter from S. Roman, from Melbourne, Australia, who introduces us to an unusual type of nocturnal light---one which, for a change, has a ready and interesting explanation.

"The tide was out one day as a friend and I were walking along a beach. As we walked on the littoral zone---the part of the beach between low and high tides---strange blue lights lit up around our feet as we stepped on the sand. The lights were similar to lightning and the harder we stepped on the ground the more intense the blue lights became. Nobody has been able to provide us with a satisfactory explanation and, no, we were not under the influence of any drugs. Just what was happening? (R123

These bright-blue sparks created by beach walkers turn out to be a ubiquitous but rarely mentioned sort of nocturnal light. For another example, this time from California, we quote A. Hastings:

"I also had an experience with "Sparks on the Beach" [as mentioned above]. This was on the Pacific Ocean Beach at San Gregorio, south of San Francisco, several years ago. I was walking on fairly wet sand, just above the tide line. As I stepped, the sand around my feet lit up with small bright dots of phosphorescence. I would not have said that the color was blue, but it could have been like blue-white, like the star Rigel. I found that if I stepped hard or stamped my foot, the lights flashed brighter and the lit area went out farther from my foot. I could see the movement expanding out. After a stamp or two, they did not light up as much. I assumed that this was caused by some organism that lit up when it felt pressure, and 'wore out' after it had done this a few times---a refractory period probably occurred." (R124

From E. Widder, at the Harbor Branch Oceanographic Institution in Florida, we have a good explanation these beach "sparks."

"Flashing blue lights, such as those described, are bioluminescence, which is visible light made by living organisms.

.....

"Light sources in the sand are probably bioluminescent dinoflagellates or possibly bioluminescent ostracods.

.....

"Bioluminescent ostracods, sometimes called sea fireflies, are tiny crustaceans about the size of tomato seeds, which release a cloud of bioluminescence to attract mates as well as for defence. Ostracods retain their bioluminescent chemicals when dead and light can be activated by a mechanical mixing of the chemicals [i.e., the pressure of footsteps]." (R125

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GLN2 High-Level Nocturnal Lights

Description. Stationary and moving lights, usually well above tree-top level, that cannot be correlated with known objects or phenomena. These lights may move erratically, often at great speeds and with accelerations seemingly incompatible with the characteristics of human-built vehicles. The color of the lights may vary during the observation. Radar and visual contacts are sometimes made together.

Background. The high-level nocturnal light is a classic type of UFO. Few observations of this phenomenon are to be found in the mainstream scientific literature, which is the focus of the Sourcebook Project. However, many thousands of cases exist in newspapers, UFO journals, and in the files of UFO investigators. Some of this material will be incorporated in future editions of this catalog.

Data Evaluation. High-level nocturnal lights are reported almost every day in some part of the world, as any UFO clipping service clearly demonstrates. The real question is not the existence of such lights but whether they can be correlated with known vehicles and/or physical processes. Rating: 1.

Anomaly Evaluation. If it is actually impossible to identify all high-level nocturnal lights, a major scientific anomaly must exist, for these lights seem to possess properties (accelerations, color changes, velocities, materialization and disappearance) that lie far outside the explanatory capabilities of present-day science. Rating: 1. (Note: if high-level nocturnal lights are ultimately identified as extraterrestrial vehicles, the anomalousness of the situation will decrease, because current thinking leans towards a universe teeming with other intelligent civilizations.)

Possible Explanations. Terrestrially built vehicles, including aircraft, spacecraft, missiles, and balloons; misidentified astronomical objects, such as meteors and planets; anomalous electrical discharges; ball lightning (GLB); antimatter meteorites; physiological and psychological phenomena associated with the observer; extraterrestrial vehicles; holograms.

Similar and Related Phenomena. Low-level nocturnal lights (GLN1), ball lightning (GLB), erratic meteors (AYO), enigmatic astronomical objects (AEO), unrecognized life forms (BXU), unrecognized artifacts (XSU).

Examples of High-Level Nocturnal Lights

X1. Summer 1896. Iowa. Looking out the door of the mail car on a moving train. "The darkness was intense; not a ray of light was visible from any point, except from the train. When a few miles out from Princeton, and while traveling almost due north, I observed a peculiar light low down on the western horizon. It appeared to be perfectly round and about a foot in diameter, of a dull rose color, or, possibly, like a piece of live coal. When first observed it seemed to be floating within a hundred feet of the earth, but soon rose to a height about midway between the horizon and the zenith. For a time it floated very steadily, but soon began to oscillate up and down, at times even dropping out of sight behind hills. The wind was quite strong from the east, but the light traveled in an almost due north course. Its speed varied, sometimes seeming to outrun the train considerably, and at others it would fall behind, but never far enough to be lost to sight. Most of the time it appeared to be nearly abreast of the train and apparently from half a mile to a mile distant. Soon after it was first observed by me, my companion arose, and we both watched it closely until the town of Lineville, Iowa, was reached. There it passed out of sight behind the depot, and we saw it no more." (R1)

X2. July 1952. Florida. "On one night several airmen independently observed a light approach at a very low speed, come to a halt nearly overhead, then reverse direction with no apparent turn. On two other nights, three other lights appeared in other sections of the sky, of similar appearance, but maneuvering more rapidly. They were observed for some 10 minutes by 9 airmen, including a control tower operator, an aircraft dispatcher, and two pilots from Wright Field. In the words of one of the men, 'For the next fifteen minutes, we watched this light and speculated on what it might be. It was not a sharp light like a bare bulb but more like a light shining through frosted glass. No shape of any kind was discernible. It appeared to blink, but with no regularity whatever." (R2)

X3. July 1952. New Mexico. "Our station was notified that an unconventional aircraft had been picked up with both electronic and visual contact. Our station made electronic contact with the object and two of our men and I had gone outside the building and saw it hovering under a cloud layer to the east of us. It appeared as a large light, at an uncertain distance, and was hovering at the time. A minute or so later, it moved rapidly toward the north for a short distance and stopped as suddenly as it had begun to move." (R2)

X4. 1952. No place given. "Early last month shortly before dawn colored lights were observed in the sky southeast of the radar station. At the same time and the same azimuth, unidentified targets appeared on the scope. Only a very slight temperature inversion was present, 1^{o} at 25 000 feet. No more than two lights appeared at one time. They were observed to be moving in a rather erratic pattern and changing colors occasionally. The last thirty minutes of observation revealed the lights remaining yellow---prior to that they were red, green, and blue. They moved in no apparent formation but mostly appeared in one area and disappeared in another, when either the light went out or the objects dived behind clouds. They were starlike objects and appeared to develop long, white vapor trails, when they dived. They were motionless at times and moved rapidly at other times. This corresponded to similar movements observed on the radar scope. One light went out as it changed direction and continued as a black silhouette against the dawn sky, Observation was for a period of about an hour and was made by two airmen and a radar operator---all three observers were experienced aircraft control and warning operators. Objects were observed at 20 to 40^{o} above horizon. Radar gave distances of 50 to 80 miles. This implies a height of about 40 miles. There was no air traffic on radar within 100 miles." (R2) Except for the altitude, this observation closely resembles GLN1-X31.

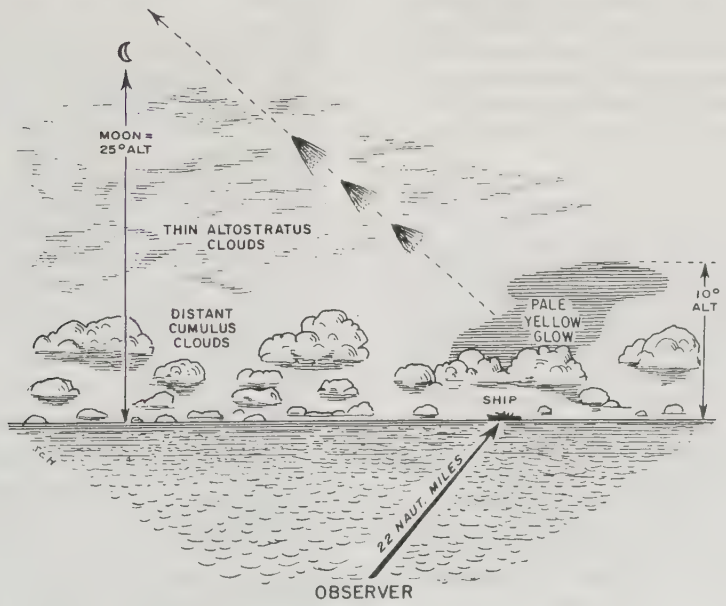
X5. No time or place given. The first observation was a series of localized light flashes in a clear, blue sky, estimated to be less than 10 miles away. Following this 3-4 second display, an off-white light 'swit-

ched on' and proceeded slowly across the sky. Apparently it traveled a straight path at an altitude of less than 10 000 feet. When viewed through binoculars, the latter light appeared as a single, spherical shape unattached to a material object. Assuming that the angular resolution of the eye is one second of arc, a solid object greater than about two feet in its largest dimensions would be resolved in the binocular field, assuming a distance of 10 miles between the observer and the object." (R3)

X6. No time or place given. "The second observation was of an off-white light that 'switched on' above a long, narrow cloud. The intensity of the light varied at a rate of about one 'blink' per second. Within a few seconds, this was accompanied by the transient 'random flash-bulb effect,' all visible in the seven-degree binocular field. Upon depressing the microphone switch of a 37.1 MHz radio, the blinking light extinguished." (R3)

X7. 1978. Ocala National Forest, Florida. "Unexplained lights in the night sky over a remote sector of Florida forest were sighted and tracked on radar at a Navy electronic center, naval personnel have confirmed. They say one light hovered in midair, then sped away after eluding computerized tracking gear." (R4) There are thousands of similar reports in newspapers and the UFO literature.

X8. April 11, 1978. North Atlantic Ocean. "At approximately 2200 GMT three cone-shaped lights as shown in the sketch emerged from a large pale-yellow glow in the sky. The lights appeared to be equally spaced and were travelling at great speed; they were brightest at the apex. Each light was observed for about one minute---the time taken to travel from the yellow glow to a point just above the layer of altostratus cloud---before fading rapidly and disappearing at an altitude just above the moon." (R5)



In 1978, a line of three cone-shaped lights was seen traveling at high speeds over the North Atlantic. (X8)

X9. March 8, 1892. Hochlanda, Sweden. Here is an old observation of lights in the sky that is of more than passing interest. According to a report in a Stockholm newspaper, on the above date, in the environs of Hochlanda:

"...there was seen, between 9 and 10 o'clock at night, in the direction of the North, to the West of the Great Bear, and pretty high up in the sky, a large star which seemed to be of the first magnitude, and which rendered itself conspicuous by its extraordinary movement. At first it advanced with great rapidity, and in a straight line, towards the East for an estimated distance of 125 yds. (!), appearing then to be oblong, and approximately 12 in. long by about a quarter of that wide, and to be of a fiery-red colour. It then returned to its first position, afterwards to move not less rapidly towards the West, to regain, after about an equal interval, its original position; subsequently rising slowly, then descending considerably below it, and finishing by recovering it. It moved principally in straight lines, with a very slight elliptical curvature, but incessantly changing colour. This agitation (or movement) continued for 10 hours, when it ceased. The phenomenon was observed by several people." (R6)

Although the above announcement suffers in translation, it is manifest that the light cannot be a meteor, and, in 1892, it can hardly be any man-made machine.

X10. 1948-1949. U.S. Southwest. The purpose of this entry is two-fold: (1) to provide a short account of the series of vivid green "meteors" that streaked across the U.S. Southwest in the 1948-1949 time frame; and (2) to inform the reader that this spate of anomalous meteors is described in more detail in Section AYO1 in our catalog The Sun and Solar System Debris.

Here follows a digest of an article that appeared in the APRO Bulletin in March 1978, in which one detects the implication that these green "meteors" might have been anomalous.

Under the recent law making most government records available to the public, B.S. Maccabee obtained the FBI's UFO file. His analyses of this file have been serialized in the APRO Bulletin, an early, but now defunct, journal for UFO enthusiasts. One of the most unsettling revelations concerns the FBI data on the notorious "green fireballs" of the 1948-1949 era. According to the verbatim transcript of the FBI record, dated January 31, 1949, File No. 65-58300, the phenomenon was concentrated over top secret facilities in the American southwest, including Los Alamos, New Mexico. Many sightings were made by highly creditable witnesses.

Briefly, the "fireballs" were a brilliant green, sometimes beginning and ending with red or orange flashes. The objects travelled mainly on an east-west line at an average speed of 27,000 miles per hour. They seemed to pass over in level flight at altitudes of six to ten miles. On two occasions vertical changes of course were noted. Size was about one-fourth the diameter of the full moon. Multiple fireballs appeared in two instances. No sound was ever noted. No debris was ever discovered. (R7)

X11. November 28, 1958. North Pacific Ocean. As observed from the S.S. Alameda.

"At 0350 G.M.T., November 28, 1958, in lat. 34°40'N., 147°08'W., on passage from Seattle, Wash., to Sidney, Australia, a bright pulsating white light in the sky was observed. The light was first observed bearing 145° altitude 30° (the same altitude as Diphida and adjacent to it). The light slowly sank vertically to the horizon taking several minutes until it became obscured by clouds at about 5° altitude. During the time it was visible, it continued to pulsate from the brightness of a first magnitude star (about as bright as Altair) to that of about third magnitude." (R8)

The large-amplitude pulsations in brightness and long duration are of most interest here.

X12. February 25, 1959. During a DC-6 flight between Bradford, Pennsylvania, and Detroit, Michigan. The lights were also seen by two other aircraft in the vicinity.

The American Airlines DC-6 was joined by three bright, whitish lights when flying over Bradford at 8,500 feet. These lights accompanied the plane for 45 minutes until it descended for a landing at Detroit. The lights were not close to the plane, but at intervals one would move in closer and then retreat to take its place in the formation. (R9)

This is a rather typical UFO report for the period and one which was well-observed by experienced pilots. There are, of course, hundreds of similar accounts of good quality on file. Consider this entry as a cross reference to an immense hoard of similar reports of high-level nocturnal lights. (R9)

The subject lights are also reminiscent of World War-II's "foo fighters" in their pacing of the DC-6. (GLB18) We intend to tackle UFO-like phenomena more directly in a future catalog.

X13. April 4, 1959. Caribbean Sea. M.V. Cumberland, enroute Curacao to Liverpool. Time: 0051 G.M.T.

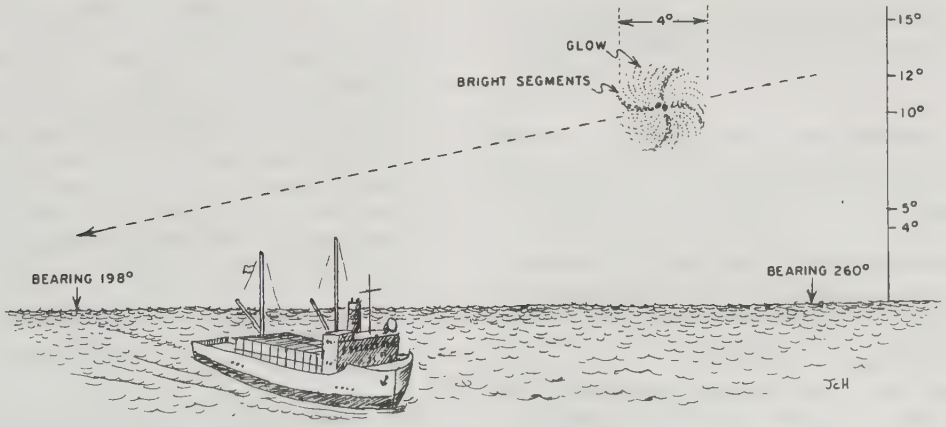
"4 stationary pale white lights at 50-60° alt., bearing 140°, evenly spaced in straight line. '...appeared roughly circular or elliptical and remained in formation and stationary for about a minute. Then the lowest one moved slowly away from the others toward the horizon. Object gained speed, passed behind cloud at 10° alt., brilliant blue-white flash from behind cloud lit most of E horizon. Light with slight red color then seen falling slowly behind cloud; light now very bright. Then disappeared just above horizon. Remaining 3 lights then maneuvered in formation, bunched together into cigar shape and faded in size, disappearing at 0054 G.M.T." (R10)

If it were not for the "maneuvers" and multiplicity of these lights, they could be readily ascribed to U.S. rocket tests.

X14. February 25, 1964. North Atlantic Ocean. Report from the M.V. Corinaldo enroute Montevideo to Vigo.

"Body in sky emitting a glow, 12°+ alt., bearing 260°. Through binoculars, 2 or more bright white lights at center and pinwheel-like glow with radius about 2°, with several curved brighter segments. Body was in motion, reaching 13°+ alt. at 2044 G.M.T., disappearing at 2048 G.M.T. at 4° alt., bearing 198°." (R10)

Actually, the pinwheel pattern, which doubtless seems anomalous to those unfamiliar with the pyrotechnics of rocket launches, could very well indicate a missile test. Rocket launches and their stage separations give rise to unusual,



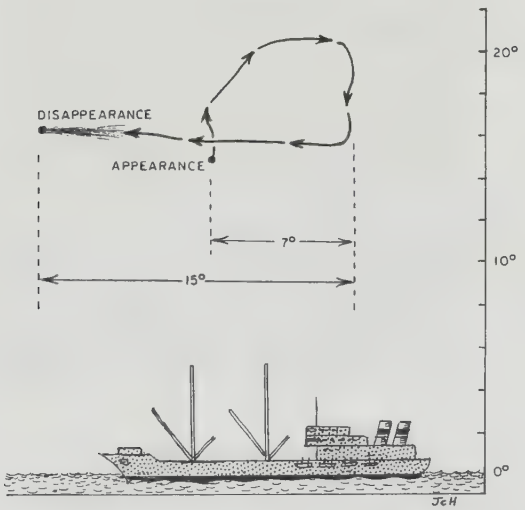
A pinwheel-like luminous phenomenon was observed over the North Atlantic in 1964. (X14)

sometimes spectacular, visual displays down range.

X15. February 16, 1967. Caribbean Sea. Observed from the R.M.S. Carmania. Time: 0621 G.M.T.

"Bright white circular object, approx. minus-one magnitude at brightest, appeared bearing 70° rose to 20° leaving comet-like tail, circled & disappeared to N; tail dispersed leaving thin 'clouds.' Same phenomenon repeated at 0721, 0821, & 0921 G.M.T." (R10)

Without question, it is the precise repetition of this phenomenon that makes it interesting. Otherwise, one would just write it off as a missile test.



Caribbean Sea, 1967. A bright circular object traveled an erratic course. (X15)

X16. October 4, 1967. North Atlantic Ocean, off New York. S.S. Alaunia, enroute London to New York. Time: 2320 G.M.T.

"Two bright-white or silvery patches of light bearing 240° (i.e., WSW toward coast) alt. 3°, each about size of full moon. Faded, brightened, changed shape (ovals, bands, & irregular patches) for 30 mins. but maintained same position. Appeared uninfluenced by wind; no echoes on radar." (R10)

This phenomenon could also be connected with NASA or military activities.

X17. May 13, 1960. Caribbean Sea. "At 0930 G.M.T. May 13, 1960 in lat. 17°50' N., long. 76°15' W., two large bright unidentified objects were observed. They appeared bearing 70°, altitude 40°. Both were bright white in color with long smoky luminous trails. One was 2° higher than the other and appeared to rise sharply to the right a disappeared. The other continued on a course of W by S gradually fading until 0945 G.M.T. when it disappeared completely at an altitude of 30° bearing 75°. The latter object was observed to have a quick-flashing red light 1° directly below it throughout this period." (R11)

Another missile test perhaps? It is hard to separate them from natural phenomena without examining rocket-launch schedules. We have tried to select a few that might not be the latter. In the forgoing case, the flashing red light is suspicious.

X18. September 21, 1961. North Pacific Ocean. The following report was from the S.S. Iberville.

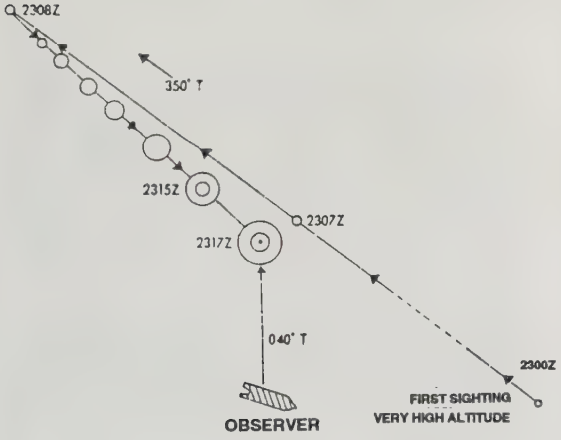
"At 1700 G.M.T. on September 21, 1961, while in lat. 31°30'N., long. 175°30' E., a few minutes before morning twilight, a white opaque mass about twice the size of the full moon appeared in the northwest at an elevation of about 20°. It continued to climb toward the zenith and at about an elevation of 40°, the mass opened gradually to appear as a huge halo with a satellite in the center having very nearly the brightness of a first-magnitude star." (R12)

The phenomenon faded away after 8-10 minutes.

X19. October 16, 1976. Aboard the m.t. Farnelia on the Barents Sea fishing grounds.

"At 2307 GMT while I was visiting the wheelhouse, the Skipper pointed out to me an object flying across the sky. It had already been in view for some five minutes or more and was first observed on a bearing of 140°T heading due North. I first sighted it on a bearing of 050°T.

"Observation was constantly kept by myself and the Skipper with the aid of binoculars from the time I first sighted the object. It could be described as being a brilliant light travelling at a very high altitude, leaving a bright V-shaped trail of rays which could be likened to the sun's rays as they would appear from behind a cloud. However, they were very much smaller due to the height and were also horizontal. The object followed a course from south to north to be astern of us at 2308. It then commenced to come back along its course while losing altitude. I would point out here that there was no visual evidence of the object actually turning back but rather as though it had been put into reverse.



Barents Sea, 1976. A carefully observed luminous object seemed to reverse its course. (X19)

"The appearance and shape of the object was now changed, becoming totally circular in shape, still losing height and coming closer. The outer edge of the circle I would describe as glowing and

At 2315Z, the Barents Sea object consisted of a brilliant, pulsating light surrounded by a luminous halo. (X19)

within that was another circular object, more intense, and within that was a brilliant pulsating white light as when the object was first sighted. The object reached its closest point to us by 2317 on a bearing of 040°T.

"The object stayed in this position for approx. two minutes and then vanished within the outer glow, this glow finally fading from our sight also. At 2320 nothing was left to be seen of either the object or the glow.

"I have tried to reproduce what the Skipper and I saw in sketch form. The object was also seen by several other vessels who were fishing in the area with us. The night was fine with a small amount of low cloud, a quarter moon and an average number of stars. Position of ship: 69° 56'N, 33° 46'E." (R13)

Unlike so many of the preceding entries, this sighting in the far north is difficult to write off as just another missile test.

X20. January 17, 1980. Santiago, Chile. F. Noel is an astronomer at the National Astronomical Observatory located on the outskirts of Santiago. He is a veteran of hundreds of nights of stellar observations over almost 30 years. In a 1993 number of the Journal of Scientific Exploration, he reported some of his more perplexing observations of nocturnal lights in the Chilean skies, one of which is recounted below:

"At approximately 22:30 local time on January 17, 1980, I was in front of my

home in the eastern suburbs of Santiago de Chile. The sky was cloudless, although there was some smog, especially in the west in the direction of downtown. Sunset had occurred at 20:55 local time.

"At that time I observed a point-shaped luminous object at an elevation of about 20 degrees; it was moving at a rather slow angular velocity from southwest to west approximately. No noise was heard and it looked like an artificial satellite, except for the direction of its motion. Its brightness, color and angular velocity reminded me of the old Echo artificial satellite from the 1960s. The object disappeared from sight during the few seconds it took me to call two persons to participate in the observation. It was not apparent how the object had disappeared from view since there were no sources of obscuration evident. Having become puzzled by this observation I continued watching that same region of sky from time to time.

"About fifteen minutes later (22:45 local time) and more or less in the same region where the bright light had been observed I spotted a faint luminous object moving slowly toward the zenith. During the first few seconds of observation it had the appearance of a luminous thread, oriented perpendicular to its direction of motion. However, as it approached the zenith, I could see that it was in fact a group of at least 30 lights distributed in a broad, symmetrical V-configuration, reminiscent of a boomerang. Three members of my family who were with me also observed the group of lights.

"Each individual light of the group looked like a star of third or fourth magnitude; the color was a pale white similar to a neon light, with a slight tint of yellow. The brightness was rather steady, with no apparent flicker. The angular width of the group was about 4 degrees, and the central angle of the V was about 150 degrees. It was first visible about 20 degrees above the western horizon and disappeared at about that altitude in the east. The disappearance was gradual, probably as a result of atmospheric extinction. Since the group was in view for approximately two minutes, the mean angular velocity must have been a bit more than one degree per second. All these estimates are approximate of course. No noise was heard during the observation." (R14)

Noel added that the lights maintained a rigid V-formation. He ruled out birds as the source of the phenomenon. Given the experience of Noel and his geographical location, it is difficult to dismiss this fascinating sighting as a rocket launch or artificial satellite.

X21. March 13, 1989. North Pacific Ocean. Observations from the Nostra Lin, enroute Coos Bay to Brisbane.

"At about 1632 G.M.T. a group of at least six very bright lights of a basically orange/white colour were seen, bearing 235°. The lights dimmed momentarily, then reappeared equally as bright but in different positions. Then, the tail of an object was seen heading away from the group. On first glance, the initial assumption was that the phenomenon was flares or a group of aircraft lights or something else. See point A on sketch.

[Sketch not reproduced because this event is almost certainly a spacecraft reentry and not an anomalous natural phenomenon.]

"Following this, two very bright objects were seen heading across the sky close together. Each had a distinct, solid head followed by a very white tail, and the two bodies were separated by about 1° of arc. See point B. When the second object reached a bearing of 335° (point C), there was a sudden, very bright green/blue flash from its head and the whole thing disappeared, its tail also fading quickly. At a bearing of 350° (point D), a similar ending befell the leading object, which, through binoculars, appeared to disintegrate with small pieces falling away after the flash." (R15)

The entire sequence related above occupied 15-20 seconds of time. By way of explanation, one authority suggested that the phenomenon was the reentry and disintegration of an artificial satellite---possibly the Soviet Cosmos 1813.

We post this observation as a possible anomalous natural phenomenon, but it is certainly possible that it could have been the reentry of a spacecraft. One would have to check the old re-

entry records. Call this another cautionary tale!

X22. January 14, 1993. Eastern North Pacific. From the m.v. B.P. Adventure, enroute Panama to Chiba.

"At 0235 UTC the phenomenon shown in the sketch was first seen about 15° above the horizon, bearing 265°. It was initially thought to be a downward-pointing spotlight from an aircraft: it was bright (nearly white), conical in shape and about 1° high. During further observation the shape slowly enlarged, becoming more bell-shaped with a darker elliptical patch at the bottom. As it increased in size, the shape faded away and moved slowly towards the horizon in a slightly southerly direction before disappearing just above the horizon at 0254, bearing 260°.

"The maximum height reached by the shape was about 5° and throughout the observation stars could be seen through it, while at one point it was nearly obscured by cloud of which there was 1 okta. The only other bright object nearby was Venus, being slightly higher and to the south, bearing 248°, elevation about 20°. Visibility was excellent as about 10 minutes after the observation a ship was spotted bearing 280° at a distance of 16 n.mile. The observers felt that the shape was too regular to be a cloud and had no real idea of its origins. (R16)

X23. November 20, 1995. North Atlantic. As observed from the m.v. Uruguay Express enroute Santos to Bilboa.

"At 0230 UTC a very bright light was noted on the port side about 50° from the bow, it lasted for about 5 seconds and then disappeared.

"Knowing of no bright star in that position, the observers checked the area with binoculars and saw two small lights which were as bright as a star of very small magnitude, travelling at a very fast rate and at a steady distance from each other. No navigation lights were seen. One light then disappeared and the other changed course upwards before disappearing about 3 seconds later, neither object left a trail." (R17)

Visibility was good. The vessel was about 200 miles south of the Cape Verde Islands.

This is one more maddening, elusive, UFO-like sighting, of which there are many from similarly reliable sources. One wonders what caused the initial "very bright light." (Note: stars with lower magnitudes are brighter, the very brightest even bear negative magnitudes.)

X24. August 21, 1996. Sarpy County, Nebraska. 1,800 miles/second! That's 6,480,000 miles/hour! This speedy luminous phenomenon was captured on video tape by D. Morss and P. McCrone. These researchers were monitoring the top of a thunderstorm with low-light, high-speed video equipment, when the ball of light "popped out" of the top of a thundercloud and flashed across their instrument's field of view in 1/10 of a second. Nevertheless, it was caught on six video frames. Morss commented as follows:

"It's something that you're going to have to scratch your head and think, 'What kind of phenomenon could form this kind of light?'

.....

"It's got to be some kind of trapped charge that popped out of the top of a thunderstorm." (R18)

Perhaps that 1,800-miles-per second figure should really be 1,800 miles per hour? This velocity would be comparable with that of another very speedy "ball of light" seen under similar conditions. See X25. Both X24 and X25 may be related to conditions that give rise to sprites, elves, and other electric-discharge phenomena long-seen above thunderclouds but only acknowledged by mainstream science as "real" phenomena since about 1990. See GLL1.

X25. May 25, 1997. Near Loco, Oklahoma. In what might be called a "video replay" of the phenomenon described in X24, L. Lamphere caught a similar fast-moving "object" near a tornado-spawning storm. He and his team had a digital video

camera trained on the storm and were taking time-lapse, still photos. Lamphere reported:

"The ceiling was maybe 900 feet. We were about four or five miles from the storm, which was tracking southeast. The object was well-defined and well-lit, but was obscured briefly by scud clouds. It dipped and bobbled in its trajectory before it flew into a storm known to contain hail the size of baseballs and then reemerged, apparently undamged.

"Scientists at the Astrophysics Department at the University of Oklahoma believe the object was solid and may have been traveling between 9,000 and 20,000 mph." (R19)

Just one high-speed "object" might be dismissed as, say, a photographic artifact. But, when two are caught by cameras imaging violent meteorological events, we must conclude that something unusual is going on.

X26. May 4, North Atlantic Ocean. Aboard the s.t.s. Astrid enroute from the Azores to Dartmouth.

"At 0443 UTC a light was sighted high in the sky above the ship. The light was of the style of a satellite in appearance. However, it was seen for about 10-15 seconds moving west to northwest, with a pulsating white light. In addition, it was moving very fast and it also stopped dead a couple of times.

"At one point, the light stopped and turned in the direction of the ship. The light no longer pulsated, and for about one second it was in the form of a spotlight lighting the surrounding area. The light then turned back again and moved very, very fast across the sky before it was lost below the horizon in a matter of seconds." (R20)

The erratic motion of the object and the apparent use of a searchlight are typical of some of the UFO reports seen in popular publications. However, the Marine Observer has sound scientific credentials. It is issued by the UK Meteorological Office.

In the above "encounter," aircraft, satellites, and meteors do not fit the testimony of the observers.

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GLW MARINE PHOSPHORESCENT DISPLAYS

Key to Phenomena

GLW0 Introduction

Ships that ply the Indian Ocean, particularly the waters leading to the oil-sodden lands around the Persian Gulf, frequently encounter dazzling phosphorescent seas. As Kipling described it, the ship's wake is "a welt of light that holds the hot sky tame." Huge globes of light rise from the depths and burst on the surface. Wavetops sparkle, porpoises resemble luminous torpedoes, and broad geometrically precise corridors of light stretch from horizon to horizon. Buckets lowered into these glowing seas prove that marine organisms seem to cause most of the phosphorescent displays.

Phosphorescent ship wakes are mundane and unimpressive compared to the vast rotating wheels of light and the other fantastic luminescent displays encountered from the Persian Gulf, across the Indian Ocean, and into the South China Sea. Ridiculed as wild sailors' tales for centuries, modern ships have reported scores of bona fide geometrical displays. Mariners tell of great spoke-like bands of light seemingly spinning about some distant hub. Occasionally several wheels will overlap, while simultaneously turning in clockwise or counterclockwise senses, creating a vast tableau of moving spokes miles wide. Expanding rings of light and bright whirling crescents (the latter radar-stimulated) may also decorate the ocean surface.. Crews that see these fantastic apparitions do not soon forget them. Scientists, alas, have generally ignored these awe-inspiring apparitions.

One's first reaction is to explain the wheels of light and related geometrical displays in terms of marine bioluminescence stimulated by natural forces that, like the wake of a ship, leave behind glowing evidence of their passage. Sound waves emanating from submarine disturbances have been the most popular type of disturbance in this explanation. But what combination of seismic waves could stimulate overlapping, counterrotating wheels or hundreds of spinning phosphorescent crescents? Furthermore, there are several well-attested cases where the luminous displays were seen in the air well above the sea's surface. This fact plus the persistence of the phenomena (about half an hour) and the complex nature of the displays suggest that we look for other stimuli and nonbiological sources of light.

The physical forces that create the auroras and the Andes Glow may be at work near the ocean's surface, unlikely as it may seem. To illustrate this possibility, the luminous mist seen during some low-level auroras closely resembles the aerial phosphorescence seen in some marine displays. Some ship captains have, in fact, noted the similarities between auroral and marine phosphorescent displays. The curious interaction of radar with marine phosphorescence is also suggestive. Another potential explanation would use the collective behavior of marine bioluminescent organisms. Travelers in the tropics, for example, tell amazing accounts of the synchronized flashing of immense assemblages of fireflies. Could marine bioluminescent organisms indulge in similar cooperative action? If so, how do they communicate pattern geometries and why?

Many other questions can be asked about marine phosphorescent displays. Why are most concentrated in the Indian Ocean and South China Sea when other seas also teem with bioluminescent organisms? Where does the mysterious underwater lightning called te lape by the Polynesians fit in? Unfortunately only a few scientists have deigned to notice this fertile field of research.

GLW1 Long, Parallel, Stationary Phosphorescent Bands

Description. Horizon-to-horizon bands of bright phosphorescence in single or parallel array. The bands may vary from a few feet to a half mile in width. The phosphorescence may be steady or broken up into flashing patches. Blue and green are common colors.

Background. The wide bands of constant brightness might be a different phenomenon than the narrow strips of pulsing patches.

Data Evaluation. Several excellent descriptions exist. Rating: 1.

Anomaly Evaluation. Assuming the light is biological in origin, the geometry and large-scale organization of the display must be explained. In this instance, oceanic internal waves provide a reasonable mechanism for stimulating bioluminescence in long, straight lines where they intersect the surface. Rating: 3.

Possible Explanations. Stimulation of bioluminescence by internal waves---especially in the case of the broad lanes of constant brightness. The periodic switching on and off of the bright patches may be influenced by the ship's engines.

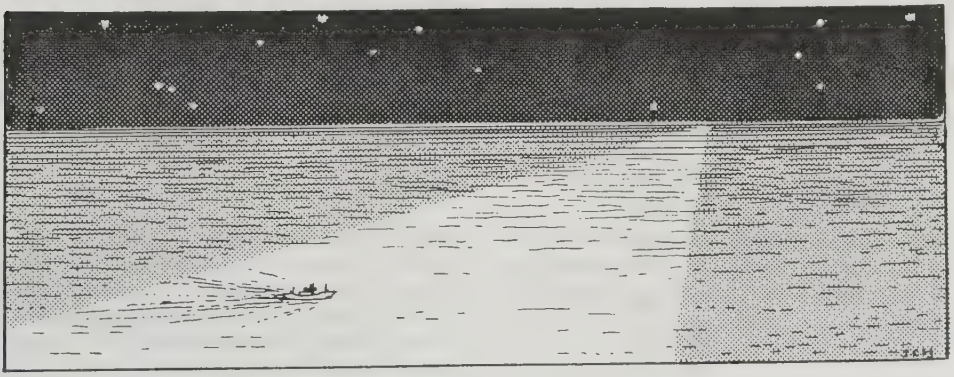
Similar and Related Phenomena. Moving bands of phosphorescence (GLW2), the milky sea (GLW9),

Examples of Long, Parallel, Stationary, Phosphorescent Bands

X1. November 24, 1908. Gulf of Mexico. "A remarkable marine phenomenon was observed by the steamship Dover, Capt. Yon A. Carlson, as that vessel steamed to Tampa from Mobile. When at a point 35 miles from Mobile light, at 7 o'clock in the evening of the 24th, the ship ran suddenly in a streak of light coming from the water which alternated blue and green, the colors being so brilliant that the vessel was lighted up as if she were covered with arc lights with colored globes. A half mile streak of dark water, and a blackness that settled like a pall over the ship followed, and a second streak of the same brilliant-hued waters was encountered. The second streak was about as wide as the first one, and when the ship ran out of it the same black waters and a night of exceptional blackness were also encountered.... Each of the streaks and the intermediate streak of black water was about half a mile wide." (R1)

X2. May 30, 1926. Arabian Sea. "On May 30th, about 1 a. m. when standing to N'd between Quoin Is. and Larak I. in about Latitude 26° 40' N., Longitude 56° 33' E., passed through a phenomenal, scintillating, phosphorescent belt of water. It was first sighted as a line of phosphorescent water stretching across the horizon ahead from east to west. As the ship approached the area, it presented a curious scintillating effect. On passing through it, it was found to be a belt about half a mile in width extending to the horizon in an east and west direction. The effect at close quarters was as though thousands of powerful beams of light directed upwards from under water, each illuminating a patch of some twenty to thirty square yards of sea surface, were being switched on and off alternately, independently of each other. If any one of these patches were watched, the intervals of light and darkness were found to be of surprising regularity about 1 to 1 1/2 seconds. The belt gradually receded astern and the display continued until it was lost over the horizon to the southward." (R2)

X3. February 19, 1968. Bismarck Sea. "At 1756 GMT, when 7 1/2 miles off Cape Gordon, a line of bright pulsating patches was observed 2 miles away on the starboard bow. Each patch was about 35 feet long and pear-shaped, flashing in unison every 1/2 sec. The engine revs. were 112 per min and the radar was not switched on. The patches became brighter as the ship approached them and the radar was switched on without producing an effect. The ship did not cut through any patches and another line of them was



Gulf of Mexico, 1908. A vessel crosses one of two wide, parallel bands of bioluminescence. (X1)

seen off to port in about the same line as the starboard one, possibly marking the edge of a local current." (R3)

X4. July 5, 1926. South Atlantic Ocean. Five bands stretching as far as the eye could see. The bright bands seemed to make the sea thick and sluggish. (R4)

X5. April 24, 1928. China Sea. Six parallel streaks. The phosphorescent regions presented an oily appearance. (R4)

X6. November 9, 1955. South African Waters. Four long streaks of bright blue phosphorescence. (R5)

X7. December 21, 1958. New Zealand waters. Strong lines of phosphorescence 4 feet wide, running east and west. A nauseating stench accompanied the display. (R6)

X8. August 3, 1929. Indian Ocean. Band of phosphorescence 1/4 mile wide. No other phosphorescence noted. (R7)

X9. January 10, 1953. Gulf of Aden. "The ship passed through several bands of brilliant phosphorescence, each band approximately 1/2 to 3/4 mile wide (edges not well-defined) and about 2 1/2 miles between each band. A glow in the sky could be seen before the bands were visible, which were continually flashing with pinpoints of light, and stretched from horizon to horizon in a 120°-300° direction. At 2307 the vessel passed through a band about 20 ft wide of exceptional brilliance (a steady not a flashing light), which temporarily illuminated the whole ship like a greenish-blue searchlight. The band had sharply defined edges and curved slightly from horizon to horizon resembling a tide line, although no floating debris was visible. The glow from this band could be seen for about 6 miles." (R8)

X10. 1880. Indian Ocean. A river of silvery white light in the sea, 1/4 mile wide. The water was full of tiny phosphorescent fish. (R9)

X11. July 8, 1977. North Atlantic Ocean. "At 2230 GMT the vessel passed through parallel bands of bioluminescence which were approximately 65 centimetres wide with a distance of about 8 metres between each band; owing to the darkness it was not possible to determine the length of the bands. Each band lay along the direction of the wind which, at that time, was SW'ly. The phenomenon was observed for 12 minutes and it was interesting to note that throughout this time the calls of seabirds could be heard and once or twice they were observed in the glow from the navigation lights. At no other time during the night were these birds heard or observed." (R10)

R12. August 23, 1977. South Atlantic Ocean. "At 0330 GMT in a position 35 n. mile southwest of the Fernando de Noronha Archipelago the vessel entered a large area of bioluminescence; it took the form mainly of parallel bands, but there were also some patches of white water and some rapid flashes on the sea surface. The bands were about 200 metres apart and they appeared to be about 5 n. mile in length and about 4 metres in width. They seemed to be moving with the wind in a north-westerly direction. The size of the individual luminous flashes varied in diameter from 15-60 centimetres. A sample of the water was taken and its temperature was found to be 26°C. The glow from the bioluminescence was considerable, so much so that it was not necessary to switch on a torch to examine the sample of the sea-water taken. The phenomenon was chiefly white in colour but there were emerald-green patches on the parallel bands and in the wake of the vessel. The vessel steamed about 40 n. mile before clearing the area of bioluminescence." (R10)

X13. December 29, 1929. Off Cape Verde, North Atlantic Ocean. (R11)

X14. November 1925. North Atlantic Ocean, near Cuba. As observed from the U.S. Navy aircraft tender Patoka. The vessel encountered a luminous band about 6 miles wide that extended as far as the eye could see in a north-south direction. The band was so bright that a newspaper could be read on deck by its light. The delineation between the phosphorescent band and normal

dark sea was distinct and sharp. (R12)

Assuming that the light in the above band is produced by bioluminescent organisms, it is difficult to imagine an oceanic disturbance or any other phenomena that would cause so many creatures to emit light so steadily in such a massive, sharply marked band.

X15. September. No further time data given. Seen from a sailboat on a foggy night while cruising along the California coast from Morro Bay to Santa Barbara.

The vessel first encountered a band of bright water running east-west perpendicular to its course. Due to the fog the length of the band could not be determined.

"It was as though there were a broad source of light well under water. As measured in reference to our boat's length, the band was at least 50 feet wide, and its ends stretched off beyond our visibility. The light seemed bright enough to be able to read by it. The edges of the band between light and dark were clear-cut, and there was no apparent change in the sea motion as we crossed it.

"The first mysterious band slowly dimmed behind us as it passed into the fog, and then another band appeared ahead. During the next two hours we crossed many successive bands. They were never perfectly regular, sometimes having a curve or jog in the general length visible to us. Even later when fog lifted slightly we could not see the ends. However, the transition from dark sea to glowing light always was delineated." (R13)

Calculations made later proved that the vessel had passed through 15 miles of parallel bands, each about 20 yards wide and separated by a few hundred yards from its neighbors. (R13)

California waters are generally quite chilly, and it is surprising to learn of such a spectacular luminous display in this region of the Pacific. Figuring ten bands per mile gives us a total of 150 parallel bands. Such a large number is hard to pin on the action of packets of internal waves or any other recognized marine disturbance..

X16. August 28, 1981. South Atlantic Ocean. Aboard the m.v. Erskine Bridge enroute Hampton Roads to Richards Bay. Blue-green luminous bands observed; 3-5 meters wide, around 200 meters long. The vessel's wake was bright blue and visible for up to 2 miles of length. Individual bioluminescent organisms seemed to be about 3 centimeters in size. However, water samples displayed no bioluminescence when stirred. (R14)

X17. June 5, 1995. North Pacific Ocean. East China Sea. Observations from the m.v. Tokyo Bay enroute Busan to Kaohsiung.

"At 1830 UTC whilst the ship was on a course of 218° at 21.5 knots, what seemed to be hundreds of fishing lights were seen right ahead of the ship and stretching from horizon to horizon. As the ship approached them, it became apparent that the lights were bioluminescence.

"The appearance was like large single 'blobs' approximately the size of tennis balls, while at the main concentration the water seemed to be 'bubbling up' in a line stretching to both horizons. When the ship passed through the line, the luminescence gave off such a glare, as bright as daylight, that it was possible to read the identification numbers of the containers on the focsle. The duration of the phenomenon was about 5 minutes or 1.5 n.mile." (R15)

P.J. Herring, of the Southampton Oceanography Centre, called this display "a most unusual account which I am unable to interpret." He opined that the blobs were probably cylindrical colonies of luminous sea squirts, but he could not account for the 1.5-mile-wide, horizon-to-horizon bright glare and associated bubbling. (R15)

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GLW2 Moving, Parallel Bands of Phosphorescence

Description. Long, parallel bars or ripples of light moving swiftly across the sea, usually at speeds of 60-100 miles per hour. The luminous bands are generally 10-30 feet in breadth, separated by about the same distance, and anywhere from a few feet in length to several miles. Large variations exist in all dimensions. In one type of display, the bands come first from one direction for about 15 minutes, then cease for several minutes, and conclude with another 15 minutes of bands from a different direction. In other occurrences, the direction changes frequently. The parallel bands often precede and follow the wheel type of display (GLW4).

Background. As in the case of stationary bands (GLW1), two distinct phenomena may exist here: (1) the common, very rapid bands; and (2) the rare, slowly moving variety, exemplified by GLW2-X2. It is also possible that the fast bands are merely manifestations of a distant wheel-type display, one so far away that the spokes seem parallel.

Data Evaluation. This phenomenon is rather variable, but many excellent observations are on file. Rating: 1.

Anomaly Evaluation. The stimulus and mechanism for generating the bands, maintaining their geometry, and effecting apparent motion are all unknown. Rating: 2.

Possible Explanations. It is generally assumed that the luminous bands owe their existence to bioluminescent organisms, although there is even some doubt here (GLW3). The illusion of high-speed bands is probably created by sequentially pulsing groups of luminous organisms; something akin to the moving patterns on a theater marquee. Just what initiates this cooperative biological action is a mystery, but some suspect the ship's radar or engine noise. It is interesting to note in this context that tropical fireflies put on spectacular rhymthmic displays (BIB). Electromagnetic stimuli should not be ruled out. Slowly moving internal waves.

Similar and Related Phenomena. Phosphorescent wheels and other geometries (GLW); synchronously flashing fireflies (BIB); ground-level, electrified, luminous patches (GLD4). luminous fogs (GLA21) which occasionally exhibits a wave-like structure.

Examples of Moving, Parallel Bands

X1. April 11, 1870. Gulf of Siam. "On both sides obliquely in front of us, long white waves of light were seen floating toward the ship, increasing in brightness and rapidity till at last they almost disappeared, and nothing was observed but a white lustreless, whirling (schwirrendes) light upon the water. After gazing for some time it was impossible to distinguish between water, sky, and atmosphere, all which were but just now clearly distinguishable, and a thick fog in long streaks appeared to be driving upon the ship with furious swiftness. The phenomenon of light was somewhat similar to that which would be produced by the whirling round of a ball striped black and white so rapidly that the white stripes seem to be lost and blended with the dark ones. The light was just as if we were enveloped in a thick white fog. The direction of the waves of light upon the ship was always on both sides obliquely from the front. The phenomenon lasted about five minutes and repeated itself once more afterwards for about two minutes." (R1)

X2. 1883. Greenland waters. "We saw suddenly behind the vessel on the surface of the sea a broad but clearly defined band of light. It shone with a steady, yellowish light, somewhat like that of phosphorescent elements, while, in spite of the speed maintained, viz, four to six knots, the band came nearer and nearer. When it reached the ship it seemed as if we were steaming through a sea of fire or molten metal. After a while the light traveled beyond the vessel, and we saw it at last disappear on the horizon.... It was beyond doubt of a different nature to the bluish-white phosphorescent light, which throughout its appearance was seen distinctly in our wake; and as the light was perfectly steady it cannot have been caused by the phosphoresence from a passing shoal of fish." (R2)

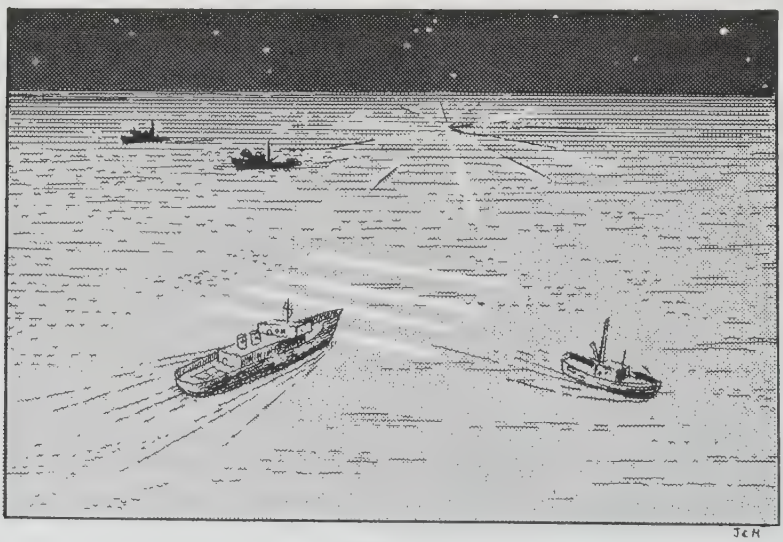
X3. Circa 1906. Gulf of Oman. "When we got to within twenty yards of the whitish water I saw it break into life and light---shafts of brilliant light came sweeping across the ship's bow at a prodigious speed, which might be put down as anything between sixty and two hundred miles an hour. Then we steamed into the light, and the effect was weird to a degree. It was just as if a large gun with a rectangular muzzle were shooting bars of light at us from infinity. These bars of light were about twenty feet apart and most regular; their brilliancy was dazzling. They first struck us on our broadside, and I noticed on our leeside that an intervening ship had no effect on the light beams; they started away from the leeside of the ship just as if they had traveled right through it. The direction from which the light bars came gradually veered round the whole compass. After a quarter of an hour of this harmless bombardment we ran into the night's ordinary darkness. But in another five minutes we were again attacked by the light bars, now traveling in a direction the exact opposite of the ship's course. This second attack lasted for about five minutes, and then the entertainment was over for the night. It was impossible to say whether the light bars travelled through the water or on its surface. I collected a bucketful of the water and examined it under the microscope, but could not detect anything abnormal." (R3)

X4. August 8, 1950. Arabian Sea. "The sea was wholly covered with bright, flashing, closely spaced patches of phosphorescence. They took the form of circles about 30 ft. in diameter and oblongs 30 ft. by 10 ft. The patches 'flashed' alternately and gave the appearance of the whole sea shimmering with lines of light running criss-cross in all directions. (R4)

X5. October 23, 1954. Java Sea. "Numerous closely-spaced patches of phosphorescence, about 3 ft in diameter, were observed extending all around the ship to a distance of at leat 1/4 mile. Each patch appeared to

flash regularly at 1/2-sec intervals. After 30 min the patches slowly increased in brilliance and bands of light were seen continuously during the subsequent 15 min, appearing as straight lines except for one short period when the seemed to radiate from a position approximately two points abaft the port beam, although no definite centre could be seen. For most of the time the bands appeared to come from no definite direction, but were continually changing, staying in one direction for only short periods, and never coming from more than one point at a time. In the observer's opinion the bands consisted of closely packed illuminated areas; they had the same frequency as the flashing of the separate patches, which remained visible throughout. The observer considers that the apparent motion was caused by the illumination of alternate bands." (R5)

X6. September 27, 1959. East Indian Archipelago. "The first indication of anything unusual was the appearance of white caps on the sea here and there, which made me think that the wind had freshened, but I could feel that this was not so. Then flashing beams appeared over the water, which made the Officer on watch think that the fishing boats were using powerful flashlights. These beams of light became more intense and appeared absolutely parallel, about 8 ft wide, and could be seen coming from right ahead at about 1/2 sec intervals. At this time, I thought I could hear a swish as they passed, but decided that this was imagination. They did not appear like rings or arcs of a circle, unless it was a circle so big as to make them appear as straight lines. It was like the pedestrian's angle of a huge zebra crossing passing under him whilst he is standing still. While this part of the phenomenon was at its height it looked as if huge seas were dashing towards the vessel, and the sea surface appeared to be boiling, but it was more or less normal around a fishing vessel which we passed fairly close. The lights of various fishing vessels were visible through the beams of light, though dimmed by the brightness of the latter. The character of the flashes changed and took on the appearance of beams from a lighthouse situated about two miles on the starboard bow, or as if the centre of a giant wheel was somewhere on the starboard bow with the beams as its spokes. As



High-speed bars of light were observed in 1959 in the East Indian Archipelago. A rotating phosphorescent wheel (GLW4) can be seen in the distance. (X6)

the beams from the wheel on the starboard bow weakened, the same pattern appeared on the port bow at the same distance and regularity. The wheel on the starboard bow revolved anticlockwise and the one on the port bow revolved clockwise, i.e. both wheels were revolving towards the ship. The wheel on the starboard bow diminished as the one on the port bow increased; when the latter was at its peak the one on the starboard bow had disappeared. The next change was that the beams appeared to be travelling in the exact course of the ship, like a following sea, i.e. the beams now seen were a reversal of those seen at first." (R6)

X7. April 1875. Gulf of Mexico. A line of light appeared on the horizon and swept past the ship in a series of luminous pulsations. (R7)
X8. April 4, 1901. Persian Gulf. Two luminous bands per second. Speed about 60 miles per second. First from one direction, then reversed. (R8, R9)
X9. April 9, 1901. Persian Gulf. Like GLW2-X8. Bands 50 feet wide. (R8)
X10. 1905. Indian Ocean. Flashes of light passed over the sea. (R10)
X11. October 27, 1924. Sunda Straits. Bands passed at the rate of two per second. Kept changing direction. (R11)
X12. March 21, 1925. Off the West Coast of India. Bands about one second apart. Anticlockwise light wheel followed. (R12)
X13. November 1, 1926. Gulf of Siam. Bands 5 feet wide, 12-16 feet apart. (R13)
X14. November 19, 1928. China Sea. Three waves of light per second for 15 minutes, then changed direction. (R14)
X15. November 19, 1930. Gulf of Oman. (R15)
X16. May 21, 1936. Gulf of Siam. Two bands per second. Duration: 30 minutes. (R16)
X17. November 9, 1953. China Sea. Long, straight, greyish bands passed at the rate of 3 per second for 15 minutes, then 25 minutes of darkness, then 15 minutes more of display. (R17)
X18. April 2, 1954. Red Sea. (R18)
X19. May 31, 1955. Gulf of Siam. (R19)
X20. April 2, 1956. Persian Gulf. Waves of light. Echometer detected shoals of fish. (R20)
X21. October 17, 1961. China Sea. (R21)
X22. April 22, 1971. Malacca Strait. Pale-green bands, 2 miles long, moving at 24 knots. (R22)
X23. December 8, 1974. Arabian Sea. Green bands, 50 x 20 meters. Many bioluminescent organisms in water. (R23)
X24. No date or place given. Sixty bands per minute, 2 miles wide. Two light wheels seen at the same time rotating in opposite directions. (R24)
X25. April 23, 1955. Persian Gulf. Medley of moving bands, wheels, and expanding circles. See description in GLW5-X3. (R25)
X26. May 13, 1955. Gulf of Aden. Waves of light 12 feet above the sea. See description in GLW3-X4. (R26)
X27. January 5, 1880. Malabar Coast, Indian Ocean. Moving bars of luminous mist above water surface. See description in GLW3-X1. (R27)
X28. May 23, 1906. Bender Abbas, Indian Ocean. A display of moving, parallel bands changes to wheel. (R28)
X29. April 5, 1953. Arabian Sea. Parallel bands change into wheel display. See description in GLW4-X23.
X30. September 6, 1955. Gulf of Aden. Displays of moving, parallel bands alternate with wheels. (R30)
X31. April 3, 1956. Persian Gulf. Moving bands change into wheel display. See description in GLW4-X35. (R31)
X32. May 7, 1963. Persian Gulf. Display of moving bands changes into two rotating wheels. (R32)
X33. May 30, 1956. Persian Gulf. (R33)
X34. March 27, 1976. Gulf of Siam. Moving band system changes into wheel display. (R34)
X35. June 12, 1980. South China Sea. (R35)
X36. April 11, 1870. Gulf of Siam. (R36)

X37. July 23, 1954. Indian Ocean. As reported by D. Brown, second officer of the S.S. City of Khios, then in the northern part of the Arabian Sea in about 200 feet of water.

"Shafts of pale white light were observed moving swiftly NE-SW. They appeared to be just above the surface of the sea and parallel with each other. They were passing the ship at the rate of about one per second. They appeared to stretch as far as the eye could see on each side of the vessel and did not at any time ap-

pear to curve. After about 15 minutes the phenomenon disappeared." (R38, also R37)

X38. July 1938. Indian Ocean. Arabian Sea. Observed from the S.S. Aristo. Rapidly moving luminous bands that traveled in a direction opposite to the wind and swell. (R38)

X39. April 23, 1963. North Pacific Ocean. South China Sea. S.S. Hyperion enroute Singapore to Japan.

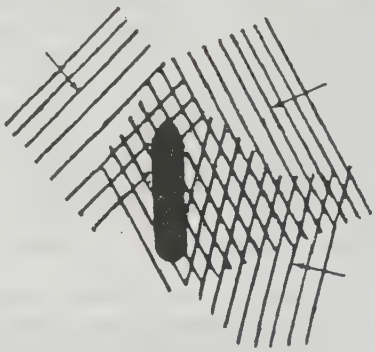
"At 2230 L.C.T. a strange light resembling dawn appeared on the horizon around the ship. The light was about half the brightness of a strong beacon and resembled rays about 5 yards wide and occurred every half second. The rays were about 2 yards apart and seemed to come from everywhere. This phenomenon lasted until 2300 L.C.T. and then faded." (R39)

Sometimes the appearance of a light wheel (GLW4) is heralded by a parallel bands arriving from different directions, as also suggested by the next entry.

X40. May 29, 1985. Indian Ocean. Java Sea. As observed by S. Gallaway, the Chief Officer, from the m.v. Entalina bound for Darwin from Singapore.

"At 0210 LMT I witnessed the start of a bioluminescent display. My first impression was that the ship was being 'attacked' on all sides from different directions by pulsing light-bands. A dull 'strobe-light' effect flashed through a mist, giving the bands a dirty-white to gray colouration which was not a 'smooth' colour, but rather grainy in appearance. The bands were about 2 m wide and about 2 m apart and moving at speed. At first it was difficult to discern whether or not the bands were in the water or just above the surface, as no form of reflection or distortion was visible off the hull. In the end, I decided that the effect must be waterborne if only because nothing was visible in the vessel's wake.

"The most intense activity was observed on the starboard side of the ship where the phenomenon appeared to stretch as far as the horizon. At this stage, it did not appear localized, just a mass of high-speed interacting bands of light. The effect is shown in the first sketch. As is usual on an 'all aft' ship, you become 'deaf' to the constant background noises, but I gradually became aware that the pulses of light seemed to match those of the main engine's throb, that is, about two per second. The radar (3-cm radar, running on the 24 n. mile range), and the echosounder (indicating a water-depth of about 35 fathoms), were switched off in turn to see if any change was discernible, but there was not.



Indian Ocean, 1985. Three systems of rapidly moving parallel bands rushed past the m.v. Entalina. (X40)

"However, at about this time, the ship passed a localized revolving system, distance off appeared to be about 150 m. My impression was that of a catherine wheel revolving and casting out waves in an angular motion, as shown in the second sketch. How many spokes it had I'm not sure owing to the speed of the pulsations, but I think that there were at least three. If viewed from above, the system rotated in a clockwise direction wheeling itself along the ship's track. No central hub was visible, just a dark area devoid of activity. One or two systems were visible farther out to starboard." (R40)

Indian Ocean, 1985. Later, the display observed from the m.v. Entalina took on the appearance of a wheel casting off waves of luminosity, as in this sketch. (X40)

Here we see a stronger connection between the parallel light bands and the rotating light wheels. It is possible that some systems of moving, apparently parallel, bands may actually be the spokes of a distant rotating wheel.

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GLW3 Aerial Phosphorescent Displays

Description. Marine phosphorescent displays observed in the air well above the surface of the water.

Background. Marine phosphorescent displays are believed to be caused by bioluminescent organisms in the sea; and indeed the bulk of the displays do seem confined to the ocean surface and just below it. In some instances, however, the observer cannot decide whether the display occurs on the surface or just above it. The situation is complicated by the possible illumination of surface mist and suspended particles by light sources in the water proper. Such borderline cases are not included here, where all accounts describe displays that seem at least several feet above the sea's surface.

Data Evaluation. Only a handful of good cases. Rating: 2.

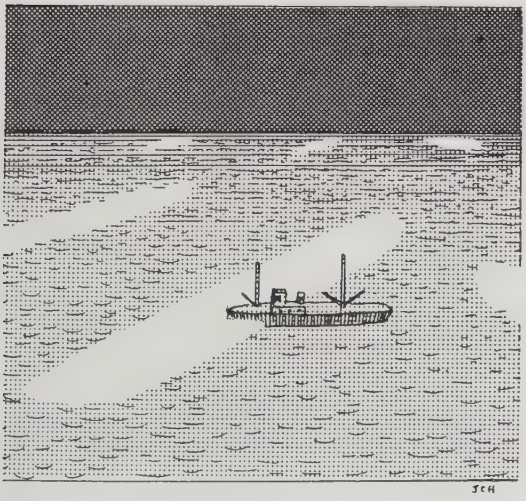
Anomaly Evaluation. Since bioluminescent organisms are not known to enter and remain suspended in the atmosphere for long periods, the aerial phosphorescent displays would seem to have no recognized source of light. Rating: 2.

Possible Explanations. The long-term suspension of bioluminescent organisms in the air is always possible, but seems unlikely. The aerial displays may result from the simple illumination of mist and fog by bright light sources in the water, although some observers specifically deny this. The strong resemblence between aerial phosphorescent displays and low-level auroras and luminous surface fogs is intriguing. Some luminous fogs, for example, seem to have a wave structure. (GLA21-X4)

Similar and Related Phenomena. Low-level auroras (GLA4), luminous fogs and mists (GLA21).

Examples of Aerial Phosphorescent Displays

X1. January 5, 1880. Malabar Coast, Indian Ocean. "At 10 P. M. we were steaming along very comfortably; there was a perfect calm, the water was without a ripple upon it, the sky was cloudless, and, there being no moon, the stars shone brightly. The atmosphere was beautifully clear, and the night was one of great quietude. At the above-named hour I went on deck, and at once observed a streak of white matter on the horizon bearing south-south-west. I then went on the bridge and drew the third officer's attention to it. It a few minutes it had assumed the shape of a segment of a circle measuring about 45° in length and several degrees in altitude about its centre. At this time it shone with a peculiar but beautiful milky whiteness, and resembled (only in a huge mass, and greater luminous intensity) the nebulae sometimes seen in the heavens. We were steaming to the southward, and as the bank of light extended, one



In 1880, off the Malabar Coast of India, a vessel was engulfed in great waves of light that seemed to float on the sea's surface. (X1)

of its arms crossed our path. The whole thing appeared so foreign to anything I had ever seen, and so wonderful, that I stopped the ship just on its outskirts, so that I might try to form a true and just conception of what it really was. By this time all the officers and engineers had assembled on deck to witness the scene, and were all equally astonished and interested. Some little time before the first body of light reached the ship I was enabled, with my night glasses, to resolve in a measure what appeared, to the unassisted eye, a huge mass of nebulous matter. I distinctly saw spaces between what again appeared to be waves of light of great lustre. These came rolling on with ever-increasing rapidity till they reached the ship, and in a short time the ship was completely surrounded with one great body of undulating light, which soon extended to the horizon on all sides. On looking into the water it was seen to be studded with patches of faint, luminous, inanimate matter, measuring about two feet in diameter. Although these emitted a certain amount of light, it was most insignificant when compared with the great waves of light that were floating on the surface of the water, and which were at this time converging upon the ship. The waves stood many degrees above the water, like a highly luminous mist, and obscured by their intensity the distant horizon; and as wave succeeded wave in rapid succession, one of the most grand and brilliant, yet solemn, spectacles that one could ever think of was here witnessed. In speaking of waves of light I do not wish to convey the idea that they were mere ripplings, which are sometimes caused by fish passing through a phosphorescent sea, but waves of great length and breadth, or in other words, great bodies of light. If the sea could be converted into a huge mirror and thousands of powerful electric lights were made to throw their rays across it, it would convey no adequate idea of this strange yet grand phenomenon. As the waves of light converged upon the ship from all sides they appeared higher than her hull, and looked as if they were about to envelope her, and as they impinged upon her, her sides seemed to collapse and expand. Whilst this was going on the ship was perfectly at rest, and the water was like a millpond. After about half an hour had elapsed the brilliancy of the light somewhat abated, and there was a great paucity of the faint lustrous patches which I have referred to, but still the body of light was great, and, if emanating from these patches, was out of all proportion to their number." (R1)

X2. July 24, 1908. Gulf of Siam. "...the steamer past (sic) thru a small field of remarkable phosphorescent patches in the form of a kind of vapor lying above the surface of the water in lengths of 500 to 1,000 feet and breadths of 100 feet approximately, and about 15 to 20 feet in depth to the surface of the water. At distances of 1 to 2 miles these 'streaks' appeared like shining silver (no moon shining), and at first were taken to be shoals of fish, but on passing directly thru one it had all the effect of a slight luminous fog. No disturbance or presence of any fish appeared in the water, which is only about 25 to 30 fathoms in depth, and no unusual color appeared in the contents of a draw-bucket taken at the time." (R2)

X3. July 23, 1954. Arabian Sea. Pale white bands of light moved just above the surface of the water. (R3)

X4. May 13, 1955. Gulf of Aden. "Shortly after leaving Aden for Suez bright pulsating waves of light having a period of 1.5 sec were observed emanating from the sea in close proximity to the ship. They were travelling in a direction of 070° for some distance and extended to a height of about 12 ft above the sea. This phenomenon was definitely not caused by the proximity of shore lights; there was no sign of phosphorescence in the sea at the time of observation." (R4)

X5. March 31, 1958. North Atlantic Ocean. "Between 2250 and 2315 G.M.T., what appeared to be phosphorescence in the air was observed. Small phosphorescent particles passed upwards from the sea to a height of about 3 1/2 ft all round the ship. At no time before 2250 or after 2315 was any phosphorescence visible either in the sea or in the air above it." (R5) Since this event occurred far from the regions where most of the marine phosphorescent displays take place, it may be unrelated to others in this category.

X6. July 10, 1979. Arabian Sea. Phosphorescence seemed at eye level to those aboard the ship. (R6)

X7. No date or place given. Spokes of a phosphorescent wheel seemed about 8 feet high. (R7)

X8. November 5, 1953. Gulf of Oman. The spokes of a wheel display appeared 1 meter above the surface. (R8)

X9. November 14, 1920. China Sea. "...a phosphorescent wheel was observed in the air above the sea, in a stratum more or less parallel to the sea surface.... Broadly speaking the phenomenon was identical with the phosphorescent wheel observed on board the Valentijn, but the spokes appeared to rotate at a level of about 30 ft. above the sea surface. It was observed, when the wheel appeared, that the water was covered with a haze, and as soon as the wheel disappeared the haze was no longer there. It was also observed that the wheel did not only turn anti-clockwise, but occasionally changed its movement into a clockwise direction. During the whole phenomenon the water was but slightly phosphorescent." (R9, R10)

X10. January 19, 1991. North Pacific Ocean. South China Sea. Aboard the m.v. Benavon. This vessel was heading for Singapore on a body of water noted for bioluminescent displays. First, flashes of light were seen in the bow wave and the ship's wake, appearing to be both on the surface and slightly below. This type of display is rather common, but another, much rarer phenomenon was also present, as observed and reported by two of the ship's crew, including the Second Officer.

"At the same time as the above form of bioluminescence, there seemed to be a second type but it was difficult to pinpoint the source. The effect was that the atmosphere around the ship and extending to the horizon had some form of faint white illumination not provided by the light in the water, which was black apart from the previously described flashes. On the other hand, there was no obvious source in the sky either, which although virtually cloudless was very dark, and certainly darker than the atmosphere at the level of the ship.

"The only conclusion that the observers could come to was that this was a faint example of (to quote The Marine Observer's Handbook), 'luminescence in the air a few feet above the sea surface when there is no light in the water'. This form lasted for about 30 minutes, whereas the bright flashes continued for three or four hours before they too eventually ceased." (R11)

It is assumed by scientists that aerial luminescence occurs when bioluminescent particles are somehow carried into the air from the ocean, but there is no evidence at all for this. A more radical notion holds that some aerial luminescence seen at sea has an electrical origin, for the phenomenon has much in common with the luminous mists associated with low-level auroras. (See GLA4)

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GLW4 Marine Phosphorescent Wheels

Description. Spoke-like bands of light rotating around a central hub. The spokes may be straight, curved, or S-shaped. Rotation is in either direction and may change during the display. In some cases, the outer part of the wheel seems to spin in a different sense from the central part. Illustrating the illusory character of the phenomenon, different observers sometimes see the same wheel rotating in opposite directions. Wheel sizes range from tens of feet to several miles, with spoke widths of 5-50 feet being common. Generally, the sources of light seem to be on or just beneath the surface, but several examples exist of wheels composed of luminous mist spinning well above the sea's surface. Spoke colors are whitish and greenish in most cases. Several wheels may appear simultaneously, rotating in various senses with overlapping patterns. Phosphorescent wheel displays are frequently preceded and followed by displays of moving, parallel bands (GLW2). Like the moving band displays, the phosphorescent wheels are most common in the Indian Ocean, especially the Persian Gulf, and the China Sea. The few wheel-like structures seen in other waters are usually poorly formed and stationary. The duration of a wheel-type display lasts from a few minutes to more than an hour.

Data Evaluation. Scores of well-observed examples. Rating: 1.

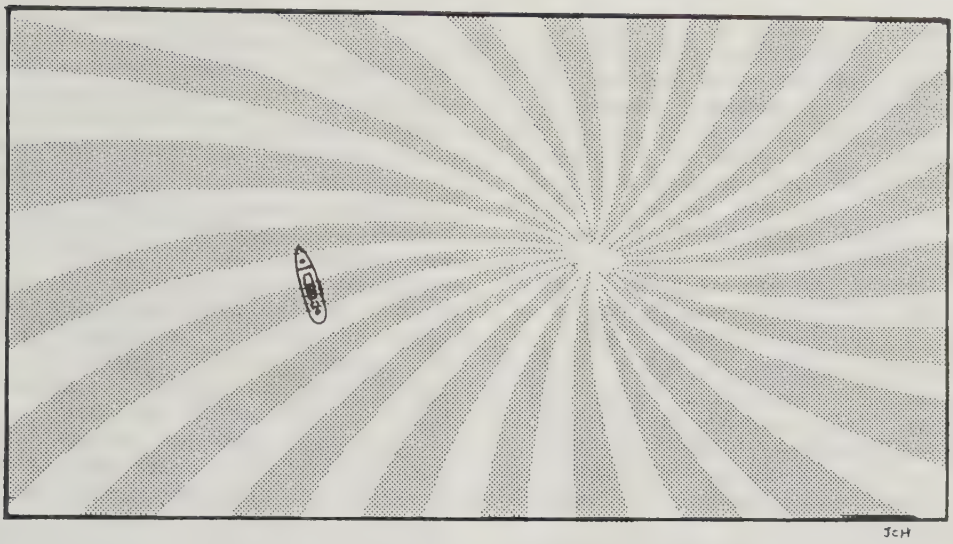
Anomaly Evaluation. As with most of the organized phosphorescent displays, the major problem seems to be explaining the origin and long-term stability of rather complex geometrical patterns. If the light source is not bioluminescence, as generally supposed, the anomaly is even stronger. Rating: 2.

Possible Explanations. Certainly bioluminescence is the most likely source of light, although observers frequently remark that the ship's wake is not luminous during wheel-type displays. The aerial wheels of luminous mist, if not illusory, would require air-borne organisms in cases where no wheel is visible in the water proper. Earthquake tremors may stimulate bioluminescence, with the interference patterns created by multiple sources accounting for the complex display geometries. The persistence of intricate geometries over many minutes seems to militate against this theory. Again, as in GLW3, the strong similarity of some marine phosphorescent displays to the so-called low-level auroras (GLA4) is striking. Some wheel observers have noted this, and electromagnetic forces should not be dismissed off hand.

Similar and Related Phenomena. The other marine phosphorescent displays (GLW), low-level auroras(GLA4).

Examples of Phosphorescent Wheels

X1. May 15, 1879. Persian Gulf. "I noticed luminous waves or pulsations in the water, moving at great speed and passing under the ship from the south-south-west. On looking towards the east, the appearance was that of a revolving wheel with centre on that bearing, and whose spokes were illuminated, and looking towards the west a similar wheel appeared to be revolving, but in the opposite direction. I then went to the mizen top (fifty feet above the water) with the first lieutenant, and saw that the luminous waves or pulsations were really travelling parallel to each other, and that their apparently rotatory motion, as seen from the deck, was caused by their high speed and the greater angular motion of the nearer than the more remote part of the waves. The light of these waves looked homogeneous and lighter, but not so sparkling, as phosphorescent appearances at sea usually are, and extended from the surface well under water; they lit up the white bottoms of the quarter-boats in passing. I judged them to be twenty-five feet broad, with dark intervals of about seventy-five between each, or 100 from crest to crest, and their period was seventy-four to seventy-five per minute, giving a speed roughly of eighty-four English miles an hour. From this height of fifty feet, looking with or against their direction, I could only distinguish six or se-



Idealized sketch of a wheel-type, marine phosphorescent display (GLW4). Far from the wheel's center the spokes may be identified as the moving, parallel bars cataloged in GLW2.

ven waves; but, looking along them as they passed under the ship, the luminosity showed much further. The phenomenon was beautiful and striking, commencing at about 6 h. 3 m. Greenwich mean time, and lasting some thirty-five minutes. The direction from which the luminous waves travelled changed from south-south-west by degrees to south-east and to east. During the last five minutes concentric waves appeared to emanate from a spot about 200 yards east, and these meeting the parallel waves from south-east did not cross, but appeared to obliterate each other at the moving point of contact, and approached the ship, inclosing an angle about 90°." (R1)

X2. May 1880. Persian Gulf. "In May, 1880, on a dark, calm night, about 11.30 p.m., there suddenly appeared on each side of the ship an enormous luminous wheel whirling round, the spokes of which seemed to brush the ship along. The spokes would be 200 or 300 yards long, and resembled the birch rods of the dames' schools. Each wheel contained about 16 spokes, and made the revolution in about twelve seconds. One could almost fancy one heard the swish as the spokes whizzed past the ship, and, although the wheels must have been some 500 or 600 yards in diameter, the spokes could be seen distinctly all the way round. The phosphorescent gleam seemed to glide along flat on the surface of the sea, no light being visible in the air above the water. The appearance of the spokes could be almost exactly represented by standing in a boat and flashing a bull's-eye lantern horizontally along the surface of the water round and round." (R2)

X3. May 23, 1906. Indian Ocean. A parallel band display changes into a wheel. The author theorizes that the wheels are seismically stimulated bioluminescent interference patterns. (R3)

X4. March 14, 1907. Malacca Strait. A wheel with spokes 300 yards long. Duration: 30 minutes. (R4)

X5. March 22, 1908. Persian Gulf. Phosphorescent wheel seemed to be revolving just above the water's surface. Duration: 20 minutes. (R5)

X6. August 1908. South China Sea. An anti-

clockwise wheel. (R6)

X7. June 19, 1909. Malacca Strait. A clockwise wheel with curved spokes concave in the direction of rotation. Duration: 15 minutes. (R6, R7)

X8. August 12, 1910. China Sea. Wheel observed, but no normal phosphorescence in the water. (R7, R8)

X9. July 3, 1919. Indian Ocean. Clockwise wheel with curved spokes. (R9)

X10. November 14, 1920. China Sea. Phosphorescent wheel visible on the underside of a thin layer of mist 30-35 feet above the surface of the water. No display seen in the water at all. The wheel changed its direction of rotation during the observation. (R8, R10)

X11. April 18, 1923. Gulf of Oman. Pale blue spokes. Duration: almost 60 minutes. (R11)

X12. March 21, 1925. Off west coast of India. Two separate wheels. (R12)

X13. September 30, 1926. Arabian Sea. Eddies of light formed discontinuous spokes of a rotating wheel. (R13)

X14. December 3, 1927. Malacca Strait. Two clockwise wheels on opposite sides of ship. Spokes concave in direction of rotation. Duration: 20 minutes. (R14)

X15. December 19, 1927. Indian Ocean. Anticlockwise wheel observed for 5 minutes; it disappears; a clockwise wheel appears for 5 minutes; it disappears; then, another anticlockwise wheel is observed for 5 minutes. (R15, R16)

X16. September 9, 1929. Malacca Strait. Bands of light wheel over the sea. Duration: 1 hour. Display combined with vivid lightning. (R17)

X17. December 28, 1929. North Indian Ocean. S-shaped spokes pass ship; hub about 5 miles away. During the display, the ship's engines were straining. (R16, R18)

X18. October 5, 1932. Andaman Sea. (R19)

X19. December 29, 1932. Andaman Sea. Duration: 26 minutes. (R19)

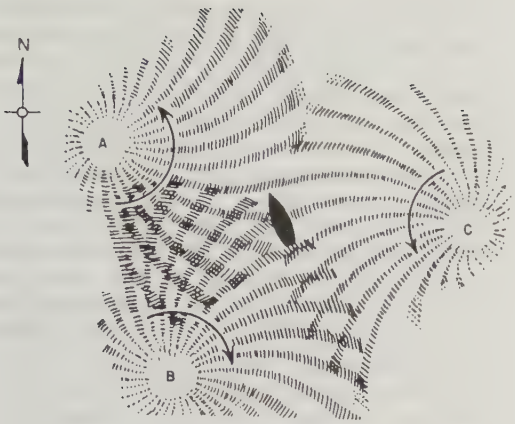
X20. February 25, 1949. Bay of Bengal. (R20)

X21. July 23, 1949. Malacca Strait. Duration: 20 minutes. (R21)

X22. April 16, 1950. Gulf of Siam. A number of wheels seen simultaneously. Duration of display: 30 minutes. (R22)

X23. April 5, 1953. Arabian Sea. "Commencing from about NNW, shafts of pale white diffused light appeared, apparently travelling on the surface of the water at a great speed. Each shaft was several feet wide and they stretched as far as the eye could see. At first they appeared in perfectly parallel lines, equally spaced, passing the ship at about one every second, but after five minutes they wheeled round in perfect formation and approached the ship from all points of the compass. They came from only one compass point at a time and each change of direction was swift and definite, though not abrupt. The most frequent directions were from NNW and SSE. After about 15 minutes the shafts occasionally formed into a rotating radial movement in which they retained their equal geometrical precision and the frequency of about one per second. At this time the pattern was continually changing about every 20-30 seconds from the parallel lines to the wheel. The periods of transition were hardly noticeable, but they were not abrupt. Each time the wheel appeared it was in a different place. On one occasion there were two distinct wheels visible at the same time. Throughout the period the wheels appeared they varied in direction of rotation, some clockwise and some anticlockwise. Five minutes later the pattern became still more complicated but remained perfectly regular and at 2150 the light faded out over a period of 30 seconds. Although the light appeared to be on the surface of the water it was completely unaffected by the wind and no disturbance of the water was produced. The most notable feature of the phenomenon was the effortless speed and mathematical precision of movement." (R23)

X24. April 24, 1953. Gulf of Thailand. "Faint flashes of light with oscillating movements were observed on the sea. The flashes gradually increased in strength until at 0230 they suddenly changed into rather intensive rays of light moving around centres lying near the horizon. Three groups of rays were present, as shown in the sketch. (a) One on the port bow having a bearing of about 300° with the rays rotating anticlockwise. (b) One on the port bow having a bearing of about 230°, rotating clockwise. (c) One on the starboard bow having a bearing of about 95°, rotating anticlockwise. The beams were curved with the concave side in the direction of the movement, and were passing the ship continuously with a fre-



In 1953, three overlapping marine light wheels were observed simultaneously in the Gulf of Thailand. (X24)

quency of about three a second; they looked more like glowing shafts than beams of light. Reflections on the ship were clearly visible.... The phenomenon lasted till 0250, and it had been clear by the increasing strength of the group ahead and decreasing strength of the groups astern, that the ship was advancing through the area of phosphorescence. Soon only the oscillating flashes could be seen and they also disappeared shortly afterwards. At 0300 the situation was normal again." (R23)

X25. September 13, 1953. Off Sumatra, Indian Ocean. Duration: 20 minutes. (R24)

X26. October 30, 1953. Gulf of Siam. Display with curved spokes, radius 2 miles. Spokes 100 yards apart one mile from hub. Wheel rotating at 20 rpm. Duration: 10 minutes. (R25)

X27. November 5, 1953. Gulf of Oman. Clockwise fog-like spokes, 1 meter above the sea's surface. Spoke radius: 2 nautical miles; duration: 2 minutes. (R26)

X28. November 12, 1953. China Sea. Close study of wheel revealed that its rotation was due to a marquee effect. (R25)

X29. May 3, 1954. Atlantic equatorial waters. A stationary wheel. (R27) It appears that wheel displays outside the usual habitat (Indian Ocean and China Sea) are rather degenerate forms.

X30. February 18, 1955. Indian Ocean. Four pale-green bands, 3 feet wide, 5 feet apart, converged just astern and fanned out ahead. No rotation. (R28)

X31. April 23, 1955. Persian Gulf. "When approaching Jazirat Tunb Island a bright flashing light was observed on the port bow, distant about one mile. Almost simultaneously another was observed on the starboard bow. On approaching it was seen that these were two revolving phosphorescent wheels. The ship passed between them, the centres being about 1/4 mile distant on either side. The wheel on the port side appeared to revolve anticlockwise, and that on the starboard side clockwise. The spokes of radius 1/4 mile were from 6 to 12 ft broad at the tips with about 15 ft between them. They passed with a frequency of 1 1/2 sec with a colour similar to that of a dull electric light. Immediately we had passed these two wheels, further phenomena were observed. On the port side concentric circles were seen to radiate from a centre, with an effect similar to that of dropping something in still water. On the starboard side there appeared lines, apparently moving away from the ship in a manner similar to the wake. As the ship passed they gradually faded from sight astern and had been in sight 10 or 15 min. At 1700 a similar phenomenon was observed to the SE., distant about 7 miles. The Master comments: The sky was overcast and the atmosphere appeared to have more than the usual amount of particles in suspension, but the all-around visibility was very good. Jazirat Tunb Light was about 20 miles away and its rotating beams were visible in the air throughout their complete revolutions. Above the sea surface there was apparently a layer of mist a yard deep. The bands of phosphorescent light appeared to float on top of this layer, but on closer examination of the beams as they passed vertically under the observer it could be seen that the sea was affected to a considerable depth. Each band was similar in colour and appearance to the Milky Way, myriads of particles of light dust with brighter and larger specks here and there. My impression, especially during the concentric ring phenomenon, was of shock waves causing millions of organisms to light up as

the wave passed through them, then going dark until the next wave struck them. I do not believe the organisms themselves were on the move. The effect on the onlookers seems to have been a feeling of weirdness, bordering on fear, similar to that experienced by people ashore during earthquake tremors." (R29)

X32. June 25, 1955. Gulf of Oman. Moving bands changed into a display of five wheels; three single wheels rotating anticlockwise, and two superimposed wheels revolving in opposite directions. (R29)

X33. September 6, 1955. Gulf of Aden. White wheels alternated with formations of white, parallel bands. The bands were 30-40 feet wide and moved unusually slowly---passing at the rate of one every 15 seconds. (R30)

X34. October 11, 1955. South Pacific Ocean. The ship was the center of about 16 converging, stationary bands. (R31)

X35. April 3, 1956. Persian Gulf. Following a disordered display. "Ten minutes later the display was resumed in the form of parallel bars of light travelling towards the ship from about four points on the port bow, leaving her on the starboard quarter. The bars passed the ship at regular intervals of about 3 sec. Then a brighter patch was seen ahead, and as this was approached it was seen to be an area of jumbled blotches of light, the parallel bar formation having ceased. As this area was watched the profusion settled itself out and began to resemble a slowly revolving wheel. Each 'spoke' of the wheel was disjointed, consisting of several separate bars of light, the component bars decreasing in intensity of light with distance from the centre of rotation . The spokes were not straight, but curved slightly in a clockwise direction. The centre round which all revolved was a brighter spot which showed no movement. This was passed by the ship at a distance of about a mile to port. The spokes could also been seen extending far off on the starboard side, not coming to an abrupt end but fading away in the distance. The wheel showed two types of motion, that of rotation and an outward rippling movement. In addition, each spoke flashed regularly in sections so that not all of it would be visible at once. The flashing occurred at a constant rate of one per second. A number of other wheels were subsequently seen, for the most part separately but a few were intermingled. At times wheels could be seen all around the ship. Each wheel appeared to keep a fixed position relative to the others. As each wheel passed astern it became distorted and indistinct, finally appearing as just a glow in the distance. All the wheels that were seen near the ship had the same character as the one described above, with visible centres and curved spokes. A difference of opinion arose as to which way the first wheel was rotating. It appeared to Mr. Youngs to be turning anticlockwise, with some distant bars moving clockwise, while the Chief Officer and the two other apprentices said the direction was clockwise. Independent opinions were therefore sought from three members of the watch, each of whom gave the movement as anticlockwise." (R32)

X36. July 2, 1956. Persian Gulf. Two clockwise wheels. (R33)

X37. February 24, 1957. Gulf of Siam. An anticlockwise wheel with curved spokes. A second wheel appeared 3 minutes later. After 3 more minutes two oppositely rotating wheels with close centers were seen. Bright flashes appeared where the spokes crossed. (R34)

X38. April 10, 1958. Persian Gulf. Two clockwise wheels that seemed like waves of light 3 feet above the sea. (R35)

X39. April 14, 1958. Persian Gulf. Many confused wheel displays. The apparent direction of rotation of some wheels could be changed by looking away and then back again. (R35)

X40. September 27, 1959. East Indian Archipelago. Moving parallel bands preceded a wheel display. (R36) See GLW2-X6 for description.

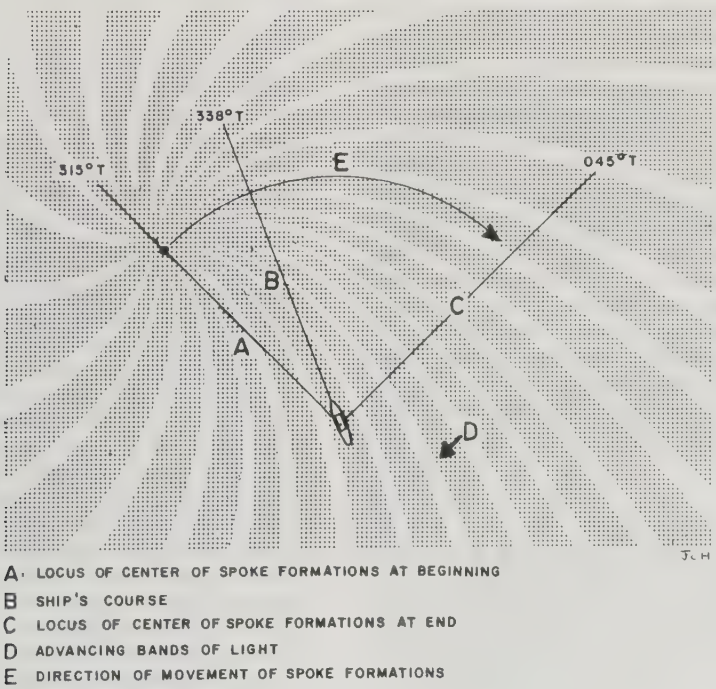
X41. September 10, 1960. South Pacific off Tocopilla, Chile. Lines spinning in a circular movement. (R37)

X42. September 9, 1961. Indian Ocean. Three phosphorescent wheels, each 80 feet in diameter, all moving northeast. (R38)

X43. May 11, 1962. South China Sea. An anticlockwise wheel changed to clockwise at its peak of brightness. (R39)

X44. May 7, 1963. Persian Gulf. Straight, moving band display changed into two phosphorescent wheels. (R40)
X45. June 17, 1963. Gulf of Siam. (R40)
X46. November 22, 1967. Malacca Strait. (R41)
X47. March 23, 1968. Arabian Sea. Anticlockwise wheel changes to clockwise. (R42)
X48. April 23, 1968. Persian Gulf. Phosphorescent wheels with S-shaped spokes seen rotating in both directions. (R43)
X49. April 13, 1970. South China Sea. Six or seven phosphorescent wheels seen, all rotating clockwise at the same speed simultaneously. (R44)
X50. April 22, 1971. Gulf of Siam. Two wheels observed rotating anticlockwise. Three minutes later, they changed to clockwise. Later, they spun in opposite directions. (R45)
X51. February 10, 1973. Manila Bay. A phosphorescent wheel seemed to rotate anticlockwise on the near side, clockwise on the far side. (R46)
X52. January 3, 1976. Southern North Pacific. Rotating circles (?) with radii of 3 nautical miles. (R47)

X53. March 27, 1976. Gulf of Siam. "At 1917 GMT pulsating bands of parallel light were observed in the sea moving towards the vessel from 045°T. After two to three minutes the bands took on a definite spoke formation, the centre of which was not seen but lay in the direction of 315°T. The spokes passed the vessel at an ever-increasing rate, two spokes per second at the fastest. At this time they were about 22 metres in width and there was 22 metres between each spoke. The light given off from the spokes was white to light green in colour, it increased in intensity with the speed of rotation. The direction of rotation



The "wheel phase" of a complex sequence of moving luminous bands and wheels seen in the Gulf of Siam in 1976. (X53)

was clockwise. By 1925 the centre of the spokes had shifted from 315° to 360°T and gradually reverted back to advancing bands of parallel light. Shortly after this the parallel bands gave way to a counter-clockwise spoke rotation. This was observed in a direction centred along 315°T from the vessel, the spokes moved across the bow to 045°T, at which point they became parallel bands which diminished in intensity. By 1934 they had completely disappeared." (R47)

X54. February 14, 1977. Malacca Strait. Clockwise phosphorescent wheel display with curved spokes convex in the direction of rotation. Changed to a V-type display. (R48) See description in GLW12.

X55. April 8, 1978. Arabian Sea. Greenish anticlockwise wheel. Duration: 10 minutes. A second wheel was seen 2 hours later. (R49)

X56. November 6, 1978. South China Sea. "At 1750 GMT bioluminescence in the form of a system of rotating bands with no central hub visible was observed. The phenomenon, which was observed on both sides of the vessel, had a milky-white appearance and pulsated at the rate of two to three flashes every second. On the port bow the bands were observed about 20° off the bow, moving towards the vessel and rotating in a clockwise direction. They disappeared from view they reappeared abaft the beam coming into the vessel amidships. On the starboard bow the bands rotated anti-clockwise and moved in towards the vessel. After moving into the vessel's side the bands sheered off astern then disappeared altogether. The phenomenon was observed for about 10 minutes." (R50)

X57. March 6, 1980. Arabian Sea. "At 1552 GMT bioluminescence in the form of diffused white light in 'whirlpool' and 'cartwheel' formations was observed; within 3 minutes it completely encircled the vessel and extended to the horizon. The 'cartwheel' formations were brightest at the centre with a halo effect surrounding the outer edges. As the vessel passed over 2 such formations the 'spokes' were estimated to be 2-2 1/2 metres in width and the entire concentration, which was more than the width of the vessel (approximately 27 metres), was observed on both sides of the bridge-wing simultaneously. The 'whirlpool' formations, with a distinct central hub, varied from 1 1/4 to 2 metres in width and from 1 to 15 metres in length. The phenomenon was observed for 40 minutes." (R51)

X58. No date given. Persian Gulf. (R52)

X59. No date or place given. A wheel of milky white mist 30 feet wide and 30 feet apart and 8 feet deep passed at the rate of two per second. (R53)

X60. General observation. Lights wheels are mostly confined to the continental shelves of Asia and Middle East. They may be caused by earth tremors. (R54)

X61. General observations similar to X60. (R55)

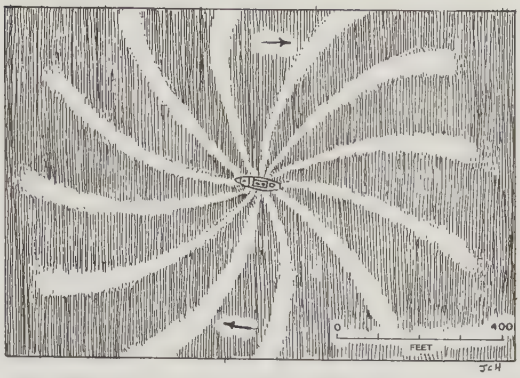
X62. General observation. Persian Gulf. Fire circles seen flitting over the surface of the water at 100 miles per hour. (R56, R57) Classification is ambiquous here.

X63. December 4, 1926. Indian Ocean. Strait of Malacca. An excellent description of the development of a marine light wheel came from J.M. Anderson, the Second Officer of the S.S. Aeneas.

"Commencing with but a few isolated points and patches of sparkling and pulsating light, the display developed until the surface of the sea from horizon to horizon had the appearance of being lit up from below by thousands of beams of light which independently flashed and were eclipsed with great regularity, at intervals of about one second. This phosphorescence increased in brilliancy until 1:45 A.M. Two distinct systems of light waves or phosphorescent wheels were observed, one to port and one to starboard. These light waves were observed to be traveling clockwise over the surface of the sea, appearing to issue from a focus around which they rotated, increasing in brilliancy and velocity of rotation until 2:05 A.M. The phosphorescent points and patches previously described were noticed to increase in brilliancy as the illuminated beams swept over them and decrease in intensity during the passage of the suc-

cessive dark spaces, and this phenomenon was quite noticeable even when the light waves, toward the end of the display, became quite faint. At 2:15 A.M. the light waves were no longer visible, and at 2:30 A.M. the last traces of phosphorescence were observed." (R58)

Of more than passing interest in Anderson's account is the apparent existence of two separate but interfering stimuli of illumination: (1) the points and patches of light (almost certainly due to bioluminescent organisms); and (2) the rotating beams of light that shone independently of the patches but, when encountering them, caused them to flare up.



On November 14, 1949, a vessel in the Indian Ocean found itself at the hub of a rotating marine light wheel. (X64)

X64. November 14, 1949. Indian Ocean. Persian Gulf. The vessel had just passed through the Strait of Hormuz bound for India. J.R. Bodler, the Captain, was called to observe a pulsating luminous phenomenon on or just below the horizon in the direction of Iran. The display resembled an aurora but was much too low. So began the vessel's transit directly through the center of a classic marine light wheel.

"At a distance of about a mile from the ship it was apparent that the disturbance was roughly circular in shape, about 1000 to 1500 feet in diameter. The pulsations could now be seen to be caused by a revolving motion of the entire pattern about a rather ill-defined center, with streaks of light like the beams of searchlights, radiating outward from the center and revolving (in a clockwise direction) like the spokes of a gigantic wheel.

"For several minutes the vessel occupied the approximate center of the phenomenon. Slightly curved bands of light crossed the bow, passed rapidly down the port side from bow to stern, and up the starboard side from aft forward. The luminosity was sufficient to make portions of the vessel's upper works quite visible. The bands of luminance seemed to pass a given point at about half-second intervals. As may well be imagined, the effect was weird and impressive in the extreme; with the vessel seeming to occupy the center of a huge pinwheel whose 'spokes' consisted of phosphorescent luminance revolving about the vessel as a hub." (R59)

The hub of the wheel slowly drifted aft. While this wheel was still in sight, another wheel appeared. This one was smaller but with clearly defined spokes. A third wheel was met a half hour later.

The observer's allusion to the aurora is pertinent because the many accounts of low-level-aurora "mists" (GLA4) resemble in some respects testimonies to the effect that marine luminous displays often appear to occur above the sea surface.

X65. No date given. Indian Ocean. Gulf of Oman. P. Newton was the Chief Officer on the m.v. Mahsuri, which was crossing the Gulf of Oman bound for Australia. It was a dark, moonless night in May.

"Then it happened. What first caught Newton's attention was a pale green glow on the horizon just ahead of the ship, but he said nothing to the cadet standing watch with him. Moments later, parallel bands of blue-green light began to sweep silently over the water toward the ship from the southeast. Still, Newton said not a word, but he felt as if he should duck. Each light band was about 10 to 15 feet wide and at least 500 feet long, and appeared to be some 15 feet

above the water. They came rapidly---every four or five seconds.

.....

"After the first ten minutes, the bands gave way to expanding circles of light that spread rapidly, like ripples created by a stone thrown into the still waters of a pond. The wheel diameters ranged from ten feet to more than 600 feet.

"'Each wheel would last for a couple of minutes, continually flashing,' Newton recalls. Successive flashes came less than a second apart and glowed a pale green. Newton noticed that the centers of the wheels appeared to travel along with the ship; those on the beam seemed to remain there until they faded and were replaced by a new pattern." (R60)

The most anomalous aspect of the forgoing report is the apparent above-the-water position of the luminescence. There have been several similar reports down the years; and they combine to cast doubt on the bioluminesence-origin theory. So wedded are the theorists to the idea that bioluminescence is the only possible source of light that these above-the-water observations usually passed over. (See GLW3)

Also of interest is the seeming tendency of the wheels to tag along with the ship. The implication is that the ship itself may somehow influence or create the phosphorescent display, say through the vibrations of its engines.

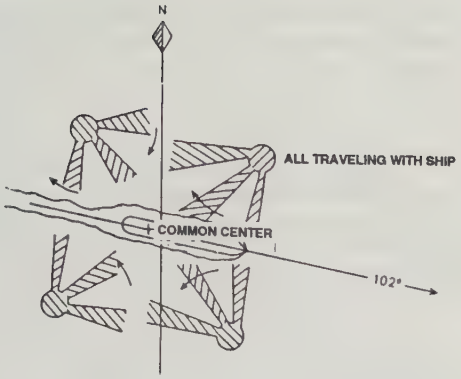
X66. April 30, 1981. North Atlantic Ocean.

"At exactly 2155 GMT, a white sea-smoke type mist was observed glowing white between 2 and 5 metres above the sea surface. Further observation revealed that we were entering a large area of circulating bioluminescence of defined spiral form which appeared to be a pale emerald green in colour. Although the direction of rotation and the centre hub of the wheel could not be determined, the bands appeared to be of great dimension. While still proceeding through the bioluminescence and observing astern, it was noted that the formation of the bands became disrupted and seemed to diffuse a ragged appearance at the perimeter of the wheel to the port side of the vessel. Judging by the distance of the vessels close by---which were being tracked by radar---the extent of the rotating bands to the west could not be determined but they were estimated to be between ¼ and ½ n. mile. The duration of the phenomenon was 4½ minutes from entering to leaving the bioluminescence." (R61)

Bright marine bioluminescence is not uncommon in the Atlantic, particularly in warm waters, but it is very unusual to find geometrically organized displays. The light wheels seen in the Persian Gulf and the South China Sea are much more frequent and more highly structured than the one above. Note that the luminous features once again seem to be above the water.

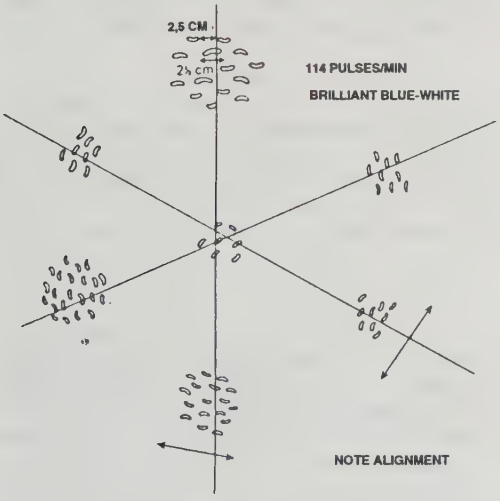
X67. April 29, 1982. North Pacific Ocean. China Sea. On this date, the m.v. Siam encountered---or perhaps it caused ---a most baffling display of marine phosphorescence lasting some 2.5 hours. The complete report is 6 pages long, with 8 diagrams, so only the highlights can be reported here.

As is often the case, this display began with parallel phosphorescent bands (2 sets) rushing toward the ship at about 40 mph. They were 50-100 cm above the sea surface. The bands then changed into two rotating wheels; then a third wheel formed. All three rotated counterclockwise, with their hubs 300, 300, and 150 meters from the ship. The spokes stretched to the horizon. The display ceased for about 20 minutes and recommenced with four systems of onrushing parallel bands, which soon metamorphosed into four rotating wheels. Radar, visible light (from an Aldis lamp), and engine revolution appeared to have no effect on the spectacle. Next, evenly distributed, circular, flashing patches of brilliant blue-white light appeared all around the ship out to a distance of about 150 meters. This system of patches flashed away simultaneously with the wheel display. The patches varied from 15-60 cm in diameter, and flashed 114 times per minute. When an Aldis lamp played steadily on the patches, nothing happened. When the lamp was flashed, the whole array of flashing patches disappeared, only to reappear in about 2 minutes. Each patch seemed to consist



China Sea, 1982. Four rotating light wheels formed around and centered on the m.v. Siam. Actually, spokes radiated in all directions from the four hubs and extended to the horizon. (X67)

of worm-like segments 2½ cm long, 2½ cm apart. The worms were all aligned perpendicular to a vector from the ship. In contrast to the bands and wheels, the worms were located about 5 cm below the surface of the water. Water samples revealed no luminous organisms ---only a few animals a few millimeters long. The sea was calm, visibility excellent, although atmospheric electrical activity could be seen all around." (R62)



China Sea, 1982. In a later phase of the display, flashing, worm-like patches of phosphorescence appeared around the m.v. Siam. (X67)

The luminous "worms" resemble the spinning luminous crescents that are somehow associated with a ship's radar. (See GLW7) Here, again, the observers were convinced that the some part of the display occurred above the water. (See GLW3)

X68. May 6, 1991. Indian Ocean. Strait of Hormuz. Observed aboard the m.v. Zidona enroute from Muscat to Ruwais. This display is notable for its complexity. Such complexity poses great difficulty to anyone trying to explain all of the simultaneous patterns with a specific source of excitation---like seismic waves.

"At 1805 UTC a blue-white pattern of fast-moving light was seen around the ship. Initially, it was thought to be a reflection in the bridge windows of the Didimar lighthouse, but on going to the bridge wing, the observers saw an amazing display of flashing lights taking place over 80-90 per cent of the surface of the water. The whole ship was surrounded by a mass of blue and white light forming complex patterns that were visible in all directions as far as the eye could see. Looking almost like an 'electric mist', it moved with such speed and ease, as if it were alive.

"At the peak of the activity, there appeared to be two central points of spiralling, each about 150 m off either side of the ship about midships. From these points there seemed to be emerging highly confused patterns of spiralling spokes moving in an anticlockwise direction on the port side and clockwise on the starboard side of the ship. It was difficult to estimate accurately how many spokes were present in each circle, but it was thought that there were three or four at any one time, moving very fast and curving to produce what could only be described as a 'whirlpool' effect.

"At the same time, there were pulsating rings expanding from the centres at intervals of about three-quarters of a second. They moved extremely fast, each circle taking about one second to reach a diameter of about 200 m before being lost in the mass of flashing blue and white lights. The thickness of each ring remained constant at about 2 m as the diameter of the circle increased; the formation was always a perfect circle.

"About 300 m off the ship's side,

large irregular shapes were observed. They were all about 3-m in diameter and changed both size and shape while flashing intensely. By 1817 the effect had completely stopped on the starboard side and only the pulsating rings were left on the port side and, with these, the intensity of the light reduced until 1822 when there was nothing more to observe." (R63)

X69. October 7, 1991. Indian Ocean. Gulf of Aden. Aboard the m.v. Wiltshire enroute from Aqaba to Fujayrah. Observations by Third Officer I.G. Macneil.

"At 1745 UTC the glow of bioluminescence was first noted around the hull of the vessel, illuminating the hull above the waterline. The passage of an area of phosphorescent wheels was recorded as follows:

1750: First large wheel of diameter approximately 15 m passed by vessel. Smell of fish in the air.
1806: Continuous wheels passing vessel 6-8 at a time down either side. The larger wheels were of 15 m diameter and the smaller ones were about 6 m in diameter.
1811: Wheels stopped but bioluminescence still visible around vessel.
1950: Bioluminescence diminished.

"The Aldis lamp was shone upon the water but gave no change, then the echo sounder was switched on and off but made no difference either. Several samples of sea water were taken which when shaken contained glowing, luminous, yellow-green specks 1 mm in size.

"The wheels were turning in slow clockwise motion and the closest that any came to the ship was about 12 m. There was intense milky-white colouring in the centres which faded to pale white towards the outer limits." (R64)

None of the radial spokes so common in phosphorescent-wheel reports were remarked in the Wiltshire report. Wheel rotation was also much slower than normal.

However, the most important feature of the above observation was the parade of a large number of rather smallish wheels, several visible at a time. This multiplicity puts severe constraints upon any theory involving the interference of seismic waves, water waves, or optical illusions.

X70. April 30, 1994. Indian Ocean. Strait of Hormuz. Aboard the m.v. BP Argosy enroute Kaohsiung to Jubail. An incredible medley of diverse luminous phenomena---a bioluminescent kaleidoscope.

"At around 1710 UTC large but faint whitish patches of bioluminescence were observed on the port side of the vessel; they were fast-moving with random directions of movement. Over the next five minutes the intensity of the bioluminescence increased to patches of brilliant florescent green, while the random pattern of movement suddenly changed to fast-moving parallel bands heading toward the vessel. The pattern then changed again to form numerous rotating spirals: some were confirmed to be rotating anti-clockwise but it was difficult to assess owing to the large number of overlapping patterns.

"At this point the vessel was surrounded by the phenomenon to a distance of approximately 1 n. mile radius. Yet again the patterns changed, this time to parallel concentric circles moving outwards from numerous centres. The display started to decrease at 1725, returning to milky-white patches before eventually disappearing at 1730." (R65)

Besides the spiral wheels, the above mix included moving parallel bands (GLW2), expanding concentric circles (GLW5), and patches moving rapidly in random directions. The overlapping of different patterns challenges the several theories that have been proposed. (X73)

X71. April 17, 1995. Indian Ocean. Persian Gulf. Aboard the m.v. British Reliance, enroute Fujairah to Kharg Island. Observers: the Master and Second Officer. Once again, a complex of several wheels rotating in different directions.

"At 1525 UTC whilst in the westbound lane of the Traffic Separation Scheme and shortly after settling on a course of 270°, a small amount of blue phosphorescence was noticed in the sea waves ahead (the

swell being very low). Suddenly, the wind appeared to blow quite strongly, swirling around the vessel and then for as far as the eye could see and all around the vessel, phosphorescent cartwheels of bright-blue light began forming. The bands of light were roughly 30 cm thick while the maximum diameter of the wheels was 15-18 m.

"Their direction of movement seemed random and they were spinning at high speed, some chasing each other, others spinning in opposite directions next to each other, see sketch.

"Whole groups dumbbelled around each other, all spinning in apparently random directions. The display lasted for about 18 minutes before petering out." (R66)

Persian Gulf, 1995. The crew of the m.v. British Reliance encountered a complex of several marine light wheels of various sizes. Some were rotating clockwise, others counterclockwise, as indicated in the sketch. (X71)

A comment by P.J. Herring of the Southampton Oceanography Centre followed the above description.

"A quite extraordinary account of phosphorescent wheels occurring in one of the places where they are most often seen. In the 200, or so, cases of this phenomenon reported in the last 100 years, never have so many wheels been described so close together, nor has there been any association with wind change. I am very intrigued but at a complete loss to explain how the wheels were produced." (R66)

The random, sometimes playful, behavior of the above wheels reminds one of the actions of some of the spook lights cataloged in GLN1.

X72. November 3, 1997. Indian Ocean. Anadaman Sea. N. Fraser was on watch aboard an oil-rig supply ship headed toward Yangon, Myanmar. As the vessel approached the Gulf of Martaban, hundreds of patches of bioluminescence appeared all around the ship. They were flashing on and off synchronously at a frequency of roughly 80 cycles per second. Then:

"Suddenly, the entire surface of the water as far as we could see was pulsating with bright wands of light, a bit like the reflection of a strobe light at a disco. Being mystified we looked up at the sky expecting to see a hovering aircraft or a 'UFO'. But there was nothing in sight, no aircraft, yachts, lighthouses, fishing boats, nothing that could make these lights. This weird display lasted only five minutes when it turned off as quickly as it had started. I estimated that these wands of light were moving at about 100 knots. The interval between them was only a second or two." (R67)

After consulting the Mariners Handbook, Fraser decided that the features he called "wands" were actually the spokes of a giant wheel.

This is a rather typical marine light wheel, but worth adding to the collection because of the observer's allusion to a strobe light. The high speed of the spokes over the surface certainly suggests some sort of optical illusion rather than bulk physical motion of the light-emitters---almost certainly bioluminescent organisms.

X73. Overview. The scientist who has followed the saga of the marine light wheels most diligently in recent years is P.J. Herring. In 1985, Herring was associated with the Institute of Oceanographic Sciences in Surrey, England. In his lengthy review of the phenomenon, published in 1985 in the Marine Observer, Herring pulled together facts from almost 230 reports of light wheels, spirals, and moving parallel bands, (R69) Even though we have provided more-than-ample descriptions of the light wheels in X1-X72, Herring's article adds some important points which we now summarize.

The earliest report of marine light wheels came from H.M.S. Bulldog in 1875,

then becalmed off Vera Cruz, Mexico. It is rather ironic that the first record of the phenomenon originated in the Gulf of Mexico, where light wheels are very rare. The next sighting was from H.M.S. Vulture in the Persian Gulf, where such phenomena are common. (X1) Both the Bulldog and Vulture were sailing vessels with wooden hulls. All subsequent reports of light wheels originated from steel-hulled vessels equipped with engines. The observations from wooden sailing ships are important because they prove that the phenomenon does not derive totally from engine vibrations or the magnetic properties of the vessel.

Another historical point of interest is the relatively late appearance of marine light wheels in the literature. An associated bioluminescent phenomenon, "white-water" or "milky-sea," was remarked as early as 1785. (GLW9-X1) Why the time discrepancy when the phenomena are equally spectacular and frequent?

Even more remarkable is the complete lack of observations of this eerie and impressive phenomenon from small vessels, such as fishing boats, which for centuries have sailed the seas where marine light wheels are most common. Malaysian and Polynesian folklore and oral traditions likewise do not mention the phenomenon.

Marine light wheels can be a kilometer across and vividly bright. Yet, Herring has collected only a single observation from aircraft. This sighting took place in 1949 when two military aircraft at an altitude of 6000 feet over the South China Sea claimed that they had seen a fast-moving, wave-like luminous display on the sea surface below.

The above facts may appear to be minor but they suggest that the perception of rotating luminous wheels on the sea's surface may be partially a matter of perspective; that is, the phenomenon is seen fully developed only by observers located at certain heights above the water's surface.

The geography of marine light wheels is fairly well defined by Herring's files. He writes:

"Consideration of the positions of the various reports shows that there is a restriction to tropical regions, between 35°N and 25°S and that it is a predominantly Indo-Pacific phenomenon, 95 per cent of the observations occurring in this area. Even within this general region there are areas of particularly frequent reports. These are, the Persian Gulf and Straits of Hormuz (48 reports), the Gulf of Thailand (47), the South China Sea (42), the Strait of Malacca (26) and the coastal seas adjacent to Karachi (11), Rangoon (7) and Bombay (6). The number is inevitably biased by the frequency of shipping in different areas but a consistent pattern of distribution is clear. All of these areas are relatively shallow, with water depths less than 200 m, and the majority of other reports are from waters of similar depths, though a few are from deep water." (R69)

As for the source of the light in the displays, Herring has little doubt that it is of biological origin. Indeed, this is universally accepted. Electroluminescence, sonoluminescence, and nonbiological chemoluminescence have been considered, but none comes close to matching the characteristics of the light seen in the displays.

Even though the origin of the light in the light wheels is known, the source of the patterns remains mystifying. In 1960, German hydrographer K. Kalle theorized that the light wheels were created by the interference patterns of seismic waves emanating from the shallow depths beneath the bright display on the sea surface above. Wherever the seismic waves combined additively, the physical disturbance was great enough to cause bioluminescent organisms to emit light. (R69, R70) Kalle's rationale was good, but it is hard to conceive of seismic waves from several sources uniting in patterns of multiple, sharply defined, spoked wheels turning in various directions. Furthermore, some areas, such as the Gulf of Thailand, where marine light wheels are relatively common, are seismically quiet.

Interference patterns can also arise when a vessel's bow waves interact with wind-driven surface waves. If light from bioluminescent organisms rises from the depths, it may be refracted to form parallel bands of light---at least in theory. Rotating, spoked wheels, however, are more difficult to account for using surface waves. It is possible, some insist, that marine light wheels are illusions of perspective. In other words, the wheels may be evident only to those observers located at a certain height.

However, theory requires that such illusions based upon perspective yield only "half-wheels" to an appropriately placed observer. In actuality, complete wheels are the rule.

That the vessel itself may create or modify a display through the vibrations of its engines has been advanced. It is true that the frequency of many marine engines is about 100 Hertz, which is close to the flashing frequency of many bioluminescent displays. So far, though, no ship's captains have silenced their engines to see if the marine light wheels disappear or take on different appearances. Conceivably, engine vibrations might affect the rate of flashing but have no influence on the bioluminescent patterns.

We have scores of light-wheel observations prior to the advent of radar. So, electromagnetic waves are not necessary for the creation of the light wheels. Radar, however, is known to modify the patterns of some bioluminescent phenomena. (GLW7 for example) Pattern modification may, therefore, like engine vibrations, be separated from the origin of the display's light.

At the present time, we have only tentative theories for pattern-formation in bioluminescent displays, and it is this aspect that is really the core mystery of the phenomenon.

Neglected in Herring's review of possible causes of marine light wheels is the possibility that they might be stimulated and shaped by atmospheric electromagnetic phenomena, such as plasma vortices or low-level electric-discharges, such as those described in GLD and even GLA4. The eerie, mist-like appearance of bioluminescent displays and their apparent location above the water's surface are curiously like GLD phenomena and low-level auroras.

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GLW5 Expanding Phosphorescent Rings

Description. Whitish or greenish ripples of phosphorescence expanding from a central point at high speeds. Several centers may be active at the same time with different velocities of expansion. Ripples are usually circular, but one elliptical observation exists. This phenomenon appears in the same regions as the wheel-type display.

Data Evaluation. A rare phenomenon with only a handful of observations. Rating: 2.

Anomaly Evaluation. The simple geometry would suggest a simple disturbance that triggers bioluminescence; but the expanding rings travel too fast for water waves and too slowly for sound waves in water. The unknowns include: light source (usually assumed to be bioluminescence), and the origins of the geometrically precise, repetitive figures. Rating: 2.

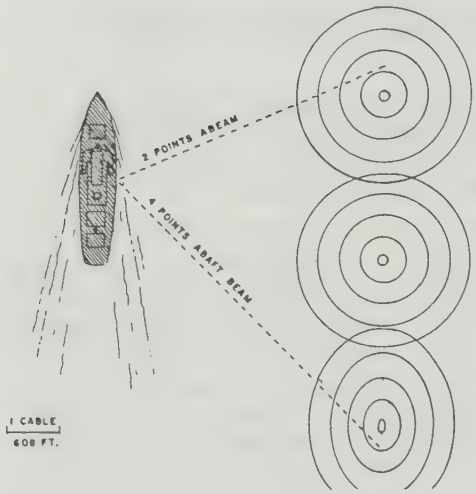
Possible Explanations. Interference patterns from seismic sources are the stimuli most frequently suggested, with bioluminescent marine organisms as the basic light producers. This explanation is strained by the observation of multiple sources synchronously emitting ripples. Electromagnetic action remains a possibility as does cooperative biological activity similar to that in tropical firefly displays (BIB).

Similar and Related Phenomena. Other marine phosphorescent displays (GLW), synchronized firefly displays (BIB), flashing volcanic arcs (GLD9-X2).

Examples of Expanding Phosphorescent Rings

X1. April 17, 1957. Persian Gulf. "...a strange effect was noticed on the sea surface about 2 miles away on the port bow. On approaching the area large bands or ripples of faint light appeared to be travelling in a confused way across the surface. Further inspection showed that these bands were spreading out from several central points distributed fairly evenly over an area about 2 miles across, in the same way as the circular ripples produced by raindrops in a puddle of water. Each band was about 70 yd wide and gave a faint white light. They spread, in unison, from the various central points, at intervals of little more than 1 sec. They travelled at a considerable speed, so that by the time one circular band was formed the previous one was vanishing, at a radius of about 1/2 mile. When first seen it was supposed that the effect was being produced by moon shadows, as the moon was at an altitude of about 35° in the west, and there was a large number of small misty clouds. The clouds were, however, all moving in the same direction and could not have produced the effect of localised circular ripples. There was some general phosphorescence in the water but the presence of moonlight made observation of this difficult." (R1)

X2. October 14, 1960. Gulf of Oman. "At 2130 GMT three very fast outward-moving rings of light were seen emanating suddenly from three separate vortices which were spaced about three cables apart in a straight line parallel to the ship's fore and aft line, and about five cables distant on the starboard side: the positions of the vortices in the water appeared to remain unchanged. The first two appeared almost simultaneously and produced circular rings, at a frequency of about one second or slightly less. The third appeared a minute or so later and produced elliptical rings which were moving much faster than the others. They appeared about 2 points forward of the starboard beam and disappeared about 4 points abaft the beam. Their disappearance was more or less simultaneous. Although the individual patterns tended to cut across and overlap each other at places, they did not become confused, nor were they stopped by the ship's hull, as the rings could be clearly seen to pass from starboard to port when in line with the bridge. There was bright moonlight, and it was therefore fairly certain that there was no disturbance on the surface at any time, such as might be caused by jumping fish, etc." (R2)



In 1960, in the Gulf of Oman, three sets of expanding rings appeared---two were circular, one elliptical. (X2)

X3. April 23, 1955. Persian Gulf. Concentric circles seen radiating from a center. Full description in GLW4-X31. (R3)

X4. March 12, 1970. South China Sea. Curved bands of luminescence seem to radiate from a center beyond the horizon. (R4)

X5. May 9, 1983. Indian Ocean, Gulf of Oman. Aboard the m.v. Mahsuri out of Bandar Abbas for Fremantle.

"At 1650 GMT, a pale green glow was seen to emanate from the horizon ahead. This gave the appearance of strong moonlight upon the surface of the water. The moon, however, was not in evidence. At 1700 GMT, rapid flashes of light were observed sweeping across the sea directly ahead of the vessel, giving the initial impression of a sudden increase of wind speed causing excessive spray. By 1715 GMT, the vessel was totally surrounded by completely random movements of light as far as the eye could see. The onset of this phenomenon was so rapid, not to say eerie, that the Master was called to the bridge to witness the event. For the next 15 minutes the sea was at a height of activity, displaying several systems of the most unusual bioluminescence. The most significant of these were what appeared to be Phosphorescent Wheels, which, although they did not seem to rotate, originated from a central hub and spread out rings in rapid succession, forming concentric circles. This was pointed out by many of those who observed them as being similar to the instance of a stone being dropped into a quiet pond and causing waves to spread out. In this case each wave crest was a band of fantastic light. Each wheel would last for a couple of minutes, continually flashing out bands of light as though a transmitter was located at its centre. Wheels could be observed in all directions. At the same time systems of moving parallel bands could be observed, again travelling in totally random directions with respect to each other and passing off into the distance, only to be followed by another set." (R5)

The complexity of the display was so great that it confused the eyes of the observers. Of particular interest was the fact that the centers of the wheels seemed to keep pace with the ship. Sometimes parallel bands of light were seen emanating from the side of the vessel itself, as if it was the center of one of the wheels!

The light bands were 3-5 meters wide; the parallel bands at least 160 meters long. Circle diameters ranged from 3 to perhaps 200 meters. Flashes occurred less than a second apart and were pale green with a touch of gold.

At 1740 GMT the vessel passed out of the display and seemed to cross a distinct line. On one side of it displays were active, on the other all was dark. Eventually, the light disappeared astern over the horizon. (R5)

In this remarkable display, we see once again the possibility that the ship itself may play a role in determining the character and development of the display, even though it did not initiate the bioluminescence. See GLW4-X73 for additional thoughts on this matter. Another feature that is hard to account for is the existence of a sharp dividing line between the region of vigorous displays and the dark surrounding area completely devoid of bioluminescent activity.

X6. March 26, 1993. Indian Ocean. Persian Gulf, Strait of Hormuz. Aboard the m.v. Liverpool Bay, enroute Jeddah to Jebel Ali. The Chief Officer and ship's company were witnesses to an incredible display of expanding luminous rings.

"At 1540 UTC while the vessel was transiting the Strait of Hormuz westbound, within the Traffic Separation Scheme, it was strangely illuminated for several minutes by what turned out to be bioluminescent organisms. Bearing in mind the size of the vessel and the height of the containers above the water (about 25 m) the intensity of the light produced was remarkable.

"The first appearance could only be described as something out of a science fiction novel, as the vessel moved through a wave-like form of light which initially appeared to be above the water in the pitch-black night. Shortly afterwards an area to port at a distance of several hundred metres exhibited an even more amazing display of concentric circles emanating from a single point; the starboard side maintained the more broken wave form but retained the same intensity of light. The vessel and deck containers were illuminated by an eerie and variable glow." (R6)

The expanding-concentric-rings displays, like the marine light wheels (GLW4), also seem to be presaged by parallel bands of bioluminescence. We also find once more the firm impression that some of the luminous phenomenona occur above the water where there should be no bioluminescent microorganisms.

X7. November 22, 1993. North Atlantic Ocean off the northwest coast of Africa. The m.v. City of Durban was sailing through patches of bioluminescence when six luminous rings appeared about 200 meters off the port side. The rings were just over a meter in diameter and had dark centers. They did not rotate or expand, although some did become elongated. (R7)

Although this entry does not possess the key GLW7 attributes of expanding and concentric rings, it was observed in the North Atlantic, rather than the Indian Ocean or South China Sea. Only rarely does one see structured bioluminescent phenomena in the Atlantic, and then the renditions are only feeble copies of those reported in the Indo-Pacific waters farther to the east, albeit at the same latitudes. Why the difference?

See X8 for another example of luminous rings that appeared in almost the same location in the North Atlantic. This apparition, too, was an impoverished example of the ring systems seen in the Indian Ocean and South China Sea.

X8. November 22, 1993. North Atlantic Ocean off the northwest coast of Africa. As observed from the m.v. Berlin Express out of Rotterdam for Fremantle. At the same longitude as the City of Durban (X7) but about 5½° farther south. In this sighting, the circles were much larger than those in X7 (5-30 meters in diameter), were much brighter, and were expanding. However, they appeared singly and were not concentric displays. (R8)

It seems probable that the rings described here and in X7 have an origin different from the typical expanding, concentric rings.

X9. October 13, 1996. Indian Ocean. Persian gulf. As seen from the tanker Arabiyah. Expanding phosphorescent rings were observed emanating from a single point. These rings were equally spaced and expanded outwards for about 500 meters before disappearing. Rings with spoke systems also formed, rotating clockwise. The observers had the distinct impression that the rings were above the sea surface. (R9)

Concentricity was not mentioned in this report but may have been present.

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GLW6 Phosphorescent Patches Moving in Circles

Description. Circular patches of light moving in large circular patterns. Several such displays may be active simultaneously.

Background. This phenomenon may be a degenerate form of the phosphorescent wheel (GLW4).

Data Evaluation. One observation of good quality. Rating: 2.

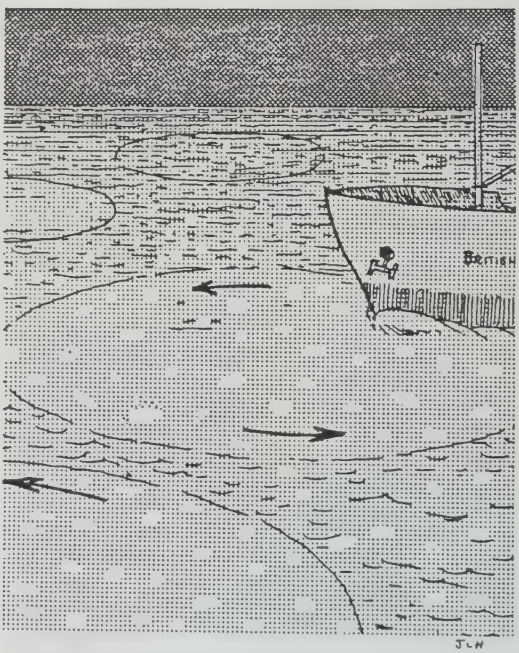
Anomaly Evaluation. See the discussion under marine phosphorescent wheels (GLW4), which is applicable here. It is, however, more difficult to conceive of interfering seismic waves creating patterns of several groups of circling circles of phosphorescence. Rating: 2.

Possible Explanation. This type of display makes seismic interference patterns look less likely, leaving some bizarre form of cooperative action of bioluminescent organisms as a better bet.

Similar and Related Phenomena. Marine phosphorescent wheels (GLW4).

Examples of Phosphorescent Patches Moving in Circles

X1. May 30, 1956. Persian Gulf. After a display of moving parallel bands. "The parallel line formation disappeared and the patches were seen to be moving fairly slowly in an anticlockwise direction round circles of from 100 ft to 300 ft in diameter. When the vessel passed through a circle the patches of light disappeared on reach- the ship's port side and reappeared in the same formation on the starboard side. After about 20 min the whole effect ceased near the ship but was still seen in the distance on the starboard quarter.... After a further 15 or 20 min more circles appeared, of varying sizes. The patches on the starboard side were small, about 1-2 ft in diameter, and were rotating in circles of about 20 ft diameter. After 10 min these dropped astern and no further phosphorescence was seen." (R1)



Persian Gulf, 1956. Several groups of luminous patches were seen. The patches were 100-300 feet in diameter and were rotating counterclockwise. (X1)

Reference

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GLW7 Phosphorescent Spinning Crescents

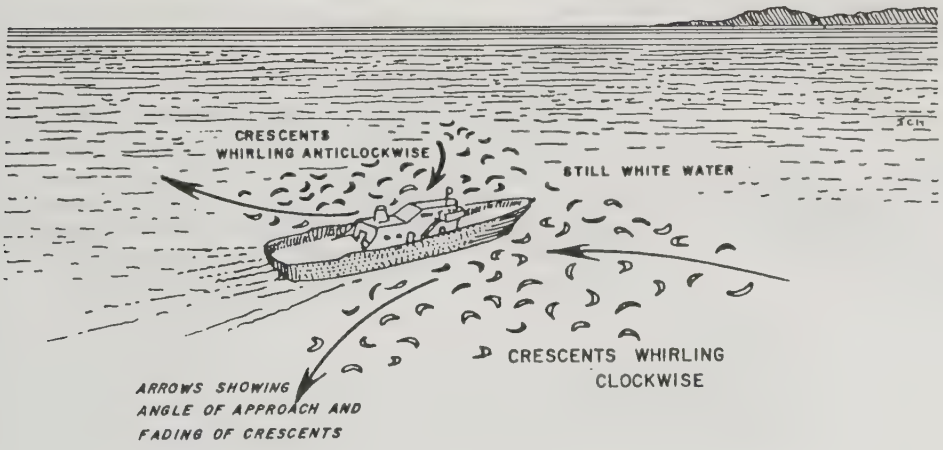
Description. A bizarre phosphorescent display consisting of rotating crescents of light centered on the ship and sweeping toward the ship or rotating around it. Observed on both sides of the observing ship, the crescents may reverse their directions of rotation at some point in their trajectory. The display characteristics seem to be bilaterally symmetric; i.e., mirror images bisected by the ship's axis. The ship's radar may influence this phenomenon.

Data Evaluation. Several observations, all slightly different, possess enough similar features to be collected in this category. The phenomenon is variable and not clear cut. Rating: 2.

Anomaly Evaluation. Most marine phosphorescent displays are not ship-centered. Here, some influence emanating from the ship seems to stimulate the phenomenon. Whatever the mechanism involved, it is not at all obvious how it creates this strange moving pattern of spinning crescents. Rating: 2.

Possible Explanations. One or more of three ship-created 'forces' may be involved: (1) the radar; (2) the engine noise transmitted through the water; and (3) the physical disturbance of the water (eddies, etc.) caused by the ship's motion. The last influence can probably be eliminated because the phenomenon commences far from the ship's wake. The engine noise is an unlikely candidate because the effect is rare in a region plied by thousands of ships with engines. This leaves the ship's radar as an attractive possibility, perhaps inferring that other phosphorescent displays may involve electromagnetic stimulation, perhaps of specific frequencies and/or repetition rates, natural or artificial. Certainly seismic tremors cannot account for all facets of these complex, ship-centered displays.

Similar and Related Phenomena. All other marine phosphorescent displays, especially GLW10.



A ship's radar initiated a display of spinning crescents in the Gulf of Oman in 1951. (X1)

Examples of Spinning Crescents

X1. November 30, 1951. Gulf of Oman. "The ship's radar apparatus had been switched on with a view to checking her position, when, in the same instant that this gear became operative, most brilliant boomerang-shaped arcs of phosphorescent light appeared in the sea, gyrating in a clockwise direction to starboard and anticlockwise to port, but all sweeping inwards towards the ship from points situated from five to six points on either bow and some two miles distant, and conveying the impression that they ricocheted from each other on meeting at the ship's bows and then turned and travelled away astern to similar points which were equidistant on either side and about four points on each quarter."(R1)

X2. July 10, 1979. Arabian Sea. "At 1200 GMT large patches of milky-grey bioluminescence were observed; the patches appeared to form circular patterns resembling cartwheels, some of the configurations, however, did not have the central hub, see sketch. The patches pulsated at regular intervals (3 or 4 times per second). They moved in an anticlockwise direction until about 3 points abaft the beam where the direction of movement was reversed. On the beam they appeared to be at eye level, at all other times they were just above the surface of the water. The average size of the 'wheels' was 35 metres. The phenomenon was observed for about 10 minutes, the pattern of the 'wheels' in the most dense areas was confused." (R2)

X3. July 11, 1980. Malacca Strait. "At approximately 2200 GMT a phenomenon similar to phosphorescent wheels was observed. The phenomenon did not seem to build up slowly, but just appeared. It took the form of curved lines of uniform crescent shape which were horizontal to the sea surface, moving in a circular path around the ship starting from just forward of the bow. The speed of the lines was hard to estimate but was in the order of three lines passing a point every second. This high speed gave the impression of pulsating light. The lines were about 100 metres long, 0.5 metres wide and appeared to some to be light green in colour although to the others they appeared silvery-white. There was some disagreement about the position of the phenomenon as to whether the lines were on the surface of the sea or above it. The phenomenon seemed to be centred about the ship and could not be seen for more than 100 metres on either side and astern, also the whole system appeared to be moving along with the ship. After about 5 minutes the lines faded away over a period of 1/2 - 1 minute." (R3)

Arabian Sea, 1979. Groups of luminous crescents were observed rotating about different centers in the Arabian Sea in 1979. Groups averaged 35 meters in diameter. (X2)

References

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R3. Lardler, D.A.; " Bioluminescence," Marine Observer, 51:116, 1981. (X3)

GLW8 Zigzag Phosphorescent Flashes

Description. Zigzag flashes of phosphorescence moving lightning-like across the surface of the sea.

Data Evaluation. So far, only a single observation. Rating: 3.

Anomaly Evaluation. The propagation of simple patterns of light by bioluminescent organisms, either through cooperative action or external stimulus, is not an unreasonable phenomenon. A simple circle of expanding light, for example, would be understandable. But the lightning-like propagation of well-defined zigzag flashes is hard-to-explain. Rating: 2.

Possible Explanations. Cooperative bioluminescent activity is about the only possibility, unless some form of low-altitude electromagnetic activity stimulus exists.

Similar and Related Phenomena. All other marine phosphorescent displays, particularly the te lapa (GLW11), heat lightning (GLL).

Examples of Zigzag Phosphorescent Flashes

X1. August 30, 1949. Gulf of Çutch. "In vicinity 22° 30'N., 68° 10'E., at mouth of Gulf of Cutch, brilliant phosphorescence in lightning-like zig-zag form was observed in patches of about a square mile each. These patches seemed to have a slight directional movement WNW, but the zig-zag phosphorescence flashed from left to right in a WNW-ESE direction." (R1)

References

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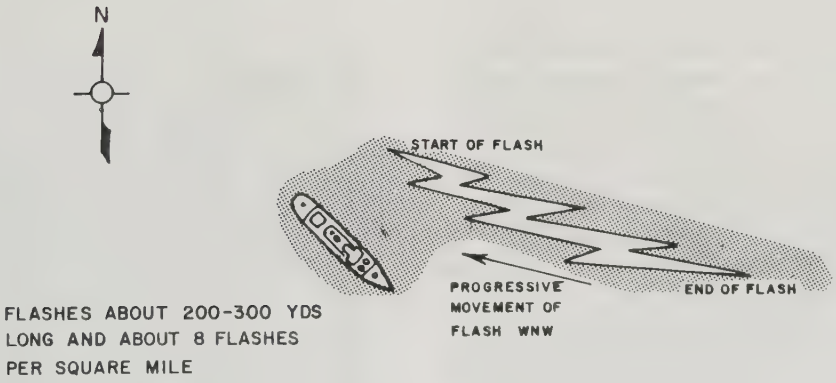


Lightning-like flashes of marine phosphorescence were reported in the Gulf of Cutch in 1949. (X1)

GLW9 White Water or Milky Sea

Description. A white phosphorescent display consisting of a soft but often brilliant luminous sea stretching for many miles. The milky sea has often been compared to a field of snow, during which the horizon may seem to disappear much as it does during arctic white-outs. The sea's surface often seems subdued during this eerie spectacle, although the motion of the ship indicates that this is not so. In some instances, the light seems to come from great depths as if from huge underwater searchlights. At other times, there seems to be a luminous fog or mist above the water surface. Milky seas can appear suddenly over a wide region. They may wax and wane over periods of several hours. The geographical distribution of milky seas is much wider than for the phosphorescent wheels, being found in all oceans at any season. Nevertheless, they seem to concentrate in the Arabian Sea during summer months.

Background. Milky seas should not be confused with ordinary bioluminescence of the sea which occurs when water is agitated by a vessel, fish, waves, etc.

Data Evaluation. Many excellent observations over two centuries. Rating: 1.

Anomaly Evaluation. The prevailing assumption is that the milky sea is produced by bioluminescent organisms, possibly bacteria, but no specific organism has ever been implicated. No one has suggested the names of any species known to be present in immense numbers and capable of producing bright, sustained light for hours. Further, water drawn from a milky sea frequently shows no bioluminescence whatever. To compound the problem, some milky seas seem lit from the depths while others derive from a luminous mist above the surface. Manifestly, there is much to learn about this phenomenon. Rating: 2.

Possible Explanation. Despite the deficiencies noted above, bioluminescence is certainly the most likely explanation.

Similar and Related Phenomena. All other marine phosphorescent displays (GLW), luminous fogs and mists (GLA21).

Examples of White Water or Milky Sea

X1. July 31, 1785. North Atlantic Ocean. "About a quarter past 7 P. M. the sea was observed to be remarkably white. The sky was every where clear, except around the horizon, for about 15°, where it was covered with a dark haze, as is usual in such latitudes. The whiteness gradually increased till past eight. The sea then was as high coloured as milk, very much resembling the milky-way in the heavens; the luminous appearance of the sea resembling the brighter stars in that constellation. It continued in this situation till past midnight, and only disappeared as day-light advanced. The whiteness prevented us from being able to see either the break or the swell of the sea, although both were considerable, as we knew from the motion of the ship, and the noise. There was much light upon deck, as we could discern all the ropes much more distinctly than usual. We drew several buckets of water, in which, even when at rest, there appeared a great number of luminous bodies." (R1)

X2. September 7, 1826. Gulf of St. Lawrence. "The night was star lit, but suddenly the sky became overcast in the direction of the high land of Cornwallis county, and a rapid, instantaneous and immensely brilliant light, resembling the Aurora Borealis, shot out of the hitherto gloomy and dark sea on the lee bow, and was so vivid that it lighted every thing distinctly, even to the mast head. The mate, having alarmed the master, put the helm down, took in sail and called all hands up. The light now spread over the whole sea between the two shores; and the waves, which before had been tranquil, now began to be agitated. Capt. B. describes the scene, as that of a blazing sheet of awful and most brilliant light. A long and vivid line of light, superior in brightness to the parts of the sea not immediately near the vessel, showed us the base of the high, frowning and dark land abreast of us; the sky became lowering and intensely obscure. The oldest sailors on board had never seen anything of the kind

to compare with it, except the captain, who said that he had observed something of the kind in the Trades. Long tortuous lines of light in a contrary direction to the sea, shewed us immense numbers of very large fish darting about as if in consternation at the scene. The spirit-sail yard and mizen-boom were lighted by the reflection as though gas lights had been burning immediately under them; and until just before day break, at four o'clock, the most minute objects in a watch were distinctly visible. Day broke very slowly, and the sun rose of a fiery and threatening aspect. Rain followed." (R2)

X3. 1871. South Atlantic Ocean. (R3)
X4. January 26, 1874. Arabian Sea. (R4)
X5. Fenruary 9-13, 1880. Arabian Sea. The sea resembled a field of snow on a clear night. (R5-R7)
X6. February 1, 1881. Indian Ocean. (R8)
X7. August 22, 1898. Indian Ocean. (R9, R10)
X8. May 1899. Indian Ocean. (R11)

X9. March 18, 1924. Indian Ocean. "A remarkable combination of submarine earthquake and phosphorescent seas has been reported to the Hydrographic Office. The stirring up of the ocean brought so many light-emitting organisms to the surface that the British steamer Trefusis on her way from Aden to Columbo seemed to be steaming across a snow-covered plain. It was during the middle watch of March 18, a dark night, quiet sea, and as usual in the northern Indian Ocean, the wake of the ship rather brilliantly phosphorescent while the rest of the sea was dark. Just before four o'clock a distant tremor was felt, followed quickly by others, as if a series of mines were being set off at great depths. Immediately, great patches of light rose to the surface and spread in all directions until for miles around the ship the whole ocean was a brilliant foaming glitter of phosphorecence, the pale blue glow lightning the deck of the vessel with a wierd light." (R12)

X10. August 27, 1925. In the East Indies. The whole sea was suddenly illuminated by a soft, lambent light. (R13)

X11. February 9, 1926. China Sea. The sea appeared to be illuminated from below. (R14)
X12. October 4, 1926. South Atlantic Ocean. A milky sea disappeared during two stormy periods, reappearing afterwards. (R15)
X13. August 12, 1928. Arabian Sea. (R16, R17)
X14. August 14, 1928. Banda Sea, South Pacific Ocean. (R16)
X15. July 31, 1929. Arabian Sea. (R17)
X16. August 2, 1929. Gulf of Aden. (R18)
X17. August 20, 1930. Gulf of Aden. (R19)
X18. August 28, 1930. Arabian Sea. (R19)
X19. June 10, 1931. Persian Gulf. (R20)
X20. August 28, 1933. South Pacific Ocean. The sea was lit from below---not surface phosphorescence. (R21)
X21. August 28, 1946. Arabian Sea. The sea appeared calm, but this was contradicted by the motion of the vessel. (R22)
X22. February 1, 1952. Arabian Sea. (R23)

X23. August 15, 1953. Arabian Sea. "At 1823 milky phosphorescence was observed of a slight greenish colour, which had the same light value as the sky so that the horizon was difficult to discern. At 1830 the phenomenon brightened suddenly to a full milk-white. Spray looked darker than the surrounding sea. At 2004 the luminous appearance of the sea ceased abruptly, although a glow could be seen in the sky ahead. The appearance of the sea at 1823 and 1830 was repeated at 2023 and 2045 respectively. The full milk-white appearance reached maximum brightness at 2103 when the horizon was very sharply defined. At 2133 the brightness commenced to fade again until the light values of sea and sky were the same. More variations of brightening and fading occurred again from 2200 to 2203, but at 2219 the phosphorescence brightened so that the horizon was easily discernible, and these conditions remained much the same until 2320 when it all ceased abruptly.... It was noted that the phosphorescence was not carried aboard by spray, this appeared dark against the background of the sea. During the brightest periods the phosphorescence completely masked the wave crests and gave the sea an appearance of unnatural calm at once belied by wind, motion of the ship and spray coming aboard." (R24)

X24. August 19, 1958. Arabian Sea. (R25)
X25. February 8, 1962. Indian Ocean. One could read a book on the bridge by the light of the sea. (R26)
X26. July 30, 1971. Arabian Sea. (R27)
X27. January 6, 1976. Indian Ocean. (R28)
X28. January 23, 1976. Indian Ocean.(R28)
X29. January 25, 1976.Indian Ocean. (R28)
X30. July 22, 1976. Arabian Sea. (R29)
X31. July 30, 1976. Indian Ocean. (R29)

X32. August 4, 1977. Indian Ocean. "At 1735 the vessel encountered a very large area of milky sea, the area stretched as far as the horizon. The intensity was so great that the deck appeared to be just a black shadow. There was an apparent increase in humidity and a small number of fish together with a small amount of seaweed were observed. During the phenomenon the Radio Officer reported a decrease in signal strength on HF and static on MF frequencies. The intensity of the phenomenon decreased for five minutes at about 1800, thereafter, it increased again and was observed until 1911." (R30) Radio reception may be suppressed during low-level auroras (GLA20-X2).

X33. August 12, 1977. Timor Sea, South Pacific Ocean. (R30)

X34. September 6, 1977. Indian Ocean. "At 1830 GMT an area of bioluminescence, which had the appearance of white sea fog, was observed to the west of the vessel. About 20 minutes later, when the vessel entered the affected area, a diffuse milky light effect was observed just above the sea surface. The sea was clearly visible, but the white horses were noticably reduced in brightness. No effect was observed on the bioluminescence when the Aldis lamp was switched on. At its brightest the phenomenon was sufficient to illuminate the clouds. There was no moon that night, the luminous effect was, therefore, due entirely to the phenomenon. The bioluminescence began to reduce in intensity at about 2100 and was no longer observed about half an hour later. A sample of sea-water was taken and was observed to be clear and normal. It was also noted that the water showed no response when exposed to a fluorescent ultra-violet light." (R30)

X35. September 16, 1977. Arabian Sea. (R30)
X36. General observation. White water phenomenon sometimes seems like a luminous fog in which sea and sky seem to join, and all sense of distance is lost. (R31)
X37. General observation. Observations of white water seem to be concentrated in the Arabian sea during August. (R32)
X38. General observations. (R33)

X39. Circa 1811. Indian Ocean. We have here another very early record of a milky sea. Note that this entry and X1 (a 1785 observation) precede the first marine-light-wheel sightings by some two centuries.

"One evening we were surprised by a singular phenomenon, which gave rise to many conjectures, though without any satisfactory solution as to its cause. About 8 o'clock in the evening, the sea as far as the eye could distinguish, became, nearly, all at once, like milk, or rather resembling a thick solution of chalk in water; the surface was quite unruffled; neither was there the slightest mixture of that luminous or phosphoric appearance often observed at night during the agitation of the sea. It continued for several hours, the sky at the same time being clear, and in the stillness of the evening, the effect could not be otherwise than uncommon;--- floating on an ocean seemingly of milk, was a novel, and certainly a most unusual spectacle. I do not recollect to have read of anything similar in the narratives of voyagers; and have exhausted all my conjectures respecting the agency of the land and the water, the sky and the atmosphere in producing it, but in vain. I may add, however, that not the smallest peculiarity was observable in the water, though repeatedly drawn up and examined." (R34)

Note that in his exposition of the phenomenon, Prior separates the milky-sea display from the bioluminescence so common in tropical waters. The implica-

tion is that milky seas may have an origin that is quite different, although probably still of a biological nature.

X40. June 1854. Indian Ocean south of Java. Aboard the American clipper Shooting Star. Captain Kingman reporting---colorfully:

"The whole appearance of the ocean was like a plain covered with snow. There was scarce a cloud in the heavens, yet the sky...appeared as black as if a storm was raging. The scene was one of awful grandeur; the sea having turned to phosphorus, and the heavens being hung in blackness, and the stars going out, seemed to indicate that all nature was preparing for that last grand conflagration which we are taught to believe is to annihilate this material world." (R36)

We selected this account of the milky-sea phenomenon because of its vivid verbiage---something absent from the modern reports.

X41. January 30, 1902. Indian Ocean. The sea was white as snow, and the horizon black. (R37)

X42. August 13, 1925. North Atlantic Ocean off the northeast coast of Africa. P. Hawkins, Second Officer of the S.S. Somersetshire, reported a fairly typical episode of milky sea, but he added, with emphasis, some interesting supplementary observations that may have a bearing on the origin of the phenomenon.

"A white line seemed to be coming toward the ship at a tremendous speed from the eastward, which had the appearance of breakers. Very shortly after, the whole sea was quite white, with now and again circular and streaky black patches, and the whole surroundings were brilliantly lighted up.

.....

"During this time (9:20 P.M. till 10:40 P.M.) the atmospheric conditions were extraordinary. No sound was heard, not even the wind nor the breaking of the sea. No swell was visible, which had previously been rolling heavily, had practically no movement on her. In fact, one could almost have been in dock." (R39)

In other words, the complete milky-sea phenomenon may also encompass sea-state and atmospheric conditions. But in what ways?

X43. October 1931. North Atlantic Ocean. The "milky sea" phenomenon is far from rare in the Indian Ocean. As of 1993, scientists had accumulated 235 observations of these eerie luminous displays. Almost all of these observations come from the Indian Ocean, particularly the northwestern section. This exclusive nature of the milky sea makes the following observation from the North Atlantic in 1931 all the more remarkable.

"A phenomenon on the Atlantic resembling a 'sea of milk' has just been reported to the local hydrographic office by A.V. Potter, third officer of the British steamship Asphalion.

"Steaming into a heavy southwest swell, the Asphalion was recently in the Atlantic at Lat. 12 degrees 51 minutes N., Long. 54 degrees 55 minutes W. when rough broken seas were met, Potter reported. The water, however, appeared to be smooth, because each combing breaker left a shadowless wake of white, boiling water.

"'The expanse of water had every semblance of a sea of milk,' he reported. The phenomenon continued for five hours, throwing the horizon of ink-black sky and milky sea into bold contrast." (R40)

X44. March 3, 1933. Kamaisi, Japan. Following the great earthquake on this date, there were numerous reports of bright light radiated from the sea. (R41, R42) It is not clear that these luminous apparitions are generically related to the milky-sea phenomenon. They might be earthquake lights. (GLD8)

X45. No date given. Okhotsuk Sea, Japan. The "mysterious light in the Okhotsuk Sea," mentioned in some popu-

lar publications, was discovered by the crew of the Japanese training ship Unyo-mara. The light was so strong that it illuminated the top of an 80-foot mast. Those on deck could read newspapers. Water collected revealed the presence of bioluminescent organisms. (R42)

X46. November 14, 1961. North Pacific Ocean. A report from L.M. Smith, Third Officer of the S.S. C.E. Dent told of a 5-mile stretch of milky sea accompanied by strange atmospheric conditions.

"At 1430 G.M.T., November 14, 1961, on passage from Midway Island to Yokohama, course 270°, speed 20.7 knots, a rather ghostly haze was found to have enveloped the area around the ship. The sky overhead was clear but the haze around the horizon had a strange effect on bodies near the horizon. Canopus, for instance, appeared to have its light magnified a thousandfold and its reflection on the water to the south of the ship was equal to that of a full moon. A 10-12 knot wind from the southeast had been blowing, but now everything was still. No breeze, nothing but a smoothly rippled ocean surface. It was then noted that the sea was filled with luminescent particles. (R43)

Another example of a connection between weather and the milky sea.

X47. July 31-August 1, 1981. Indian Ocean, Arabian Sea. At 2036 GMT, the sea suddenly turned milky-white. This continued until 0100 GMT the next day. (R44)

X48. July 31, 1981. South Pacific Ocean. Chilean coastal waters. At 0025 GMT, the m.v. Oropesa passed an extensive area of sea that glowed with a pale, milky light. (R45)

X49. August 1, 1981. Indian Ocean, Arabian Sea. The m.v. Mena spent 4 hours transiting an area of milky sea about 45 n. miles in extent. The display began at 2130 local time.

One should remark that the three appearances of milky sea (X47-X49) were close time-wise but geographically separated. The Oropesa was on the other side of the planet, while the other ships were roughly a degree each of latitude and longitude apart. Interesting, but not too much should be made of this.

X50. August 13, 1986. Indian Ocean, Arabian Sea. The entire sea surface took on an intense white glow which was not unlike viewing the negative of a photograph. (R36)

X51. September 3, 1989. Indian Ocean, Arabian Sea. A horizon-to-horizom "snow scene." A sharp line separated the milky sea from the normal sea. (R47)

X52. August 18, 1990. Indian Ocean. A report from the Captain of the m.v. Benalder, enroute from Singapore to Jeddah.

"18 August 1990. At 1640 UTC the sea surface was noticed to have a white appearance which at first was thought to be low-lying fog. This theory was disproved when shining a light in the water gave no noticeable increase in luminance.

"The phenomenon extended to the horizon in all directions and was bright enough to make the ship's foredeck and the sky appear much darker than the sea. Its appearance and disappearance was gradual apart from an area of normal sea which was passed about five minutes before the phenomenon faded away by 1725." (R48)

X53. January 25, 1995. Indian Ocean Aboard the S.S. Lima, Juaymah to Rotterdam. Third officer, S.M.F. Masud, and others of the ship's company observed another instance of one of the sea's more enigmatic phenomena.

"At 1800 UTC on a clear moonless night while 150 n.mile east of the Somalian coast a whitish glow was observed on the horizon and, after 15 minutes of steaming the ship was completely surrounded by a sea of milky-white colour with a fairly uniform luminescence. The bioluminescence appeared to cover the entire sea area, from horizon to horizon but above the surface, and it appeared as though the ship was sailing over a field of snow or gliding over the clouds.

"There was no damping effect on

capillary waves or reduction of visibility at all and there was no mist at deck level although at a distance it seemed as if there was either low-lying mist or the upwelling of the luminescence itself. The bow waves and the wake appeared blackish in colour and thick black patches of oil were passing by. Later, the Aldis lamp revealed that the 'oil patches' were actually light-green kelp, amazingly black against the white water." (R49)

A water sample contained many single-celled microorganisms, but they displayed no luminescence. After 6 hours, the luminescence disappeared.

Commenting on this report, P.J. Herring, of the Southhampton Oceanography Centre, said that milky seas are most often associated with the Southwest Monsoon. This one was was rare in that the Northeast Monsoon prevailed. His final remark was: "The mystery of its cause remains unsolved." (R49)

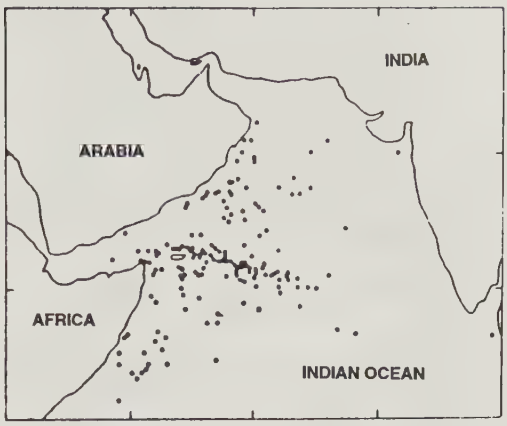
X54. September 2, 1997. Equatorial Pacific Ocean, Molucca Sea. The entire sea surface resembled a sea of milk. The water was so bright that the sky seemed dark. (R50)

X55. July 16, 1996. Indian Ocean. The sea was so bright that the ship's hull could be seen to a depth of several meters. (X55)

X56. Overview. The milky sea is a rather common phenomenon. In fact, the British Meteorological Office has established a Bioluminescence Database, which presently [1993] contains 235 reports of milky seas seen since 1915. P.J. Herring and M. Watson have employed this Database in a review paper on these impressive displays.

Geographical plotting of the reports shows a strong concentration in the northwest Indian Ocean (see figure). Seasonally, there is a strong peaking in August and a secondary blip in January. The phenomenon is independent of water depth and distance from land.

Surely bioluminescent organisms must be the explanation for milky seas. But most such organisms simply flash briefly and are incapable of generating the strong, steady glow of the milky sea.



Milky-sea reports are most common in the northwest Indian Ocean. (X56)

Marine bacteria alone glow steadily. However, calculations show that unrealistic concentrations of bacteria would be needed to generate the observed light. Furthermore, samples from the affected waters show no such bacteria. Herring and Watson admit there is no acceptable explanation of the milky sea. What, they ask, is so special about the northwest Indian Ocean? Why do milky seas not occur in the adjacent Red Sea and Persian Gulf? These bodies of water seem equally promising. (R36, R52, R53)

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GLW10 Radar-Stimulated Phosphorescent Displays

Description. The initiation or enhancement of marine phosphorescent displays by radar.

Data Evaluation. The few examples that exist involve somewhat different circumstances, but a tentative causal connection seems justified. Rating: 2.

Anomaly Evaluation. Since there is no recognized connection between radar and marine phosphorescence, this phenomenon has more than usual interest. Rating: 2.

Possible Explanation. The bioluminescent organisms which supposedly cause marine phosphorescent displays may, in fact, be stimulated by electromagnetic fields. If this is the case, this phenomenon supports the suggestion that some displays may be controlled by natural electromagnetic forces.

Similar and Related Phenomena. The detection of marine phosphorescence by radar (GLW14), the resemblance of marine phosphorescent displays to some auroral phenomena. (GLA4, GLA21)

Examples of Radar-Stimulated Phosphorescent Displays

X1. February 9, 1953. Gulf of Oman. "Between 0130 and 0200 white patches of light were observed on the sea surface. Milky-white patches were first noticed on the starboard beam about 2 cables away and appeared to 'flash' about once every second. Later they moved closer to the ship, being as bright as a phosphorous patch, although there was no indication of phosphorescence in the water even when the ship's wake broke into the patches. The patches had many different movements, each one continuing for a minute or so---rotary, clockwise and anticlockwise---towards the ship in waves and away from it in waves parallel to the ship's course. During the entire time of observation the period of reaching maximum brilliance and fading was about 1 sec, giving a regular flashing appearance. At 0152 the waves reached their maximum brilliance, appearing to travel from the starboard quarter to the port bow. On switching off the radar the phenomenon ceased abruptly close to the ship, but it was still faintly discernible on the port beam about 2 cables away. At 0157 the radar was switched on again, the phenomenon did reappear close to the ship but only faintly, and soon disappeared altogether. Nothing was observed on the radar screen during this time that was out of the ordinary." (R1)

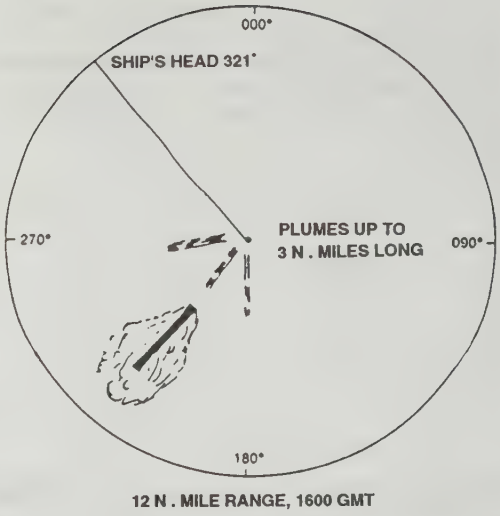
X2. March 4, 1955. Solomon Islands. "At 1707 GMT the vessel was bound north and in the vicinity of Savo Island when it passed through an area of oval patches of phosphorescence. An amber light appeared to come from beneath the surface which was found to be pulsating 94 times per minute in direct time to the ship's engine revolutions, but not simultaneously with them. The progressive form of the phenomenon was as follows: 1700 GMT Radar in use, no phosphorescence observed; 1705 First patch sighted on starboard bow, about 1 mile distant, with appearance of breaking reef; 1707 Radar in use, an increasing number of flashes seen, covering a field up to 2 miles from the ship; 1710 Vessel surrounded by flashes of intense light and visibility reduced; 1715 Radar in use, fewer lights, less intense and dying out; 1725 Radar off, no phosphorescence visible; 1726 Radar in use, phosphorescence observed close to, and encircling, ship; 1730 Radar in use, phosphorescence diminishing; 1800 Radar in use, no phosphorescence observed. At no time was any effect visible on the radar screen. The patches were about 50 ft. in length, and the strongest light came from the end furthest away." (R2, R3)

X3. November 30, 1951. Gulf of Oman. The instant the ship's radar was switched on, rotating, crescents of phosphorescence appeared. See GLW7-X1. (R4)

X4. March 8/9, 1989. Indian Ocean, Arabian Sea. Observations from the m.v. British Esk sailing from Vishakapatnam to Bahrain. Here we have a rather tenuous association of bioluminescence with a vessel's electromagnetic environment. Could it be a cause-and-effect situation?

"During the night a particularly strong and distinct patch of radar interference was noted by all observing officers. The sketch shows the phenomenon as seen on the 12-n.mile range of the 3-cm radar. The racon type mark varied in length from 1-3 n.miles at a nearest range of 5-10 n.miles. The effect was minimal on the 10-cm radar.

"The bearing of the mark remained fairly constant at about 20° abaft the port beam or about 230°. Of particular note was that around 1600 GMT to 1700 GMT (about 2 hours after sunset), when the mark on the radar was very distinct, the satellite communication system suffered a loss in signal strength sufficient to prevent transmission or reception, the bearing of the satellite being almost due south of the vessel. It was thought at the time that the signal mast had become aligned between the aerial and the satellite, but alteration of the ship's head to port or starboard did not cure the low signal strength.



Radar interference in the Arabian Sea associated with bioluminescence. (X4)

.....

"Of note, although this may have been a coincidence only, was that the vessel was passing through patches of bioluminescence at the time, mostly only bright enough to show up in the breaking waves of the ship's wake, but during the period of low signal strength, the whole area of white, foamy water along the ship's side frequently shone a bright greenish colour." (R6)

Apparently, some sort of electromagnetic disturbance affected not only the radar but also satellite communications and, just possibly, the bioluminescent organisms in the water. It is pertinent

that we at least mention all potential connections between bioluminescence and atmospheric phenomena, because the latter might well play a role in shaping complex bioluminescent patterns, such as the marine light wheels. (GLW4) The descent of a plasma vortex to the sea's surface might, for example, stimulate bioluminescent organisms to form organized displays.

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GLW11 Te Lapa: Underwater Lightning

Description. Streaks of light, flashes, and glowing plaques appearing well below the surface of the ocean, apparently emanating from distant land masses. Supposedly used by Polynesian navigators.

Data Evaluation. One account in a popular publication. Rating: 3.

Anomaly Evaluation. So little is known about this phenomenon that it is difficult to estimate its challenge to current theories. If te lapa is simply bioluminescence due to wave action, it is primarily a curiosity. But some unrecognized process may be involved. Rating: 2.

Possible Explanations. Oceanic internal waves reflecting off land masses might possibly produce deep patterns of bioluminescence.

Similar and Related Phenomena. Some marine phosphorescent displays seem to originate in the depths rather than near the surface. Similar in appearance are the zigzag flashes of surface phosphorescence (GLW8).

Examples of Te Lapa

X1. General observation. Pacific Ocean. A conversation with a Polynesian at sea. "'Of course,' he said rather hesitantly, looking back at me over his shoulder, 'you must know all about te lapa.' I truthfully denied knowing anything about it at all. 'Then look.' Tevake pointed over the side. 'No, not on top, deep down. You see him all same underwater lightning.' The phrase was apt. Streaks, flashes, and momentarily glowing plaques of light kept appearing well below the surface. Tevake explained that te lapa streaks dart out from directions in which islands lie. The

phenomenon is best seen eighty to a hundred miles out and disappears by the time a low atoll is well in sight. He stressed that it was quite different from ordinary surface luminescence. Tevake told me it was customary to steer by it on overcast nights." (R1)

X2. General observations. P.J. Herring and P. Horsman have added a few details about te lapa to our meager file on this puzzling phenomenon.

"Polynesian and Micronesian folklore does include descriptions of waves of light in the sea and their use as navigational aids. 'Te lapa' (as this phenomenon is known) is only encountered at least 8 or 9 n. miles offshore, though said to be best seen 80-100 n. miles out, and is described as like underwater lightning some way below the surface. Its direction indicates where land lies and its flickering rate gives an indication of range. According to Lewis [R2] it is probably produced by reflected swells but it appears to be unrelated to 'phosphorescent wheels' and parallel bands, which are extremely rare in the area concerned." (R3)

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GLW12 Moving, V-Shaped Phosphorescent Displays

Description. V-shaped or herring-bone patterns of phosphorescent light moving across the ocean surface. This phenomenon, like the moving parallel bands (GLW2), seems linked generically to the phosphorescent wheels (GLW4).

Background. V-shaped displays may be simply ramifications of moving, parallel band displays.

Data Evaluation. A single, carefully described observation. Rating: 3.

Anomaly Evaluation. Essentially the same as that for the moving, parallel band display. See GLW2. Rating: 2.

Possible Explanations. See discussion in GLW2.

Similar and Related Phenomena. All marine phosphorescent displays, especially the moving parallel bands (GLW2) and the wheel displays (GLW4).

Examples of V-Shaped Phosphorescent Displays

X1. February 14, 1977. Malacca Strait. A wheel-type display appeared to the starboard. "Soon afterwards a change in the pattern was observed. The spokes had formed an inverted V-shape with the apex pointing away from the ship and were rushing towards the ship's starboard side, reappearing on the port side and moving away. The pattern then changed twice more in quick succession; first to an anti-clockwise revolving wheel and then to a clockwise wheel, both times with the centre to starboard. As the vessel steamed past the latter wheel, a further wheel was seen ahead revolving anti-clockwise---the spokes of this wheel overlapping those of the other. The pattern changed twice more; first, back to the V-shape but moving in the opposite direction and finally to an anti-clockwise revolving wheel with the centre to starboard. By this time, the phenomenon was rapidly fading and soon disappeared altogether. The display lasted 10 minutes." (R1)

Phosphorescent Vs sweep past a vessel in the Malacca Strait in 1978. (X1)

Reference

R1. Banna, J.; "Bioluminescence," Marine Observer, 48:16, 1978. (X1)

GLW13 Colored Rays Emanating from Ships

Description. A very rare, multicolored phosphorescent display consisting of rays of light emanating from the observing ship. The rays appear in the water like a horizontal fan and possess various colors.

Data Evaluation. A single observation. Rating: 3.

Anomaly Evaluation. Any multicolored phosphorescent display is anomalous, for almost all

other displays are white or whitish-green. The beams radiating from the ship form a structure that is likewise difficult-to-explain. Rating: 2.

Possible Explanations. None.

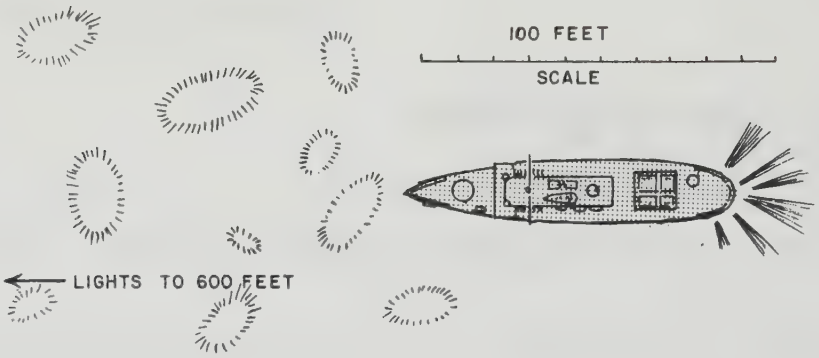
Similar and Related Phenomena. None.

Examples of Colored Rays Emanating from Ships

X1. June 1, 1959. Arabian Sea. Elliptical flashes of light were observed in the sea. "At the same time the lookout on the forecastle reported coloured rays of light radiating from the stem of the ship, over the surface of the water to a distance of about 20 ft. Some of the colours noted and remembered by the lookout were red, purple, blue and green. The whole phenomenon lasted about 3/4 hour." (R1)

Reference

R1. Rattray, J.; "Phosphorescence," Marine Observer, 30:64, 1960. (X1)



Arabian Sea, 1959. Flashes of light appeared ahead of the vessel, while colored rays diverged astern. (X1)

GLW14 Radar Detection of Phosphorescence

Description. Radar echoes apparently reflected by patches of marine phosphorescence.

Data Evaluation. The modicum of evidence relies upon the geographical coincidence of radar echos and phosphorescence. Since no other obvious targets are evident, marine phosphorescence is blamed. Rating: 2.

Anomaly Evaluation. Marine phosphorescence is generally considered to be a surface or subsurface phenomenon, providing no radar target whatsoever. Rating: 2.

Possible Explanations. Unseen mist or airborne particulate matter may exist in the air above the phosphorescent displays---perhaps caused by the bioluminescent organisms themselves. Bioluminescent displays might involve electromagnetic activity; perhaps with the production of ionization in the air above the phosphorescence. The ionized air might produce a radar echo. Some observers of phosphorescent displays have noted their similarity to some auroral displays.

Similar and Related Phenomena. Radar-stimulated bioluminescence (GLW10), low-level auroras (GLA4), luminous fogs and mists (GLA21), spurious radar echos (GER).

Examples of Radar Detection of Phosphorescence

X1. September 5, 1954. Equatorial Pacific waters. "We were fixing the ship's position by cross bearings as well as by radar, and I noticed that the radar screen showed what appeared to be a rain squall in the area of phosphorescence. To the eye the light did have rather the appearance of a white squall of fierce wind and rain, except for the illumination. As we got closer the light showed up in horizontal streaks, like sandbanks or submerged reefs, and as we were going to meet the area before we could alter course it was quite alarming. The masses of phosphorescence and the echo on the radar both covered an area of about 2 miles square. The set was Marconi Radiolocator Mark IV, 3-mile range, sweep speed 21 r.p.m. At 0220 the ship met the area, and the nearest patch passed under the ship. Our breaking bow wave showed up dark against the light, which seemed to be at least 2 fathoms down. The long patches seemed to be round in section and had rounded ends, and while most of them were parallel to the horizon, some curved sharply away..... Light rain was falling from an overcast sky, with a lot of fractonimbus about. The ship reached the radar echo at the same time as the phosphorescence, but there was no noticeable increase in precipitation or wind force. The illumination was very brilliant but did not vary or pulsate, nor did it have any proper motion except relative motion caused by the ship's speed of 10 kt. The wind was light, about SE, force 2, with slight sea and swell. Air temp. 78°F, wet bulb 76°, sea temp. 80°. In the circumstances I came to the conclusion that the phosphorescence was actually shown on the radar screen." (R1, R2)

X2. March 18, 1977. North Atlantic Ocean. "Throughout the day spurious echoes had periodically appeared on the radar screen. The echoes, which resembled those of small clusters of fishing vessels, rarely closed the vessel to less than a range of 8 n. mile before disappearing from the screen. At 2200 another such cluster appeared on the radar screen directly ahead at a range of 10 n. mile. This cluster began to spread out on either side of the bow and a number of stronger echoes appeared in it until it gave an impression similar to than expected from a coastline. The echoes behaved as stationary objects and closed to a range of 5.5 n. mile when they again began to spread out until the ship was at the centre of a complete circle of echoes, none of which closed to within less than 5 n. mile of the ship. The radar appeared to be functioning normally throughout. At about this time, the sea took on a milky-white colour and the beam from the Aldis lamp revealed a mass of

luminescent organisms each about the size of a flashlight bulb---yet each clearly distinguishable from the other. This phenomenon continued for about 45 minutes after which time both the luminescence and the various spurious radar echoes disappeared." (R3)

X3. June 20, 1977. South Atlantic Ocean. "At 0600 GMT, and for about 40 minutes, a more-pronounced area of bioluminescence was observed, during which time white caps from the wind waves were visible up to about 5-6 n. mile. During this period unusual echoes were observed on the radar screen. What was thought to be a patch of rain was observed moving towards the vessel from the west, against the wind. The patch had a rather distinct edge to it unlike those edges associated with rain areas. When the vessel was observed on the radar screen to be in the centre of the patch, there was no precipitation." (R4)

References

R1. Hilder, Brett; "Phosphorescence and Radar," Marine Observer, 25:119, 1955. (X1)
R2. Hilder, Brett; "Radar and Phosphorescence at Sea," Nature, 176:174, 1955. (X1)
R3. Richards, A. W.; "Radar Echos and Bioluminescence," Marine Observer, 48:20, 1978. (X2)
R4. Turney, R. J.; "Bioluminescence," Marine Observer, 48:69, 1978. (X3)

GLW15 Deep-Sea-Vent Glows

Description. Non-thermal radiation of uncertain provenance emitted by the water gushing from hydrothermal deep-sea vents.

Data Evaluation. In stark contrast to the predominantly anecdotal sources cited in support of the 14 other marine luminous phenomena of this chapter, the observations made of the light around deep-sea vents were made by scientists employing sophisticated instruments in submersibles. Given the location of the phenomenon, there is, of course, no other way! Rating: 1.

Anomaly Evaluation. At the deep-sea vents there are at least a half-dozen non-thermal mechanisms that could produce the radiation not fitting the black-body curves for the observed water temperatures. No deep mystery exists here; it is simply a matter of waiting until further research discovers which processes are active. Rating: 3.

Possible Expanations. Chemiluminescence is the most likely source of the enigmatic radiation, but the other potential sources listed in X1 may also contribute.

Similar and Related Phenomena. The unknown sources of some earthquake luminous phenomena (GLD8).

Examples of Light Emitted at Deep-Sea Vents

X1. General observations. In 1988, a group of scientists from the University of Washington photographed deep-sea vents located along the Juan de Fuca Ridge, which is located some 300 kilometers off the coast of British Columbia. These vents are at a depth of 2200 meters where all is supposed to be in perpetual darkness. Nevertheless, these researchers were searching for light sources at the vents.

This seemingly futile search was undertaken at the suggestion of C.L. Van Dover, then a student at Woods Hole Oceanographic Institution in Massachusetts. Van Dover had been studying eyeless shrimp that had been collected at deep-sea vents located along the Mid-Atlantic Ridge. Strangely and suspiciously, these blind shrimp carried light-sensitive organs on their backs. Van Dover reasoned that since Nature rarely, if ever, develops biological organs needlessly, there might be unsuspected light sources along the deep-sea vents that the eyeless shrimp employed to guide themselves to their food sources.

Following Van Dover's hunch, the University of Washington scientists, along with Van Dover, descended to the Juan de Fuca Ridge in the Alvin submersible. They photographed the vents with and without artificial light. They found no eyeless shrimp, but their highly sensitive electronic camera did record flame-like images emanating from the vents in the absence of artificial light. The light was too faint to register on human retinas, but it was there. (R1)

Three questions were raised by this discovery:

(1) What were the sources of the light?

(2) Do eyeless shrimp detect this light and, if so, how to they use it?

(3) Could the feeble "flames" playing around the deep-sea vents have had roles in the history of life on earth?

The latter two questions are properly relegated to our Series-B catalogs that deal with biological enigmas, but a preview is not out-of-place here. Science speculators wonder if life might actually have originated at deep-sea vents rather than Darwin's warm little surface ponds. Or, perhaps, the vents, protected by a mile of two of sea water, might have served as refuges for life when the earth's surface was wracked by volcanism and meteor strikes. Given a light source, photosynthesis might even have evolved in the marine abyss rather than on the planet's surface. (R1-R7)

Photograph of the flame-like luminous phenomenon emanating from a deep-sea vent. (X1)

As for the source of the light at the deep-sea vents, it was first assumed to be thermal radiation from the hot (often 350°C) water gushing from the cracks in the planet's integument. (Incidentally, there are cold-water, deep-sea vents.) However, further studies of the spectra of the glows around the vents convinced scientists that some part of the light---especially at short wavelengths---was of non-thermal origin. There are more possible non-thermal sources than one might expect:

- Sonoluminescence
- Chemiluminescence
- Crystalloluminescence
- Triboluminescence
- Cerenkov radiation
- Combustion of methane in supercritical water. (R4)

As of the year 2001, the most likely candidate seems to be chemiluminescence, specically sulfide oxidation. (R8) However, science has not "closed the book" on this phenomenon at this writing.

References

R1. Dayton, Sylvia; "The Underwater Light Fantastic," New Scientist, p. 32, August 25, 1988. (X1)
R2. Travis, John; "Probing the Unsolved Mysteries of the Deep," Science, 259:1124, 1993. (X1)
R3. Monsastersky, Richard; "Light at the Bottom of the Ocean," Science News, 145:14, 1994. (X1)
R4. Van Dover, Cindy Lee, et al; "Light at Deep Sea Hydrothermal Vents," Eos, 1994. (X1)
R5. Van Dover, Cindy Lee, et al; "Light at Deep-Sea Hydrothermal Vents," Geophysical Research Letters, 23: 2049, 1996. (X1)
R6. Zimmer, Carl; "The Light at the Bottom of the Sea," Discover, 17:62, November 1996. (X1)
R7. Flanagan, Ruth; "The Light at the Bottom of the Sea," New Scientist, p. 42, December 13, 1997. (X1)
R8. Copley, Jon; "Seeing the Light," New Scientist, p. 6, March 20, 1999. (X1)

TIME-OF-EVENT INDEX

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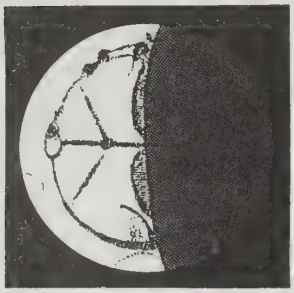

One drawing of the Venusian radial-spoke system

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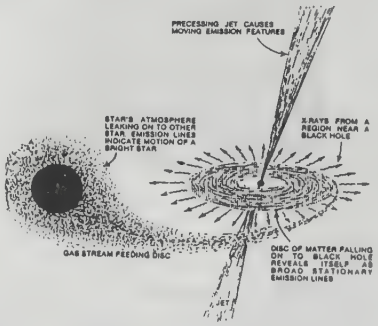

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- Episodes of luminous mists
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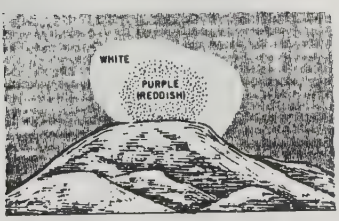
- Earthquake lights
- Ball lightning with tails
- Rocket lightning
- Lightning from a clear sky
- Ghost lights, ignis fatuus
- Darting streaks of light (sleeks)
- The milky sea and light wheels
- Radar-stimulated phosphorescence of the ocean
- Double ball lightning
- Luminous phenomena in tornados
- Black auroras



Luminous display over Mt. Noroshi during an earthquake storm

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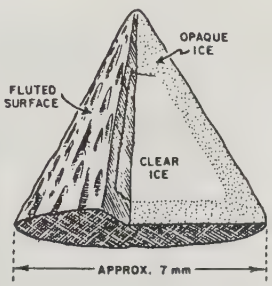

Conical hailstones with fluted sides

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- Ice fogs (the Pogonip)
- Conical hail
- Gelatinous meteors
- Point rainfall
- Unusual incendiary phenomena
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- Tornado electricity
- Multiwalled waterspouts
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Sand craters created by earthquakes

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- Sun-dominated tides
- Immense, solitary waves
- Animal activity prior to earthquakes
- Earthquake geographical anomalies
- Earthquake electricity
- The sound of the aurora
- Musical sounds in nature
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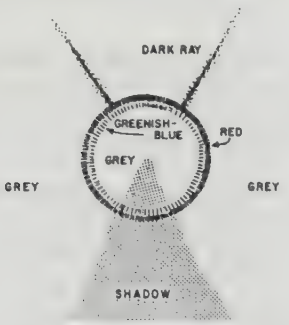
- Sandbows
- Offset and skewed halos
- The Brocken Specter
- The Alpine Glow
- Unexplained features of the green flash
- Fata Morganas
- Telescopic mirages
- Long-delayed radio echos
- Eclipse shadow bands
- Geomagnetic effect of meteors
- Intersecting rainbows
- The Krakatoa sunsets
- Kaleidoscopic suns



Shadow of Adam's Peak with glory and radial rays

COMMENTS FROM REVIEWS

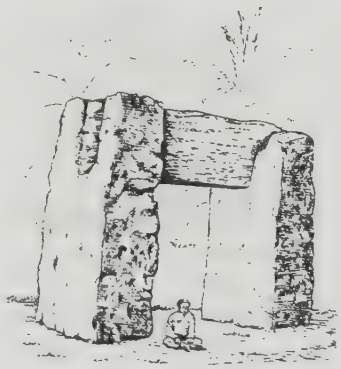
...all in all it's a fascinating book. SKY & TELESCOPE

...any student of the physical sciences will find it fascinating. SCIENCE BOOKS & FILMS

244 pp., hardcover, $16.95
111 illus., 5 indexes, 1984
569 references, LC 84-50491
ISBN 0-915554-12-7, 7x10

ANCIENT INFRASTRUCTURE: Remarkable Roads, Mines, Mounds, Stone Circles

Ancient peoples raised standing stones on all continents save Antarctica. They dug canals 50 miles long and erected even longer walls. Gleaned from hundreds of volumes of Science, Nature, Antiquity, and other science journals, this massive collection of archeological puzzles will keep researchers digging for decades.



The Haamonga Stones resemble Stonehenge but they are found on palm-dotted Tonga in the South Pacific. But they may have also been used by ancient astronomers.

- Costa Rica's enigmatic stone spheres
- Peru's Intervalley Canal
- Iraq's 100,000 miles of subterranean tunnels (the qanats)
- Nova Scotia's "Money Pit"
- Egypt's canal to the Red Sea
- North America's calendar sites
- Medicine wheels and woodhenges
- Sculpted hills and mountains
- Chaco Canyon's curious roads
- The puzzling East Bay walls
- Lake Superior's copper mines
- Stone arrays and meanders
- Florida's shell keys
- Poverty Point and Watson Brake
- Malta's strange "cart ruts"

412 pages, hardcover, $24.95
255 illus., 3 indexes, 1999
855 references, LC 99-94987
ISBN 0-915554-33-x, 7 x 10

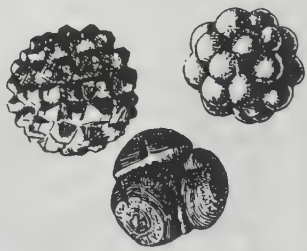
ARCHEOLOGY HANDBOOK

ANCIENT MAN; A Handbook of Puzzling Artifacts

Now in its fifth printing, our archeology Handbook reproduces hundreds of fascinating items from difficult-to-obtain archeological journals.

TYPICAL SUBJECTS COVERED

- Ancient Florida canals
- The Maltese "cart tracks"
- New England earthworks
- Ancient coins in America
- Ancient Greek computer
- Inscriptions and tablets in unexpected places
- The great Tiahuanaco ruins
- Zimbabwe and Dhlo-dhlo
- Costa Rica stone spheres
- The Great Wall of Peru
- Ancient batteries and lenses
- Mysterious walls everywhere
- Pacific megalithic sites
- Scottish fused forts



Scottish carved stones from circa 1000 B.C.

COMMENTS FROM REVIEWS

...a useful reference in undergraduate, public, and high school libraries. BOOKLIST

792 pp., hardcover, $23.95
240 illustrations, index, 1978
References, LC 77-99243
ISBN 0-915554-03-08, 6x9

GEOLOGY CATALOGS

CAROLINA BAYS, MIMA MOUNDS, SUBMARINE CANYONS; A Catalog of Geological Anomalies

Topographical phenomena are the subject of this Catalog. The ups and downs of the earth's surface exhibit many anomalies. Could continental drift be inferior to the expanding-earth hypothesis? Have ocean levels fluctuated wildly down the eons?

TYPICAL SUBJECTS COVERED

- Carolina bays and oriented lakes
- Large circular structures
- Immense craters
- Raised beaches
- Guyots (flat-topped seamounts)
- Island arcs
- Doubts about plate tectonics (continental drift)
- Mima mounds
- Drumlin anomalies
- Patterned ground
- Esker problems
- Lake walls and ramparts
- Crevicular structure
- Submarine canyons

Pyramid of frozen foam on the Bozenkill, New York State

COMMENTS FROM REVIEWS

...enough terrestrial intrigue to keep us thinking for years.
PURSUIT

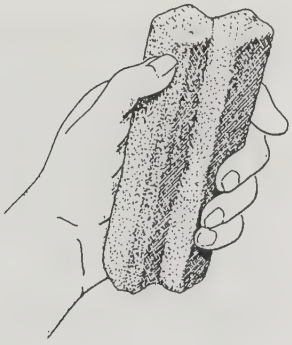
245 pp., hardcover, $17.95
84 illus., 5 indexes, 1988
682 references, LC 87-63408
ISBN 0-915554-22-4, 7x10

ANOMALIES IN GEOLOGY: PHYSICAL, CHEMICAL, BIOLOGICAL; A Catalog of Geological Anomalies

Journey here into ice caves, exhume Siberian mammoths, see animals perish in gas-filled valleys---a little media hype is justified here. But more serious questions posed in this volume include the origins of oil, coal, and natural gas.

TYPICAL SUBJECTS COVERED

- Biological-extinction events
- Musical sands, ringing rocks
- Questions about oil's origin
- Ice caves, frozen wells
- Natural fission reactors
- Marine organisms and fossils found far inland
- Siberia's frozen mammoths
- Radiometric-dating problems
- Anchor ice, frazil ice
- Violent lake turnovers
- Flexible rocks
- Origin of the oceans
- Skipping in the fossil record
- Valleys of death

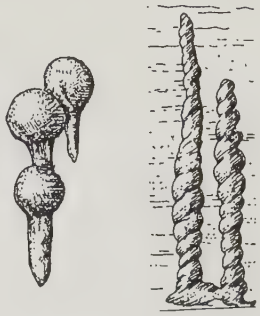


Prismatic sandstone from Missouri

335 pp., hardcover, $18.95
55 illus., 5 indexes, 1989
1260 references, LC 89-90680
ISBN 0-915554-23-2, 7x10

NEGLECTED GEOLOGICAL ANOMALIES; A Catalog of Geological Anomalies

Neglected but far from insignificant are the anomalies cataloged here. Do we <u>really</u> know how concretions and geodes form, where natural glasses come from, and whence the immense deposits of superficial debris found all over the globe?



Mace-shaped and sand-spike concretions from the Colorado Delta

TYPICAL SUBJECTS COVERED

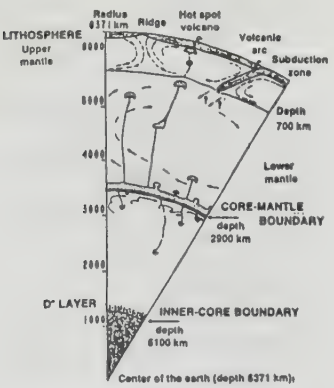
- Concretions and geodes
- Tektites and microtektites
- Erratic boulders and gravels
- Polystrate fossils
- Bone caves and bone beds
- Giant basalt flows
- Natural glasses
- Surging glaciers
- Driftless regions
- Stretched pebbles
- Inclusions in crystals
- Rarity of fossil meteorites and tektites
- Elevated erratics
- Stone rivers, rock glaciers

333 pp., hardcover, $18.95
80 illus., 5 indexes, 1990
1030 references, LC 90-60568
ISBN 0-915554-24-0, 7x10

INNER EARTH: A SEARCH FOR ANOMALIES;
A Catalog of Geological Anomalies

The focus of this, the eleventh volume in the Catalog of Anomalies, is the earth's interior, which is revealed to us mainly through seismic signals, magnetic variations, and the flow of heat from great depths. Hundreds of kilometers below the surface lurk huge chunks of foundered continental crust and bizarre structures of unknown origin.

TYPICAL SUBJECTS COVERED
- Anomalous gravity signals
- Mid-plate volcanism
- Mysterious seismic reflectors
- Seismic-velocity discontinuities
- Deep-focus earthquakes
- Incompleteness of the stratigraphic record
- Cyclothems and rhythmites
- Exotic terranes
- Compass anomalies
- Earth-current anomalies
- Problems with paleomagnetism
- Polarity reversals



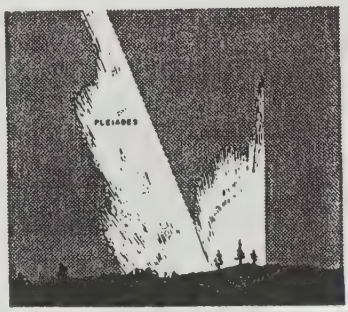
A model of the earth's interior

230 pp., hardcover, $18.95
52 illus., 5 indexes, 1991
619 references, LC-90-92347
ISBN 0-915554-25-9, 7x10

ASTRONOMY HANDBOOK

MYSTERIOUS UNIVERSE;
A Handbook of Astronomical Anomalies

Our astronomy Handbook covers much the same ground as the three astronomy Catalogs just described, but in greater depth---the quotations are more extensive.



Unexplained rift in the zodiacal light

TYPICAL SUBJECTS COVERED
- The lost satellite of Venus
- Transient lunar phenomena
- Ephemeral earth satellites
- Venus' radial spoke system
- Relativity contradicted
- Cosmological paradoxes
- Changes in light's velocity
- Vulcan, the intramercurial planet
- Knots in Saturn's rings
- Bright objects near the sun
- The sun's problematical "companion star"
- "Sedimentary" meteorites
- Life chemistry in outer space
- Sunspots and planetary positions

COMMENTS FROM REVIEWS
...highly recommended...excellent value for money. NATURE (Astronomy Book Club selection)

716 pp., hardcover, $19.95
103 illus., index, 1979
References, LC 78-65616
ISBN 0-915554-05-4, 6x9

SCIENCE FRONTIERS:
Some Anomalies and Curiosities of Nature

An indexed compilation of the first 86 issues of our newsletter SCIENCE FRONTIERS.

COMMENTS FROM REVIEWS
This fun-to-read book may lead some to new scientific solutions through questioning the phenomena presented. SCIENCE BOOKS & FILMS

356 pp., paperback, $18.95p
417 illus., index, 1994
1500+ references, LC 93-92800
ISBN 0-915554-28-3, 8½x11