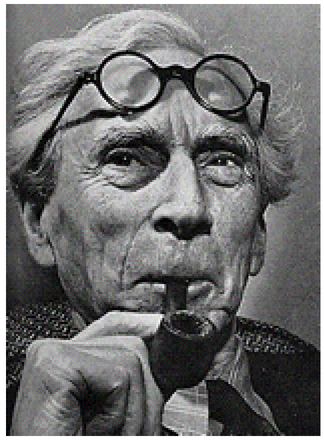

Philosophical Consequences of Relativity

Bertrand Russell

Of the consequences in philosophy which may be supposed to follow from the theory of relativity, some are fairly certain, while others are open to question. There has been a tendency, not uncommon in the case of a new scientific theory, for every philosopher to interpret the work of Einstein in accordance with his own metaphysical system, and to suggest that the outcome is a great accession of strength to the views which the philosopher in question previously held. This cannot be true in all cases; and it may be hoped that it is true in none. It would be disappointing if so fundamental a change as Einstein has introduced involved no philosophical novelty. (See SPACE-TIME.)

Space-Time.--For philosophy, the most important novelty was present already in the special theory of relativity; that is, the substitution of space-time for space and time. In Newtonian dynamics, two events were separated by two kinds of interval, one being distance in space, the other lapse of time. As soon as it was realised that all motion is relative (which happened long before Einstein), distance in space became ambiguous except in the case of simultaneous events, but it was still thought that there was no ambiguity about simultaneity in different places. The special theory of relativity showed, by experimental arguments which were new, and by logical arguments which could have been discovered any time after it became known that light travels with a finite velocity, that simultaneity is only definite when it applies to events in the same place, and becomes more and more ambiguous as the events are more widely removed from each other in space.

This statement is not quite correct, since it still uses the notion of "space." The correct statement is this: Events have a four-dimensional order, by means of which we can say that an event A is nearer to an event B than to an event C; this is a purely ordinal matter, not involving anything quantitative. But, in addition, there is between neighbouring events a quantitative relation called "interval," which fulfils the functions both of distance in space and of lapse of time in the traditional dynamics, but fulfils them with a difference. If a body can move so as to be present at both events, the interval is time-like. If a ray of light can move so as to be present at both events, the interval is zero. If neither can happen, the interval is space-like. When we speak of a body being present "at" an event, we mean that the event occurs in the same place in space-time as one of the events which make up the history of the body; and when we say that two events occur at the same place in space-time, we mean that there is no event between them in the four-dimensional space-time order. All the events which happen to a man at a given moment (in his own time) are, in this sense, in one place; for example, if we hear a noise and see a colour simultaneously, our two perceptions are both in one place in space-time.

When one body can be present at two events which are not in one place in space-time, the time-order of the two events is not ambiguous, though the magnitude of the time-interval will be different in different systems of measurement. But whenever the interval between two events is space-like, their time-order will be different in different equally legitimate systems of measurement; in this case, therefore, the time-order does not represent a physical fact. It follows that, when two bodies are in relative motion, like the sun and a planet, there is no such physical fact as "the distance between the bodies at a given time"; this alone shows that Newton's law of gravitation is logically faulty. Fortunately, Einstein has not only pointed out the defect, but remedied it. His arguments against Newton, however, would have remained valid even if his own law of gravitation had not proved right.

Time not a Single Cosmic Order.--The fact that time is private to each body, not a single cosmic order, involves changes in the notions of substance and cause, and suggests the substitution of a series of events for a substance with changing states. The controversy about the aether thus becomes rather unreal. Undoubtedly, when light-waves travel, events occur, and it used to be thought that these events must be "in" something; the something in which they were was called the aether. But there seems no reason except a logical prejudice to suppose that the events are "in" anything. Matter, also, may be reduced to a law according to which events succeed each other and spread out from centres; but here we enter upon more speculative considerations.

Physical Laws.--Prof. Eddington has emphasised an aspect of relativity theory which is of great philosophical importance, but difficult to make clear without somewhat abstruse mathematics. The aspect in question is the reduction of what used to be regarded as physical laws to the status of truisms or definitions. Prof. Eddington, in a profoundly interesting essay on "The Domain of Physical Science," [Footnote 1] states the matter as follows:--

In the present stage of science the laws of physics appear to be divisible into three classes--the identical, the statistical and the transcendental. The "identical laws" include the great field-laws which are commonly quoted as typical instances of natural law--the law of gravitation, the law of conservation of mass and energy, the laws of electric and magnetic force and the conservation of electric charge. These are seen to be identities, when we refer to the cycle so as to understand the constitution of the entities obeying them; and unless we have misunderstood this constitution, violation of these laws is inconceivable. They do not in any way limit the actual basal structure of the world, and are not laws of governance (op. cit., pp. 214-5).

It is these identical laws that form the subject-matter of relativity theory; the other laws of physics, the statistical and transcendental, lie outside its scope. Thus the net result of relativity theory is to show that the traditional laws of physics, rightly understood, tell us almost nothing about the course of nature, being rather of the nature of logical truisms.

This surprising result is an outcome of increased mathematical skill. As the same author [Footnote 2] says elsewhere:--

In one sense deductive theory is the enemy of experimental physics. The latter is always striving to settle by crucial tests the nature of the fundamental things; the former strives to minimise the successes obtained by showing how wide a nature of things is compatible with all experimental results.

The suggestion is that, in almost any conceivable world, something will be conserved; mathematics gives us the means of constructing a variety of mathematical expressions having this property of conservation. It is natural to suppose that it is useful to have senses which notice these conserved entities; hence mass, energy, and so on seem to have a basis in our experience, but are in fact merely certain quantities which are conserved and which we are adapted for noticing. If this view is correct, physics tells us much less about the real world than was formerly supposed.

Force and Gravitation.--An important aspect of relativity is the elimination of "force." This is not new in idea; indeed, it was already accepted in rational dynamics. But there remained the outstanding difficulty of gravitation, which Einstein has overcome. The sun is, so to speak, at the summit of a hill, and the planets are on the slopes. They move as they do because of the slope where they are, not because of some mysterious influence emanating from the summit. Bodies move as they do because that is the easiest possible movement in the region of space-time in which they find themselves, not because "forces" operate upon them. The apparent need of forces to account for observed motions arises from mistaken insistence upon Euclidean geometry; when once we have overcome this prejudice, we find that observed motions, instead of showing the presence of forces, show the nature of the geometry applicable to the region concerned. Bodies thus become far more independent of each other than they were in Newtonian physics: there is an increase of individualism and a diminution of central government, if one may be permitted such metaphorical language. This may, in time, considerably modify the ordinary educated man's picture of the universe, possibly with far-reaching results.

Realism in Relativity.--It is a mistake to suppose that relativity adopts an idealistic picture of the world--using "idealism" in the technical sense, in which it implies that there can be nothing which is not experience. The "observer" who is often mentioned in expositions of relativity need not be a mind, but may be a photographic plate or any kind of recording instrument. The fundamental assumption of relativity is realistic, namely, that those respects in which all observers agree when they record a given phenomenon may be regarded as objective, and not as contributed by the observers. This assumption is made by common sense. The apparent sizes and shapes of objects differ according to the point of view, but common sense discounts these differences. Relativity theory merely extends this process. By taking into account not only human observers, who all share the motion of the earth, but also possible "observers" in very rapid motion relatively to the earth, it is found that much more depends upon the point of view of the observer than was formerly thought. But there is found to be a residue which is not so dependent; this is the part which can be expressed by the method of "tensors." The importance of this method can hardly be exaggerated; it is, however, quite impossible to explain it in non-mathematical terms.

Relativity Physics.--Relativity physics is, of course, concerned only with the quantitative aspects of the world. The picture which it suggests is somewhat as follows:--In the four-dimensional space-time frame there are events everywhere, usually many events in a single place in space-time. The abstract mathematical relations of these events proceed according to the laws of physics, but the intrinsic nature of the events is wholly and inevitably unknown except when they occur in a region where there is the sort of structure we call a brain. Then they become the familiar sights and sounds and so on of our daily life. We know what it is like to see a star, but we do not know the nature of the events which constitute the ray of light that travels from the star to our eye. And the space-time frame itself is known only in its abstract mathematical properties; there is no reason to suppose it similar in intrinsic character to the spatial and temporal relations of our perceptions as known in experience. There does not seem any possible way of overcoming this ignorance, since the very nature of physical reasoning allows only the most abstract inferences, and only the most abstract properties of our perceptions can be regarded as having objective validity. Whether any other science than physics can tell us more, does not fall within the scope of the present article.

Meanwhile, it is a curious fact that this meagre kind of knowledge is sufficient for the practical uses of physics. From a practical point of view, the physical world only matters in so far as it affects us, and the intrinsic nature of what goes on in our absence is irrelevant, provided we can predict the effects upon ourselves. This we can do, just as a person can use a telephone without understanding electricity. Only the most abstract knowledge is required for practical manipulation of matter. But there is a grave danger when this habit of manipulation based upon mathematical laws is carried over into our dealings with human beings, since they, unlike the telephone wire, are capable of happiness and misery, desire and aversion. It would therefore be unfortunate if the habits of mind which are appropriate and right in dealing with material mechanisms were allowed to dominate the administrator's attempts at social constructiveness.

Bibliography A. S. Eddington, Space, Time, and Gravitation (Cambridge, 1921); Bertrand A. W. Russell, The A. B. C. of Relativity (1925).

(B. A. W. R.)

Footnote 1: In Science, Religion and Reality, ed. by Joseph Needham (1925).

Footnote 2: A. S. Eddington, Mathematical Theory of Relativity, p. 238 (Cambridge, 1924)

[The mathematician, philosopher, and social thinker Bertrand Russell was at work on his classic exposition of Einstein's theory of relativity, The A. B. C. of Relativity, when he agreed to write this piece for the Thirteenth Edition (1926) of Britannica. It makes for an unusual encyclopedia article--it is tentative, somewhat speculative--but it provides an interesting counterpoint to Einstein's own, more technical article.]