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Meson production based on the Thomson energy correlation

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Attention is drawn to a remarkable energy correlation which uniquely determines the rest-mass energies of all the intermediate particles in the electron-proton energy spectrum. The correlation formula uses a classical expression formulated by J. J. Thomson, which represents the charge of a particle as confined within a sphere of radius $2e^2/3mc^2$.

The myriad of elementary particles has led to empirical investigation in search of evidence of quark components in an endeavor to explain particle constitution in terms of a few fundamental energy quanta. On this theme, MacGregor[1-3] has identified empirically the quanta 70.0, 74.6, 330.6, and 336.9 MeV, the first being a neutral element, the second and third being singly charged $\pm e$, and the fourth being doubly charged $\pm 2e$, e being the electron charge unit. His analysis envisages these quarks forming together in a caber-like structure to form the composite elementary particles. He also recognizes that an energy of three times 70 MeV could be a quark in its own right. However, apart from the 210-MeV energy quantum, these quantities have little direct connection with observation of actual particles.

210 MeV is approximately the energy of the dimuon, and the presence of a dimuon is now a recognized feature of the decay of certain particles. LoSecco,[4] for example, in 1976 drew attention to the then recently discovered decay activity involving dimuons and argued that the data revealed the existence of an important particle of energy approximating 2.5 GeV.

The author has a particular interest in this subject, because theoretical work[5] in 1966 predicted that there was a basic particle at 2.587 GeV which decayed by shedding dimuon energy quanta 211 MeV. The theory related G, the constant of gravitation, with the 2.587-GeV graviton and explained why muon pairs necessarily featured in the processes governing field structure. Two equations which were deduced are

$$\sqrt{G} = \frac{4\pi}{(108\pi)^3(5063)^4}\frac{e}{m_e} \qquad (1)$$

and

$$\alpha^{-1} = \frac{hc}{2\pi e^2} = \left[(144\pi)^5 3\pi\left(\tfrac{3}{2}\right)^3\mu\right]^{1/8}. \qquad (2)$$

In (1) e/m_e is the electron charge-mass ratio in cgs esu. The magnetic permeability and dielectric constant of the vacuum are unity. 5063 is 2.587 GeV in units of m_e. In (2) α is the fine-structure constant, and μ denotes the basic muon mass quantum in terms of electron mass units.

Later, in 1975, it was shown[6] by the author, collaborating with Dr. D. M. Eagles of CSIRO in Australia, that the calculated dimuon-electron mass ratio could be incorporated into an extremely simple energy correlation formula and used to evaluate the proton-electron mass ratio. The theory gave a value of 1836.1523, which is now in accord with the latest measurements by Van Dyck, Moore, and Schwinberg[7] at the level of one part in ten million. Their value is 1836.152470(80). For further comment on this, see Aspden.[8,9]

The advance reported in this paper is to show that the same energy correlation that was used to connect the muon and the proton can be applied to give account of the mass energies of all the other intermediate particles in the energy spectrum from the electron to the proton. Beyond the proton, one has to bring in the 2.587-GeV energy quantum mentioned above, as exemplified by the analysis of the psi particles $\psi(3100)$ and $\psi(3685)$ and the decay of the latter.[10,11] It seems best, therefore, in this work to restrict attention to the range for which the analysis is complete and relies only on the well-identified proton.

As applied to two charges $+e$ and $-e$, confined within radii a and b, respectively, according to the Thomson formula, we find that their energies E_1 and E_2 are given by

$$E_1 = \frac{2e^2}{3a} \quad \text{and} \quad E_2 = \frac{2e^2}{3b}. \qquad (3)$$

The mutual attraction will bring their charge surfaces together, so that there is an offset potential

$e^2/(a+b)$ to add to E_1 and E_2 to determine the total energy W of this two-charge system. Then, from (3), we have

$$W = E_1 + E_2 - \frac{3E_1E_2}{2(E_1+E_2)}. \quad (4)$$

As thus formulated, we have an extremely simple and seemingly naive result, lacking all the sophistication of modern particle theory, but it happens to yield a quite remarkable result and so deserves attention.

The argument then is that E_1 and E_2 have a definite correlation if W is a minimum-energy state. Regard the energy E_1 as that of the proton, and take it as a constant for variation of E_2. We find that W is a minimum when

$$E_2 = \left(\frac{\sqrt{3}}{\sqrt{2}} - 1\right)E_1. \quad (5)$$

Put E_1 as 938 MeV, the proton rest mass energy. E_2 becomes 211 MeV, the dimuon energy. Proceeding further, put E_1 in (4) as the dimuon energy nucleated by a charge $+e$, and imagine that an electron of charge $-e$ adds its small additional mass energy so that W is approximately equal to E_1. The electron might then change state in nucleating the energy E_2 in (4). When $W \approx E_1$, we see, from (4), that $E_2 \approx \frac{1}{2}E_1$. The electron has become a muon, in effect, because it now has an energy of approximately half 211 MeV. For such a dimuon-muon system it would need the energy quantum of one muon to drive the two charges well apart.

With this scenario there is clearly the possibility for particle building connected with the energy correlation formula under discussion. Protons, muons, and dimuons, as well as electrons and positrons, are then the main contributors in determining the energy thresholds at which particles become stable. There will, of course, be many other controlling factors related to spin, interactions, and resonances, as well as possible quark structure based upon fractional charge, but the source energy thresholds, which are seldom the crucial factors in symmetry schemes, could have a simple classical foundation dependent upon this Thomson correlation.

It cannot be expected that the muon mass will be precisely half that of the dimuon energy, as correlated with the proton mass energy. The isolated muon will be subject to influences affecting its mass that are not contemplated here, but are dealt with elsewhere.[12] However, to demonstrate the precision of the method presented above, let us deduce the value of μ from (2), taking the measured value of α^{-1} as 137.035965, the best reported value of record,[13] and compare this with the dimuon energy deduced from (5) using the measured proton-electron mass ratio mentioned above. It is found that 2μ, the dimuon energy quantum operative in Eq. (2), is $412.666m_ec^2$, and that the same energy quantum E_2 evaluated from (5) is also $412.666m_ec^2$. This agreement is a good check on the accuracy of the physical principles used in deriving the formulas (2) and (5), the more so as the theory gives independent foundation for a value of $412.666m_ec^2$ which is outside the scope of the present paper.

Proceeding, we will use the notation $(P{:}Q)$ to signify the two-charge system represented by (3), with P replacing E_1 and Q replacing E_2. Here P denotes the proton and Q the dimuon. We next enquire into the analogous system comprising two like charges and one of opposite polarity. This three-charge system would form in line, a caber-like arrangement similar to that proposed by MacGregor. If their charge energies are E_1, E_2, E_3, in that order, then we can denote the three-charge system as $(E_1^-{:}E_2^+{:}E_3^-)$, where the plus and minus signs now denote charge polarity. The energy formula is

$$W' = W + E_3 - \frac{3E_2E_3}{2(E_2+E_3)} + \frac{3E_1E_2E_3}{2(E_3E_2 + 2E_1E_3 + E_1E_2)}, \quad (6)$$

where W has the value given by (4).

Our object now is to suggest that when a muon collides with $(P{:}Q)$ it may drive the dimuon out to create a residual particle, or it may build the two-charge system into a three-charge system, including a proton and two identical new particles of opposite polarity. Denoting these by the symbol Π, the system is expressed as $(P{:}\Pi{:}\Pi)$. Another process would involve an electron or positron e attaching itself to $(P{:}Q)$ to create a charged particle. The next process that can occur is for the system $(P{:}\Pi{:}\Pi)$ to decay by collision with either an electron, a positron, or a muon of opposite polarity. Alternatively, since the field is permeated by oppositely charged muons undergoing annihilation in a random migratory motion and being recreated elsewhere in a statistical field-related manner, we can admit the possibility that mutual annihilation close to $(P{:}Q)$ or $(P{:}\Pi{:}\Pi)$ can add the 2μ energy and trigger decay.

These seem to be the only reactions available in the decay mode. If we now make the assumption that in the primary reactions just mentioned only one charged particle and one type of neutral particle can result, we are able to tabulate the consequences in Table I.

It may be verified from (4) that when $P = 938$ MeV and $Q = 211$ MeV we obtain $W = (P{:}Q) = 891$ MeV. Similarly, from Eq. (6), the value of $E_2 = E_3$ which, with $E_1 = 938$ MeV, makes $W' = 891 + \frac{1}{2}(211)$ is 139 MeV. Thus $(P{:}\Pi{:}\Pi)$ is 996 MeV. From this it can be seen that the listed reactions all give good numerical agreement with the measured quantities. Equally important is the fact that there is a particle state matching each of the theoretically possible reactions.

There are two mesons listed by the Particle Data Group[14] but not included in the table. These are the charged kaon of 493 MeV and a meson of lesser importance, $\rho(770)$, which has a measured mass energy of 776 ± 3 MeV. The latter has an empirical connection with our foregoing thesis, if we can regard it as the decay product of a pair of charged kaons. Note the energy relationship:

$$K^+(493) + K^-(493) = Q(211) + \rho(775). \tag{7}$$

Should the decay involve a dimuon quantum, a muon from each kaon, then the residue would account for the meson state. It is noted that muons feature prominently in kaon decay, so this explanation seems the likely solution. However, our account is not complete unless we can show that our energy correlation formula can also deal with the creation of the charged kaon. The answer is found immediately we generalize our analysis and exclude the proton from the base system.

We argue that energy, charge parity, *and* the space volume occupied by charge are all conserved in any truly stable particle system, but that there are transient oscillating state changes in which the "quark" constituents of a particle can change parity or even be annihilated or created, provided energy and charge parity are conserved overall. Permanent changes such as a decay involve both parity and space conservation, but admit energy transfer, e.g. by gamma radiation, not involving charge elements.

The above argument was not devised to expedite the following analysis; it features in meson-lifetime considerations[15] and psi-particle creation theory,[10] already of record.

TABLE I

(1)	$(P{:}Q) + e \to K^*$	$K^*(892)$
(2)	$(P{:}Q) + \mu \to \omega + Q$	$\omega(783)$
(3)	$(P{:}Q) + \mu \to (P{:}\Pi{:}\Pi)$	$\Pi(139)$
(4)	$(P{:}Q) + \mu + \mu \to \eta^0 + \eta^0$	$\eta^0(549)$
(5)	$(P{:}\Pi{:}\Pi) + e \to K^0 + K^0$	$K^0(498)$
(6)	$(P{:}\Pi{:}\Pi) + \mu \to \eta^0 + \eta^0$	$\eta^0(549)$
(7)	$(P{:}\Pi{:}\Pi) + \mu + \mu \to P + \Pi^0 + \Pi^0$	$\Pi^0(135)$

We apply our three-charge energy correlation to a system comprising two charges having the same energy and another charge of different energy—S, S, and K, respectively. The task is then to determine whether S and K can be such that mutual annihilation of the S charges will leave an isolated charge having the same energy K as the three-charge complex.

There is an answer, expressed by the exchange reaction

$$(S^-{:}K^+{:}S^-) \rightleftharpoons (K)^-, \tag{8}$$

because a parity exchange between K and S followed by S pair annihilation leaves K in isolation. Energy has to be conserved, and it may be verified from equations (4) and (6) that this requires that $K = 8S$.

This is a unique reaction, and it can be matched to a unique particle state if we argue that it is formed exclusively from the coalescence of n muons. The controlling criteria are then that:

(a) n must be odd for there to be a residual unit charge e,

(b) n must be at least large enough to ensure that there is enough energy from the muon source to create K, and

(c) the sum of the charge volumes of S and K must be exactly equal to the total charge volume of n muons.

From the J. J. Thomson formula, condition (c) prescribes that

$$n\left(\frac{1}{\mu}\right)^3 = \left(\frac{1}{S}\right)^3 + \left(\frac{1}{K}\right)^3, \tag{9}$$

where

$$n\mu \geq K \tag{10}$$

Putting $S = K/8$ then gives

$$\left(\frac{K}{\mu}\right)^3 = \frac{513}{n}, \quad \text{where} \quad \left(\frac{K}{\mu}\right)^4 \leq 513. \quad (11)$$

This condition is not satisfied by less than five muons, but it is satisfied as soon as five muons come close enough to react. Then, with $n = 5$, we have the remarkable consequence that $K^{\pm}$ is uniquely determined as $(\frac{513}{5})^{1/3}\mu$. Since μ has been shown to be $\frac{1}{2}(\sqrt{3}/\sqrt{2} - 1)P$, where P is 938 MeV, we find

$$K^{\pm} = 493 \text{ MeV}, \quad (12)$$

exactly the mass energy of the charged kaon.

The muons involved in kaon creation are probably sourced in the electromagnetic field accompanying fast-moving pions or protons brought into collision with other protons, for example. Virtual muon pairs constitute much of the field energy, and there is a statistical chance that the near presence of enough muons concentrated by particle collisions will trigger kaon creation in the manner just described.

The use of an energy correlation deduced directly from the classical Thomson formula has had the rather awesome consequence of determining the energies of all nine of the meson energy states lying in the particle spectrum between the electron and the proton. All that has to be known is the proton-electron mass ratio.

It is submitted, therefore, that there is justification for focusing upon this energy correlation method as an underlying foundation on which to build particle theory. This does not preclude acceptance of some of MacGregor's empirical conclusions about quark constituents of particles, nor does it preclude belief in fractionally charged quarks, provided these are contained within the Thomson radius assigned to unit charge.

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