The theory of the proton constants

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(Received 16 November 1987)

The proton/electron mass ratio and the proton magnetic moment measured in nuclear magnetons have values now known to a very high degree of precision. The only theory of record that gives physical reasoning which can account for these dimensionless numerical ratios is one reported in the *Hadronic Journal* in its extended application to the neutron and the deuteron. In view of the recent CODATA specification of the proton constants, which is of higher precision than was known when the proton theory was first published, it is appropriate to review that theory and present it in a simplified and updated form. It is found that the theory remains viable, notwithstanding the stringent demands imposed by the measurement data.

I. INTRODUCTION

The proton is the most important charged particle in the universe, accounting for almost all of the mass of electrical matter. Yet, physicists accept that all that is known about the proton is the fact that it has a charge equal in magnitude but opposite in polarity to that of the electron, a mass that is 1836.152701(37) times that of the electron, and a magnetic moment in spin that is 2.792847386(63) times that expected from the classical theory of its response in orbital charge motion in a magnetic field. In addition there is some indication from experiment that it has a three-part composition.

Surprisingly, all the interest centers on the latter aspect and the related quark theories in the context of what is known as "quantum chromodynamics" (QCD), and little, if any, independent interest is shown in the direct physical justification for the numerical ratios, which are so clearly the personal "signature" of this fundamental particle, guiding enquiry into its nature.

Equally surprising is the fact that those scientists engaged on precision measurement of particle properties can actually achieve such remarkable accuracy in a quest that surely has to be seen as probing the consistency and universality of the physical world. Something determines the ratio 1836.1527, and physics cannot claim to be on track until we determine a causal basis.

The author has proposed such a theory[1] and has subsequently reported on developments,[2] but this theory is seen as outside the mainstream interest, which wills that the answers must emerge from QCD. Accordingly, there is little that can be done besides wait for QCD to run its course, except to refine the presentation of the theory and test and update it as new precision measurements are reported. The recent CODATA revision[3] is an event bearing upon this task. The proton data are now so precise that some very fine features of the proton theory come under scrutiny. This paper reports on this examination and shows that the theory holds up well.

It is stressed at the outset that the methods used by the author in this proton theory do not stand in isolation. They have connection with the whole spectrum of particle physics and the quantum properties of the vacuum field, as evidenced by the nature of the photon. To support this, reference is made to several recent papers concerning hadron mass determination.[4-6] It is the object of this paper to confine attention to the proton per se, though opportunity will be taken to develop the analysis that leads to the formulation and derivation of the fine-structure constant.

II. THE PROTON MASS

We will proceed directly to the calculation of the proton electron mass ratio.

The scenario under discussion is that of an extremely active field with surplus energy that could not be accommodated into a quiescent "equilibrium" background of the vacuum state. The protons are stable, and the creation process relates essentially to events in parts of the universe and at

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periods when the proton could be created. In quiescent space and matter as we know it locally, we may suppose that there are processes occurring that involve Nature's attempts to create new protons, but that these actions fail to reach the creation threshold. Obviously, in the high-energy particle experiments conditions may be produced that result in transformations and could conceivably produce protons from particles of lower rest-mass energy, but pending such discoveries the interest centers on the process which could have been effective in the early period of creation of the universe.

The key factor in this enquiry is the synthesis of the proton from the merging of n virtual muons, a virtual muon in this context being a feature of an active vacuum state in which pairs of virtual muons of opposite charges populate unit cells of space and are mutually annihilated and recreated at random positions at the Compton electron frequency.

The virtual muon signifies an energy quantum that is slightly smaller than the mass energy of the real muon. It is calculable from first principles in terms of the electron rest-mass energy, but before discussing the rigorous determination of this quantity we will proceed on the tentative basis that the virtual muon/electron mass ratio is approximately 206.333.

The major step, outlined in Ref. 4, which accounts for proton creation is then the process described by the equation

$$n\mu + (k\mu : z)\text{min} \rightarrow (P : k\mu)\text{min} + z \rightleftharpoons P. \tag{1}$$

This equation declares that, if an even number k of virtual muons μ of both polarities come together to create a neutral complex, this complex can restructure in a minimal-energy configuration in which a single charge (say $-e$) of energy $k\mu$ has close association with a single charge ($+e$) of energy z, such that z has a value corresponding to least energy of the total complex. Then, suppose enough (n) virtual muons impact this complex to drive out z and leave a residual complex in which a new positive charge of energy P is paired with $k\mu$ in a minimal-energy configuration. The condition specified by the equation is that z can then merge with this complex to destroy itself and the $k\mu$ unit to leave P in isolation.

The conditions just specified are somewhat special, because the techniques used to formulate the energy of a charge pair complex are very precise. The energy of the complex $(k\mu : z)$ is simply the sum of $k\mu$ and z plus the negative potential of the Coulomb interaction between the charges nucleated by $k\mu$ and z. We use the classical J. J. Thomson formula for energy as $2e^2/3a$, where a is the charge radius, to find that two such charges of different energy in surface contact (touching radii) would have a mutual Coulomb potential of $-3k\mu z/2(k\mu + z)$. Adding $k\mu$ and z to obtain an overall energy expression and differentiating this energy to find its minimum as z varies and $k\mu$ is constant then leads to a minimal energy which can be verified as being $(\sqrt{6} - \frac{3}{2})\, k\mu$, because $z/k\mu$ becomes $\sqrt{\frac{3}{2}} - 1$.

On this basis Eq. (1) assumes the form

$$n\mu + \left(\sqrt{6} - \tfrac{3}{2}\right)k\mu = \left(\sqrt{6} - \tfrac{3}{2}\right)P + \left(\sqrt{\tfrac{3}{2}} - 1\right)k\mu = P. \tag{2}$$

It may be verified that there are integer solutions for n and k satisfying this double equation and that their minimal values are $n = 7$ and $k = 2$.

This, in itself, is surprising, and it makes the proton equation (1) rather special. It gives a physical basis for the belief that a natural stable particle form P would be created if there were surplus energy in the virtual muon field. The particle would develop from a merging of nine virtual muons and would have a rest-mass energy in electron units equal to the value of P given by Eq. (2), namely,

$$P = (4 + 2\sqrt{6})\mu. \tag{3}$$

In order to determine P it is next necessary to establish how Nature decides the value of μ.

III. THE VIRTUAL MUON

It is inappropriate to think in terms of the mass of the virtual muon. The quantum involved is an energy of μ times the rest-mass energy of the electron, but, as the virtual muons define an inertial rest frame in the space field we shall now analyze, there is no reason for attributing a mass property and particularly a gravitational property to that hidden field which characterizes the space medium. The evidence that these virtual muons do exist in the vacuum field is really the success of theory which builds on that supposition. The virtual-muon mass has to be a quantity calculable from the theory, since it cannot be directly measured and it would be inappropriate to assume that it is identical to the mass of the real muon. Indeed, the only reason for calling the virtual muon a "muon" is that we know that P is approximately 1836 and Eq. (3) tells us that μ will be of the order of 206, which is close to the real muon/electron mass ratio.

In spite of this, it is convenient to think in terms of an energy density in the virtual-muon field and use an equivalent mass density ρ, even though ρ could never be sensed as mass. This represents the statistical incidence of a virtual-muon population in the equilibrium field of vacuum space. Take a characteristic cubic cell of such space of side d, corresponding to the presence of a virtual muon pair of notional mass $2\mu m$, where m denotes electron rest mass. Then

$$\rho = 2\mu m/d^3. \tag{4}$$

Now, from the photon theory that will be summarized in a later section, it is known that

$$d = 108\pi a, \tag{5}$$

where a is $\frac{2}{3}$ times the classical electron radius e^2/mc^2. Therefore, the chance of there being one or more virtual muons within a sphere bounded by the radius a is calculable. Indeed, it is relevant on a cosmological scale to the determination of the Hubble constant.[7] However, our interest centers here on the "equilibrium" condition, which is that the density ρ assigns a notional mass m' to a characteristic volume of space that we relate to a sphere of radius b:

$$m' = \frac{4\pi}{3}b^3\rho. \tag{6}$$

An intuitive step that we now take assigns the electron charge e to this space quantum of notional mass m' and identifies the electric energy of such a quantum with the energy represented by this mass term. The applicable formula relating the radius bounding the charge to the energy is that already used for the electron, so that

$$\frac{m}{m'} = \frac{b}{a}. \tag{7}$$

By now writing N as $(b/a)^3$ it is possible to combine Eqs. (4) to (7) so as to eliminate all quantities except N and μ. The resulting equation is

$$N^{4/3}\mu = 3(108\pi)^3/8\pi. \tag{8}$$

To find N we next take the result already deduced. The threshold for proton creation depends upon nine virtual muons merging in their statistical migration in the space region that they populate. Imagine that this process involves initial electron-positron creation governed by the threshold set through the value of N in the system just described. N is really the number of electron-charge volumes that can be matched to the characteristic charge volume of the m' quantum. Given the charge e of this quantum unit, the creation of charge pairs as electrons and positrons and the creation of a residual electron imply that N must be odd. Otherwise, charge parity would be violated.

The condition for "equilibrium" space requires that N must be the odd number just below the threshold at which nine virtual muons can initiate the proton creation process. Then there will be attempts at creation of protons in a space occupied by these below-threshold quanta m', but the action will depend upon vacuum fluctuations which lead to instabilities and preclude excitation of stable proton states.

Note that the proton equation (1) requires that μ should be the same for all nine virtual muons involved in a successful transition to a proton.

Before developing this theme further, we will first estimate μ by writing the approximate relationship

$$N \approx 9\mu. \tag{9}$$

Combining this with (8),

$$N^{7/3} \approx \frac{27}{8\pi}(108\pi)^3, \tag{10}$$

from which N is approximately 1849. Remember then that N must be an odd integer, but equally we would like μ to be an odd integer if the virtual muons are to create electron-positron components in their attack on the m' system. Equation (8) does not permit both N and μ to be integers, and N has to be unique. Therefore, there is no alternative to accepting that the most expedient physical solution to the system requirements is that μ occurs as a mixture of two types of virtual muon for which the μ values are adjacent odd integers. To satisfy (9) with N having a value near 1849 there must be a mixture of $\mu = 205$ and $\mu = 207$ in the virtual-muon population of the equilibrium space field.

Then, bringing nine such virtual muons together, four of one polarity and five of opposite polarity, the latter being opposite to the charge polarity of the m' quantum, we have a basis for initiating the process according to Eq. (1) and producing a proton plus an electron or an antiproton plus a positron.

Considering the physical effects in the intense energy fields accompanying proton creation, one could argue that it is unlikely that the constants of physics as we now know them for equilibrium space could be affected. Thus, supposing that N has a certain value for equilibrium space, it would seem that N could be marginally different at times when space is violently disturbed. A spread of N-values including those conducive to a process involving nine virtual muons of the same μ value could occur in such very energetic fields. This is the basis on which this argument now proceeds.

The essential point, so far as the quantitative aspects of the theory are concerned, is that the lower μ value of 205 sets the threshold for the chaotic state permitting proton creation. The equilibrium space condition sets in when N is the odd number just below 9 times 205. It follows that N is uniquely determined as 1843.

From Eq. (8) we then know the precise composition of the mixture of the $\mu = 205$ and $\mu = 207$ virtual muons, because the mean value of μ is shown to be 206.3329, meaning that there are very nearly two $\mu = 207$ virtual muons for every such muon with $\mu = 205$.

IV. THE PRECISE MASS OF THE PROTON

It is now possible to deduce the precise mass of the proton, assuming that protons were created in a very energetic phase and that, as a stable particle family, the two types of proton that would be generated from the two virtual-muon types would exchange energy to adjust to equal mass values. Thus the mean value of μ as given by Eq. (8) with $N = 1843$ is determining.

The proton/electron mass ratio is rigorously formulated by combining Eqs. (3) and (8) with $N = 1843$. Accordingly,

$$P = (4 + 2\sqrt{6})\frac{3}{8\pi}(108\pi)^3(1843)^{-4/3}, \quad (11)$$

which gives

$$P = 1836.152317. \quad (12)$$

To compare this with the measured value it is necessary to make allowance for the fact that the theory assigns a finite volume to the electron charge. If the quanta m' have a charge $-e$, then the remainder of a unit cell of the space field must have a distributed charge totaling $+e$, because the vacuum is electrically neutral overall. It follows that the motion of an electron is accompanied by the countermotion of a small amount of positive charge given by

$$\delta e = \frac{4\pi}{3}\frac{e}{(108\pi)^3}. \quad (13)$$

Therefore,

$$\delta e/e = 1.07 \times 10^{-7}. \quad (14)$$

In effect, the electron manifests an electrodynamic charge effect that is not the universal charge quantum e but is larger than this by 1.07 parts in ten million. It follows that a measurement of the proton/electron mass ratio that assumes that proton charge and electron charge are of equal magnitude will be in error by amounts of this order.

This is a vital consideration, because measurements now exceed this degree of precision. The proton itself is known to exhibit a finite form nucleated on more than one charge and attributed to a quark structure. The dimensions of this finite form are known to be of an order measured in femtometers, which applies also to the charge volume assigned above to the electron by use of the radius a. Evidently the measured proton/electron mass ratio will be affected by both the finite form of the electron charge and that of the proton. Our theory estimates a few parts in ten million as the expected discrepancy between the true mass ratio as given by (12) and the mass ratio expected from measurement.

On this basis it is interesting to take the latest CODATA value for this measurement, namely 1836.152701(37), and compare it with the true mass ratio given by Eq. (12). The discrepancy is 2.09 parts in ten million, which, allowing for the uncertainty in the measurement, is equivalent to a $\delta e/e$ effect of twice that given by Eq. (14).

The empirical indication is that the proton itself involves the finite volume of an electron-positron pair, which underestimates the effective charge of the proton by 2.14 parts in ten million in a measurement effectively referenced on a point electron charge. Alternatively, the proton has on average a single finite electron volume associated with it, and, being positive, this means an effective charge reduced by one of the units under discussion, with the ratio measured against an electron which has its electric charge effectively increased by one such unit.

The calculated estimate of the measured proton/electron mass ratio on this basis gives the value

$$P = 1836.152711. \tag{15}$$

Before commenting further on this, it is appropriate to look now at the other precision constant relating to the proton. This is its magnetic moment measured in nuclear magnetons.

V. THE PROTON MAGNETIC MOMENT

Here it is not proposed to give the full analysis of the formulation of the proton magnetic moment. It is based on similar principles to those outlined above, and a summary analysis is presented in a reference of recent record.[8] Suffice it here to note that, consistent with the above principles, the proton is involved in a resonant interaction with the virtual-muon population. This resonance is governed by the $\mu = 205$ quantity for one-third of any period of time and by the $\mu = 207$ quantity for two-thirds of the time. However, the prior reference did not develop that theme. It merely gave the two criteria for either one such resonance or the other and noted that some intermediate effect would probably apply in fact.

The new CODATA value of the measured quantity is, however, so precise that it becomes necessary to take this argument to its limits and check the theory at its extreme prediction.

The reason that very high precision is expected from the technique adopted is the success of related theory for the electron magnetic moment,[9] which rivals quantum electrodynamics (QED) by giving what is a precise theoretical correlation, as judged against the CODATA value of the electron g factor in relation to the fine structure constant. The theory for the proton magnetic moment matches up to this test and has no rival theory in QED or QCD that can warrant comparison.

The formula deduced in Ref. 8 has the form

$$\gamma = 2\left(1 - \frac{3r}{4R}\right), \tag{16}$$

where

$$R^2 = (2r)^2 + r^2 - 2(2r)\cos\theta \tag{17}$$

and θ is an angle of approximately 120 degrees determined in a resonant wave field centered on the proton by interactions involving the virtual-μ system. The angle θ complements two other angles ϕ and β, summing to 180 degrees, which are related to the trigonometry of a triangle of sides R, $2r$, and r, so that

$$\sin\beta = 2\sin\phi, \tag{18}$$

and 2ϕ is determined by the number X of such double triangles that represent a complete resonant wave pattern set up by making Y complete revolutions around the proton. This really says that

$$2\phi = \frac{Y}{X}360, \tag{19}$$

where ϕ is in degrees of angle.

The optimum resonant states are determined when the Y/X values for each of the two μ-state resonances give very nearly the same value of γ. These are found to be $Y/X = 615/5765 = 123/1153$ for the $\mu = 205$ state and $1035/9702 = 115/1078$ for the $\mu = 207$ state. Note that $615 = 3(205)$ and $1035 = 5(207)$. Also 123 and 205 have the common prime factor 41, whereas 115 and 207 share the prime factor 23. The proton characteristic enters via the approximation of 5765 to π times 1836, the proton/electron mass ratio. By working through the equations just presented to determine γ for either resonance, one can then obtain for the $\mu = 205$ resonance

$$\gamma = 2.792845439, \tag{20}$$

and for the $\mu = 207$ resonance

$$\gamma = 2.792847883. \tag{21}$$

The credibility of the theory depends, in the main, upon the degree of assurance that the Y/X ratios quoted are determined by optimum physically resonant processes. The crux of the analysis is to find an X/Y ratio close to a value which makes θ equal to 120 degrees. The ratio should be about 9.42. However, for resonance with the two muon states and near-equality of the γ-values to assure minimum fluctuation during transitions, the reader can verify that the resonances specified are the only ones that can apply on optimum physical grounds.

Since the above argument was developed for Ref. 8, the new CODATA measurements have appeared, and γ is quoted to the number of digits given in (20) and (21) with a standard deviation of 63. It is therefore appropriate to extend the calculation by first allowing for the mixture of interacting muon states in the 2-to-1 ratio of $\mu = 207$ to $\mu = 205$. This gives an operative value of

$$\gamma = 2.792847068. \tag{22}$$

Also, just as has been seen for the proton mass, this might be the true gyromagnetic factor, but there could be some aspect of the measurement that causes the finite form of the proton to get involved. The actual measurement of γ is indirect and is a composite of three other measurements, one being the electron g factor. The measurement of the spin-magnetic-moment ratio of electron and proton is involved, as is the connecting measurement, namely that of the proton-electron mass ratio.

When we look at the empirical indications, there is a case for allowing γ to be incremented by one unit of the factor of 1.07 parts in ten million. This puts γ as deduced from the theoretical value as

$$\gamma = 2.792847367, \tag{23}$$

which compares with a CODATA measured value of 2.792847386(63).

VI. THE ELECTRON-POSITRON FIELD

The determination of γ of the proton is based on a direct estimate of the proton-electron mass ratio. The double-unit electron-charge volume affecting this term equally affects the measurement of γ. The extreme accuracy of the computation of the electron g factor shows that no such charge-volume term has any net effect upon that measurement. This then requires the spin-magnetic-moment ratio of electron to proton to be subject to a single-unit electron-charge volume increment factor. This is a valid theoretical proposition because the electron is a discrete charge having the relevant volume and the proton component in spin will be the core proton component, in which the mass is concentrated and which must have negligible charge volume.

The clear indications are, therefore, that the proton in translational motion exhibits motion of a charge that has, on average, displaced that unit volume of the classical Thomson electron. For such a positive charge this reduces its effective charge by one unit, whereas that of the electron is effectively increased. Hence the double unit factor in the measured proton-electron mass ratio.

The model of the proton which this conjures in the author's mind is one of a concentrated single unit of charge which in translational motion depends upon association with an electron-positron field. To obtain the single-unit electron-charge volume, there then has to be a two-state condition with energy conservation as the electron-positron pair cycles between mutual annihilation and recreation so as to spend effectively half the time in existence. Possibly the exchanges could involve the concentrated core of the proton and account for its quarklike properties. In the latter case, so far as the derivation of γ is concerned, this did not depend upon the particular mass or charge of the charge core involved. The ratio calculation is based on pure geometry of the cavity resonant field system. Hence the same factor applies to all the quarks for a theory in which the proton has a three-part quark composition.

This, of course, is speculation and is a matter for further development. The extremely precise way in which the earlier analysis has led to the derivation of a γ value in perfect accord with the measured value is indicative that the fundamental resonance contemplated has a sound basis. Certainly, there is little scope left for developing the calculation further.

VII. THE PHOTON DATA

Equation (5) needs to be justified to make the above analysis self-contained. This comes from a derivation of an expression involving Planck's constant h in two separate ways based on the dynamics of a synchronous electrical lattice. The theory is of prior record[10]; see also Ref. 11. The key steps in the analysis involve deducing the two-dimensional harmonic oscillator condition in which the energy E stored is equal to the angular momentum added (H) times the natural angular frequency $\omega = 2\pi mc^2/h$ of the system. Then a $3 \times 3 \times 3$ cubic lattice group of the m' quanta is taken as the basic spin unit. From considerations analogous to hydrodynamics, the effective inertial mass of a sphere moving in a fluid having the same mass density is exactly half that of the quantum m' involved. The spin unit has a angular momentum H when spinning at an angular speed of $2\pi(f/4)$, where f is the perturbation frequency resulting from the four corners of the cubic spin unit. The angular momentum of such a spin unit is $36d^2(m'/2)$ times its angular speed. Therefore,

$$H = 9\pi d^2 m' f. \tag{24}$$

Replacing H by the expression involving E,

$$E = 18\pi^2 d^2 m' f mc^2/h \tag{25}$$

Now note that E is hf, so that this equation gives

$$h^2 = 18\pi^2 d^2 c^2 m' m. \tag{26}$$

A corresponding equation is deduced from the natural frequency ω of the system by matching the restoring-force rate against the centrifugal effects of m'. Allowing for dynamic balance, so that the motion is about a radius x with displacement $2x$,

$$4\pi \frac{e^2}{d^3}(2x) = \frac{m'}{2}\omega^2 x, \tag{27}$$

Substituting $2\pi mc^2/h$ for w then gives

$$h^2 = \frac{\pi}{4}\frac{d^3c^4}{e^2}m^2m'. \tag{28}$$

Comparing (26) and (28),

$$d = 72\pi e^2/mc^2 = 108\pi a, \tag{29}$$

which is the equation (5) that we sought to verify.

Putting this value of d in Eq. (26) and using the Thomson electron formula gives

$$\frac{hc}{2\pi e^2} = 108\pi\sqrt{\frac{2m'}{m}}, \tag{30}$$

which, from our early derivation of m'/m via the N expression, is $108\pi(8/1843)^{1/6}$, or 137.0359148.

The latest CODATA value of this constant is 137.0359895(61), and the extension of the theory to deduce this constant with equally high precision is a task to be covered elsewhere. It can be recorded here, however, that because the charges e associated with m' are at rest in the electrodynamic reference frame (in that they define that frame, whereas the virtual muons defined the inertial frame), there is no charge-volume effect modifying the value of the fine-structure constant deduced above. However, when the constant is measured by the behavior of electrons, the measured value overestimates e^2 by two units of 1.07 in ten million. This means that the discrepancy we must explain is 7.59 parts in ten million. For reasons which will be discussed elsewhere[12] and which have already been outlined in a recent *Hadronic Journal* paper,[13] the author sees this as corresponding to a discrepancy matching a term $(v/c)^2/2$. Thus v, which represents cosmic motion through the space field relative to a preferred frame, has a mean value of about 370 km/s subject to the uncertainty of the measurements involved (equivalent to about 10 km/s).

One important point which will have occurred to the reader is the question of reconciling the mixed $\mu = 205$ and $\mu = 207$ with the actual measurement of the real muon/electron mass ratio. This has been done and is already of record.[14,16] The real muon is a changing condition of a $\mu = 205$ and $\mu = 207$ system which involves an electron-positron field. Field cavity resonance gives a precise formula for the real muon/electron mass ratio (ignoring the electron-charge volume factor introduced in this paper). The value obtained is 206.7683078, which compares with the CODATA value of 206.768262(30). The discrepancy happens to be 2.22 parts in ten million, or within a few percent of two of the units discussed in this paper. However, until even more precise data are available or data are available which might highlight differences between negative and positive muons, there is little value in debating this subject. It is further noted that the theory as applied to the real muon affords a precise estimate of the muon lifetime[15] and also explains the muon g factor.[16]

The above theory for the proton shows that there is very good reason for believing that a virtual-muon population in an energetic space field accounts for the existence of the proton and causes surplus energy to materialize in the matter form seen in the hydrogen atom. This gives us a genuine reason for understanding why physics needs the muon. Hitherto, physicists have wondered where the muon fits into the general scheme. Note also that the tau lepton has a role in the gravitational interaction, as already reported.[6]

This paper has presented the author's theory in a new context, showing that the proton creation process can, via the muon interaction, determine the parameter 1843 which is crucial to the determination of the quantity m'/m, which in turn fixes the precise value of the fine-structure constant. The author's early theory[1] had approached this topic from the viewpoint of electric potential thresholds, which, though still relevant, may have appeared arbitrary in the denial of negative potential sites for m'. The present paper therefore breaks new ground by providing a much more direct approach to the determination of m'/m, with consequent simplication of the argument and confinement of it to physical events involving field structures associated with particle concentrations. Proton creation can therefore by explained without first developing what is, in effect, a new ether theory. Even so, a full understanding of photon behavior, especially in the light of the latest experimental developments in quantum mechanics, does appear to lead inevitably to a revival of some modified form of ether theory with a preferred frame.

It is concluded that the author's proton theory remains viable in spite of the very stringent demands placed by the high-precision measurements reported in the new CODATA values.

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