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# The Assessment of a Theory for the Proton-Electron Mass Ratio.

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*Summary.* – Recent precision measurements of the proton-electron mass ratio confirm a theoretical evaluation dating from 1975 to one part in $10^7$. The theory suggests that this discrepancy, which the measurements show to be $0.833 \pm 0.436$ parts in $10^7$, may evidence a very small inequality between the magnitudes of the proton charge and the electron charge, theoretically predicted to be 1.07 parts in $10^7$.

A theory for the proton-electron mass ratio $M_p/m_e$ presented in 1975 by ASPDEN and EAGLES (1) gave a value of 1836.152 317, which at that time was within 4 parts in $10^7$ of the measured value of 1836.151 52(70). There has since been considerable progress in the accuracy of the measurement techniques, leading to the latest and most precise measurement by VAN DYCK, MOORE and SCHWINBERG (2) which gives a proton-electron mass ratio of 1836.152 470(80), a value in much closer accord with the 1975 theoretical evaluation.

Bearing in mind the relative simplicity of the formulations given by the theory and the fact that the same principles had earlier in 1972 (3) yielded a value of the fine-structure constant $\alpha$ exact to one part in $10^6$, this improved accord of the proton-electron mass ratio to within one part in $10^7$ demonstrates the underlying strength of the theory and warrants some assessment.

Now that the precision of the measurement techniques has advanced so far, it becomes important to clarify a feature of the theory which has significance at the one part in $10^7$ level and which is implicit in the data of the basic papers (1,3). No further assumptions need to be introduced.

The theoretical model on which the theory was developed required the vacuum to have an electrical lattice structure, a feature which is coming more into favour in particles physics and which contemplates the vacuum having an ordered cubic structure

(1) H. ASPDEN and D. M. EAGLES: *Nuovo Cimento A*, **30**, 235 (1975).
(2) R. S. VAN DYCK jr., F. L. MOORE and P. B. SCHWINBERG: *Bull. Am. Phys. Soc.*, **28**, 791 (1983).
(3) H. ASPDEN and D. M. EAGLES: *Phys. Lett. A*, **41**, 423 (1972).

somewhat analogous to a ferromagnetic crystal [4,5]. This structure comprises an array of lattice charges immersed in a uniform background continuum of charge density $\sigma$, which effectively neutralizes the charge in the lattice. Fundamental to the author's theory is the recognition that a charge $e$ has a spherically bound form of radius $a$ for which the Thomson formula

$$mc^2 = 2e^2/3a \tag{1}$$

applies. Here $m$ is the mass associated with the charge and $c$ is the speed of light.

The volume of the continuum displaced by the sphere of charge $e$ was an important consideration in evaluating the fine-structure constant. Applying the formula (1) to the lattice charges, deemed to have the same charge $e$ as the electron, the conservation of this volume [*] in particle pair creation processes assured, for example, that an odd integer relationship had to apply to the ratio of the volume of the lattice charge and the volume of the electron or positron charge. Rigorous analysis of the energy balance in the vacuum model for minimal potential energy showed that this depended upon the mass ratio and so the charge volume ratio of the lattice charge and the electron. This led to a unique minimal energy value for the odd integer specifying this ratio. It was found by a computer analysis of the interaction energy of the electrical vacuum model to be 1843. This parameter, together with the cubic lattice dimension of $108\pi$ in terms of electron charge radius, features prominently in the derived formulae:

$$M_p/m_e = \frac{3}{4\pi}(108\pi)^3(1843)^{-4/3}\left[\left(\frac{3}{2}\right)^{1/2} - 1\right]^{-1}, \tag{2}$$

$$\alpha^{-1} = 108\pi(1843)^{-1/6}(2)^{1/2}, \tag{3}$$

which, respectively, gave 1836.152317 and 137.0359148 for these quantities.

Evident from this is the simple fact that the volume of the electron charge $4\pi a^3/3$ is smaller than the volume of the lattice cubic cell $(108\pi)^3a^3$ by a factor which is one part in $(3/4\pi)(108\pi)^3$, a parameter appearing in formula (2) for the proton-electron mass ratio.

This quantity has the value 9324644, the reciprocal of which is $1.07\cdot10^{-7}$, and since the magnitude of the continuum charge in unit lattice cell is equal to the electron charge $e$, it tells us that the electron displaces $1.07\cdot10^{-7}$ units of its own charge of opposite polarity. This was too small to warrant comment in 1975, but it is important now that experimental work has reached the 1 part in $10^7$ level of precision.

Electrodynamically the electron will exhibit a charge $e$ incremented by this factor of $1.07\cdot10^{-7}$ because its motion through the charge continuum causes displacement and counterflow of this small opposite-polarity charge quantity. This has, therefore, to be allowed for in comparing measurement data with the theory for the proton-electron mass ratio. So far as the proton itself is concerned, its form according to the Thomson

(4) C. REBBI: *Sci. Am.*, **248**, 36 (1983).
(5) V. F. WEISSKOPF: *Phys. Today*, **34**, No. 12, 69 (1981).
(*) In the first footnote of the 1975 paper (1) it was explained how, at that time, the model had difficulty assuring a reconciliation between the phenomenon of meson time dilation and the form of the charge suggested. Since then, however, the space conservation principles have proved to be essential and to have a direct bearing upon this meson lifetime issue, as shown in the very recent paper by ASPDEN (6).
(6) H. ASPDEN: *Lett. Nuovo Cimento*, **37**, 307 (1983).

formula would make its charge volume smaller than that of the electron by a factor of $10^{-10}$ and this implies a charge discrepancy electrodynamically as low as $10^{-17}\,e$, which is negligible compared with the augmented charge $1.07 \cdot 10^{-7}\,e$ of the electron.

Now in the measurements of the proton-electron mass ratio it is assumed that their charges have the same magnitude. If they have different effective charges the mass ratio adduced from frequency measurements when subjected to the same magnetic field has to be increased in proportion to their charge ratio. Thus, since the proton charge is smaller by $1.07 \cdot 10^{-7}$ than the electron charge, according to this theory, the measured value of the proton-mass ratio needs to be reduced by the same amount to make a comparison between theory and experiment (*).

It may be seen from the data presented above that the reported proton-electron mass ratio is higher than the theoretical value by $153 \pm 80$ parts in $1.836 \cdot 10^9$ or $0.833 \pm 0.436$ parts in $10^7$. If, however, we correct for the charge ratio to bring the theory fully into comparable form with the measured mass ratio, we find that the overall discrepancy between theory and experiment is $0.239 \pm 0.436$ parts in $10^7$.

This is a conclusion we arrive at in comparing a 1983 reported measurement with a theory proposed in 1975. No further assumptions have been made. Evidently the theory is well supported.

It remains to consider further the consequences of isolated protons having a charge which differs slightly in magnitude from that of the electron, at least when sensed electrodynamically. Note that, owing to the space conservation process discussed above a cluster of 1843 electrons in a body of matter would imply the annihilation of a vacuum lattice charge of equal volume and suggest that one of the electrons substitutes for the lattice charge in neutralizing the continuum. Any forward motion of this substitute electron with matter progressing through the lattice would be balanced by a reverse motion of lattice charge exchanging its lattice position with the electron. The result of this is that the continuum displacement due to forward motion of 1843 electrons in the body is balanced by the reverse motion of lattice charge. It follows that no electrodynamic action would arise.

Between the extreme of the single proton and single electron and a body containing 1843 electrons, there is scope for up to half the 1843 electrons moving without the compensation of a lattice particle. Thus the maximum out-of-balance charge to be expected on any body of matter is $\frac{1}{2}(1843)(1.07 \cdot 10^{-7})e$ or about $10^{-4}e$. In principle, therefore, the theory indicates that a residual charge of $10^{-4}e$ at most may exist as an intrinsic charge on the average particle of matter, provided it comprises enough atoms to sustain 922 electrons. Since the cancelling lattice charges will keep company only with those particles containing the substitute electrons, the result will be that this charge of the order of $10^{-4}e$ will be positive for some and negative for others, cancelling overall.

The topic of inequality of positive and negative charge in an atom is discussed in a book by MILLIKAN (7), who describes an experiment by which the positive- and negative-charge quanta on an oil drop were shown to differ by less than one part in 2000. Such work was not accurate enough to detect the $10^{-4}e$ charge suggested above, but modern research techniques along the lines suggested by MILLIKAN should allow this theory to be tested, in as much as the charge on an oil drop should fluctuate by $10^{-4}e$ as molecules evaporate from the drop. Also there may be scope for assessing whether small systematic charge discrepancies can affect the data available from atomic mass spectro-

(*) See appendix.

(7) R. A. MILLIKAN: *Electrons (+ and −), Protons, Photons, Neutrons and Cosmic Rays*, (Chicago, Ill. 1935), p. 82.

scopy and cause anomalous fluctuations in the isotopic masses, particularly for the heavier atoms.

To conclude, the author submits that the recently reported precision measurement of the proton-electron mass ratio gives positive support to the 1975 theory and justifies further effort to explore other implications of this theory.

*Appendix.* – There is experimental evidence from collision data indicating that the proton may comprise three elements and have a physical dimension of the order of $10^{-13}$ cm. This is similar to the size of the electron.

It is suggested that this may be due to the fact that the proton charge of the form suggested by the Thomson formula (1) may migrate in some statistical manner and have an intermediate « rest » condition relative to the charge continuum, in which state some of its energy is momentarily deployed in creating electron-positron pairs. A statistical transition between states involving pair creation and the state defined by the Thomson formula is the basis on which the meson lifetime dilation was explained nonrelativistically in ref. (6). Furthermore, the emission of β-particles when a neutron decays into a proton suggests that the electrons can be bound in some way to the nucleon form.

However, the essential point is that the proton's form when reacting electrodynamically to its motion in a magnetic field appears to be that having a dimension set by the Thomson formula (1).

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