Why the Proton is Smaller and Heavier than the Electron

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This paper argues that the proton is smaller and heavier (more massive) than the electron because, as opposed to the electron, the proton is negatively coupled to the Planck vacuum state. This negative coupling appears in the coupling forces and their potentials, in the creation of the proton and electron masses from their massless bare charges, and in the Dirac equation. The mass calculations reveal: that the source of the zero-point electric field is the primordial zero-point agitation of the Planck particles making up the Planck vacuum; and that the Dirac-particle masses are proportional to the root-mean-square random velocity of their respective charges.

1 Introduction

The Planck vacuum (PV) is an omnipresent degenerate continuum of negatively charged Planck particles, each of which is represented by $(-e_*, m_*)$, where e_* is the massless bare charge and m_* is the Planck mass [1]. Associated with each of these particles is a Compton radius $r_* = e_*^2/m_*c^2$. This vacuum state is a negative energy state separate from the free space in which the proton and electron exist. That is, the proton and electron do not propagate through the Planck particles within the PV, but their charge- and mass-fields do penetrate that continuum.

The proton and electron cores denoted by (e_*, m_p) and $(-e_*, m_e)$ are "massive" bare charges. The two cores are "shrouded" by the local response of the PV that surrounds them and gives the proton and electron their so-called structure [2]. These two particles are referred to here as Dirac particles because they are stable, possess a Compton radius, $r_p\,(= e_*^2/m_pc^2)$ and $r_e\,(= e_*^2/m_ec^2)$ respectively, and obey the Dirac equation. They are connected to the PV state via the three Compton relations

$$r_em_ec^2 = r_pm_pc^2 = r_*m_*c^2 = e_*^2 \qquad (= c\hbar) \tag{1}$$

which are derived from the vanishing of the coupling equations in (2).

In their rest frames the Dirac particles exert a two-term coupling force on the PV that takes the form [3]

$$F(r) = \mp\left(\frac{e_*^2}{r^2} - \frac{mc^2}{r}\right) = \mp\frac{e_*^2}{r^2}\left(1 - \frac{r}{r_c}\right) \tag{2}$$

where the $\mp$ sign refers to the proton and electron respectively. The force vanishes at the Compton radius $r_c\,(= e_*^2/mc^2)$ of the particles, where m is the corresponding mass. The PV response to the forces in (2) is the pair of Dirac equations

$$\mp e_*^2\left(i\frac{\partial}{\partial ct} + \boldsymbol{\alpha}\cdot i\nabla\right)\psi = \mp mc^2\beta\psi \tag{3}$$

(with the Compton radius $\frac{\mp e_*^2}{\mp mc^2} = r_c$) which describe the dynamical motion of the free Dirac particles.

The potential defined in the range $r \leqslant r_c$

$$V(r) = \int_r^{r_c} F(r)dr \qquad \left(F(r) = -\frac{dV(r)}{dr}\right) \tag{4}$$

leads to (with the help of (1))

$$\frac{V(r)}{mc^2} = \mp\left(\frac{r_c}{r} - 1 - \ln\frac{r_c}{r}\right) \tag{5}$$

with

$$V_p(r \leqslant r_p) \leqslant 0 \qquad \text{and} \qquad V_e(r \leqslant r_e) \geqslant 0\,. \tag{6}$$

For $r \ll r_c$, the potentials become

$$V_p(r) = -\frac{e_*^2}{r} = \frac{(e_*)(-e_*)}{r} \ll 0 \tag{7}$$

and

$$V_e(r) = +\frac{e_*^2}{r} = \frac{(-e_*)(-e_*)}{r} \gg 0 \tag{8}$$

where the final $(-e_*)$ in (7) and (8) refers to the Planck particles at a radius r from the stationary Dirac particle at $r = 0$. The leading (e_*) and $(-e_*)$ in (7) and (8) give the free proton and electron cores their negative and positive coupling potentials.

Equations (6)–(8) show that the proton potential is negative relative to the electron potential — so the proton is more tightly bound than the electron. Thus the Compton relations in (1) imply that the proton is smaller and heaver than the electron. These results follow directly from the fact that the proton has a positive charge, while the electron and the Planck particles in the PV have negative charges.

The masses of the proton and electron [4] [5] are the result of the proton charge $(+e_*)$ and the electron charge $(-e_*)$ being driven by the random zero-point electric field $\mathbf{E}_{\text{zp}}$, which is proportional to the Planck particle charge $(-e_*)$ of the first paragraph. A nonrelativistic calculation (Appendix A) describes the random motion of the proton and electron charges as

$$\frac{2\,\ddot{\mathbf{r}}_\pm}{3} = \mp\left(\frac{\pi}{2}\right)^{1/2}\frac{c^2}{r_c}\,\mathbf{I}_{\text{zp}} \tag{9}$$

where the upper and lower signs refer to the proton and electron respectively, r_c to their respective Compton radii, and where $\mathbf{I}_{zp}$ is a random variable of zero mean and unity mean square. The radius vector $\mathbf{r}$ [NOT to be confused with the radius r of equations (2) thru (8)] represents the random excursions of the bare charge about its average position at $\langle \mathbf{r} \rangle = 0$. The $2/3$ factor on the left comes from the planar motions (Appendix A) of the charges $\pm e_*$ that create the Dirac masses $m_\pm$. The $\mp$ sign on the right side of (9) is the result of the $\mp$ sign on the right side of the potentials in (5).

After the charge accelerations in (9) are "time integrated" and their root-mean-square (rms) calculated [5], the following Dirac masses emerge (with the help of (1))

$$\frac{m_\pm}{m_*} = \frac{2}{3} \frac{\left\langle \dot{\mathbf{r}}_\pm^2 \right\rangle^{1/2}}{c} \tag{10}$$

where $m_\pm$ are the derived masses whose sources are the driven charges — consequently the average center of charge and the average center of mass are the same. Equations (10) and (1) lead to the following ratios

$$\frac{\left\langle \dot{\mathbf{r}}_+^2 \right\rangle^{1/2}}{\left\langle \dot{\mathbf{r}}_-^2 \right\rangle^{1/2}} = \frac{m_p}{m_e} = \frac{r_e}{r_m} \approx 1800 \tag{11}$$

where the rms random velocity of the proton charge is 1800 times that of the electron charge because of the proton's negative coupling potential.

2 Summary and comments

The negative and positive potentials in (6)–(8) imply that the proton is smaller and heavier than the electron. Furthermore, these two facts are manifest in the $\mp$ signs of the random motion of the bare charges that create, with the help of the zero-point field $\mathbf{E}_{zp}$, the Dirac masses $m_\pm$.

In the PV theory, the radian-frequency spectrum of the zero-point electric field is approximately $(0, c/r_*)$, where the upper limit is the Planck frequency $c/r_* (\sim 10^{43}$ rad/s). On the other hand, the rms accelerations and velocities associated with the random variables $\ddot{\mathbf{r}}$ and $\dot{\mathbf{r}}$ in (9)–(11) are predominately associated with the two decades

$$\frac{c}{100 r_*}, \quad \frac{c}{10 r_*}, \quad \frac{c}{r_*} \tag{12}$$

at the top of that spectrum [6]. Thus the continuous creation of the Dirac masses $m_\pm$ takes place in a "cycle time" approximately equal to $200\pi r_*/c \sim 10^{-41}$ sec, rapid enough for the masses in (2) and (3) to be considered constants of the motion described by (3).

The theory of the PV model suggests that the proton and electron are stable particles because the PV response to the coupling forces in (2), i.e. the Dirac equation in (3) with $r_c = e_*^2/mc^2$, maintains the separate identities of the two coupling constants e_*^2 and mc^2. In other words, the charge and mass of the free Dirac particle are separate characteristics of the motion in (3), even though the $m_\pm$ are derived from the random motion of the bare charges $\pm e_*$.

Appendix A: Dirac masses

The nonrelativistic planewave expansion (perpendicular to the propagation vector $\widehat{\mathbf{k}}$) of the zero-point electric field that permeates the free space of the Dirac particles is [1] [5]

$$\mathbf{E}_{zp}(\mathbf{r}, t) = -e_* \mathrm{Re} \sum_{\sigma=1}^{2} \int d\Omega_k \int_0^{k_{c*}} dk\, k^2 \widehat{\mathbf{e}}_\sigma \left(\frac{k}{2\pi^2} \right)^{1/2} \times \exp\left[i \left(\mathbf{k} \cdot \mathbf{r} - \omega t + \Theta \right) \right] \tag{A1}$$

where $(-e_*)$ refers to the negative charge on the separate Planck particles making up the PV, $k_{c*} = \sqrt{\pi}/r_*$ is the cutoff wavenumber (due to the fine granular nature of the PV [7]), $\widehat{\mathbf{e}}_\sigma$ is the unit polarization vector perpendicular to $\widehat{\mathbf{k}}$, and Θ is the random phase that gives the field its stochastic nature.

Equation (A1) can be expressed in the more revealing form

$$\mathbf{E}_{zp}(\mathbf{r}, t) = \left(\frac{\pi}{2} \right)^{1/2} \left(\frac{-e_*}{r_*^2} \right) \mathbf{I}_{zp}(\mathbf{r}, t) \tag{A2}$$

where $\mathbf{I}_{zp}$ is a random variable of zero mean and unity mean square; so the factor multiplying $\mathbf{I}_{zp}$ (without the negative sign) is the rms zero-point field. This equation provides direct theoretical evidence that the zero-point field has its origin in the primordial zero-point agitation of the Planck particles (thus the ratio $-e_*/r_*^2$) within the PV. The random phase Θ in (A1) is a manifestation of this agitation.

The random motion of the massless charges that lead to the Dirac masses m_p and m_e are described by [4] [5]

$$\pm e_* \frac{2\, \ddot{\mathbf{r}}_\pm}{3} = \frac{c^2}{r_c} r_*^2 \mathbf{E}_{zp} = \left(\frac{\pi}{2} \right)^{1/2} \frac{c^2}{r_c} \left(-e_* \mathbf{I}_{zp} \right) \tag{A3}$$

which yield the accelerations in (9). The upper and lower signs in (A3) and (9) refer to the proton and electron respectively. The $2/3$ factor is related to the two-dimensional charge motion in the $\widehat{\mathbf{e}}_\sigma$ *plane*. The physical connection leading to these equations is the particle-PV coupling $\mp e_*^2$ in (2).

Finally, there is a detailed (uniform and isotropic at each frequency) spectral balance between the radiation absorbed and re-radiated by the driven dipole $\pm e_* \mathbf{r}$ in (A3); so there is no net change in the spectral energy density of the zero-point field as it continuously creates the proton and electron masses [5] [8].

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4. Daywitt W.C. The Source of the Quantum Vacuum. *Progress in Physics*, 2009, v. 1, 27. In the first line of the last paragraph in Appendix A of this paper "$p = \hbar/r_L$" should read "$m\gamma c = \hbar/r_L$".
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