The Electron and Proton Planck-Vacuum Coupling Forces and the Dirac Equation

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This short paper derives the electron and proton Planck-vacuum coupling forces so that both the electron and proton, and their antiparticles, possess a Compton radius and obey the Dirac equation.

1 Introduction

The Dirac equation can be expressed as [1] [2]

$$e_*^2\left(i\frac{\partial}{\partial ct}+\boldsymbol{\alpha}\cdot i\nabla\right)\psi = mc^2\beta\psi \tag{1}$$

where in the Planck vacuum (PV) theory the coefficients e_*^2 and mc^2 are particle-PV coupling constants associated with the polarization and curvature forces

$$\frac{(\pm e_*)(-e_*)}{r^2} = \mp\frac{e_*^2}{r^2} \quad \text{and} \quad \frac{mm_*G}{r_*r} = \frac{mc^2}{r} \tag{2}$$

where $(\pm e_*)$ and mc^2 are the charge and rest mass energy of the free-space Dirac particles and $(-e_*)$ refers to the separate Planck particles making up the PV continuum. G is Newton's gravitational constant, m_* and r_* are the mass and Compton radius of the Planck particles, and e_* is the massless bare charge. The 'Dirac particles' refer in the present paper to the electron and proton and their respective antiparticles.

The coupling constants in (1) and (2) are presently associated with the rest-frame coupling forces [3]

$$F(r) = \mp\frac{e_*^2}{r^2} - \frac{mc^2}{r} \tag{3}$$

but there is a problem. The negative polarization force in (3) is due to the positive charge in $(\pm e_*)$ of (2) and yields the equation

$$-e_*^2\left(i\frac{\partial}{\partial ct}+\boldsymbol{\alpha}\cdot i\nabla\right)\psi = mc^2\beta\psi \tag{4}$$

which, because of the negative sign, is not a Dirac equation. Thus these coupling forces do not lead to a Dirac particle in the positron and proton cases — nor can they produce their corresponding Compton radii $r_c = e_*^2/mc^2$ from (3), where $F(r_c)$ must vanish. So there is something wrong with these coupling forces and, to resolve the problem, it is necessary to look more closely at the foundation of the PV theory.

2 Single superforce

The two observations: "investigations point towards a compelling idea, that all nature is ultimately controlled by the activities of a single *superforce*", and "[a living vacuum] holds the key to a full understanding of the forces of nature" ; come from Paul Davies' popular 1984 book [4, p.104] entitled "*Superforce: The Search for a Grand Unified Theory of Nature*". This living vacuum consists of a "seething ferment of virtual particles", and is "alive with throbbing energy and vitality". These statements form the foundation of the PV theory [5] [6] that, among other things, derives the primary constants associated with Newton's constant $G\,(= e_*^2/m_*^2)$, Planck's reduced constant $\hbar\,(= e_*^2/c)$, and the fine structure constant $\alpha\,(= e^2/e_*^2)$.

The single-superforce idea is taken here to mean that the superforces associated with General relativity [5] and the Newton and Coulomb forces have the same magnitude. In particular it is assumed that

$$\frac{m_*^2G}{r_*^2} = \frac{c^4}{G} = (\pm)\frac{e_*^2}{r_*^2} \tag{5}$$

where the first, second, and third ratios are the superforces for Newton's gravitational force and General relativity, and the free-space forces and superforces associated with the Coulomb force.

Equating the first and second ratios in (5) leads to

$$\frac{c^4}{G} = (\pm)\frac{m_*c^2}{r_*} \tag{6}$$

where, since c^4 and G are positive-definite constants, the negative sign in (6) must refer to some other aspect of the ratio — this other aspect is the c^4/G association with the two-term particle-PV coupling forces. Equating the second and third ratios in (5) and using (6) yields

$$(\pm)\frac{m_*c^2}{r_*} = (\pm)\frac{e_*^2}{r_*^2} \tag{7}$$

both sides of which are coupling forces.

Equating the first and third ratios in (5) gives

$$G = \frac{e_*^2}{m_*^2} \tag{8}$$

as the definition of the secondary constant G in terms of the primary constants e_*^2 and m_*^2.

Using the curvature and polarization forces in (7), the two-term coupling forces take the form

$$F(r_*) = (\pm)\frac{e_*^2}{r_*^2}(\pm)\frac{m_*c^2}{r_*} \tag{9}$$

where the proper choice of the plus and minus signs leads to coupling forces consistent with the existence of a Compton radius. Thus the proper choice is

$$F(r_*) = \pm\left(\frac{e_*^2}{r_*^2} - \frac{m_*c^2}{r_*}\right) \tag{10}$$

defining coupling forces that vanish at the Compton radius ($r_* = e_*^2/m_*c^2$) of the Planck particle. The vanishing of (10) reveals a basic property of the PV state that establishes how the stable free-space particle interacts with the vacuum — i.e., via a two-term coupling force that generates a characteristic Compton radius ($r_c = e_*^2/mc^2$) for the particle.

For the free-space electron and proton and their antiparticles, the results of the previous paragraph suggest that their coupling forces should be

$$F(r) = \pm\left(\frac{e_*^2}{r^2} - \frac{m_ec^2}{r}\right) = \begin{cases}\text{electron}\\ \text{positron}\end{cases} \tag{11}$$

and

$$F(r) = \mp\left(\frac{e_*^2}{r^2} - \frac{m_pc^2}{r}\right) = \begin{cases}\text{proton}\\ \text{antiproton}\end{cases} \tag{12}$$

where the plus and minus signs correspond to the particles indicated on the right of the braces, and the subscripts 'e' and 'p' refer to the electron and proton respectively. These coupling forces replace the problematic forces in (3). The radius r in these equations is the radius from the free-space Dirac particle to the separate particles of the PV.

The vanishing of equations (10)–(12) leads to the important string of Compton relations

$$r_em_ec^2 = r_pm_pc^2 = r_*m_*c^2 = e_*^2 \quad (= c\hbar) \tag{13}$$

relating the Dirac particles to the Planck particles.

3 Conclusions and comments

The forces (11) and (12) vanish at the electron and proton, and their respective antiparticle, Compton radii

$$r_e = \frac{e_*^2}{m_ec^2} \quad \text{and} \quad r_p = \frac{e_*^2}{m_pc^2} \tag{14}$$

and lead to the Dirac equations

$$\pm e_*^2\left(i\frac{\partial}{\partial ct} + \boldsymbol{\alpha}\cdot i\nabla\right)\psi = \pm mc^2\beta\psi\,. \tag{15}$$

Dividing through by $\pm mc^2$ gives

$$r_c\left(i\frac{\partial}{\partial ct} + \boldsymbol{\alpha}\cdot i\nabla\right)\psi = \beta\psi \tag{16}$$

where the Compton radius r_c $(= e_*^2/mc^2)$ and m now represent any of the Dirac particles ($r_c = r_e, r_p$).

The particle-PV potential energy associated with the coupling forces in (11) and (12) is defined as

$$V(r) = -\int_{r_c}^{r} |F(r)|\, dr \tag{17}$$

for $r \leqslant r_c$, resulting in (using (13))

$$\frac{V(r)}{mc^2} = \frac{r_c}{r} - 1 - \ln\frac{r_c}{r} \tag{18}$$

where $V(r_c) = 0$. The potential increases as the Dirac-particle cores ($\pm e_*, m$) are approached (as r decreases), making the negative energy vacuum susceptible to free-space (where the cores reside) perturbations. This susceptibility leads to an internal vacuum structure for the Dirac particles; where, in the "The Dirac Proton and its Structure" calculations [6] [7], quantitative confirmation for the preceding Dirac-particle calculations is provided.

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