A Paradgm Shift from Quantum Fields to the Planck Vacuum[1]

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Modern fundamental physics views Newton's constant, Planck's constant, and the fine structure constant as *primary* constants. As such, the equations of fundamental physics are not amenable to a rational explanation. The emerging Planck vacuum theory shows that these constants are really *secondary* however. From there a rational explanation is easily forthcoming.

The current paradigm[2] in fundamental physics [1] assumes that quantum fields are the source of the particles from which the visible universe is constructed. This conclusion is based partly on the belief that Newton's gravitational constant, Planck's constant, and the fine structure constant are primary constants—i.e., that these constants are not reducible to something more fundamental. The strongest evidence for this conclusion comes from the astonishing success of quantum electrodynamics in tracking the experimental evidence surrounding the dynamics of the electron. But while the nature of experimental observation provides for highly accurate mathematical descriptions of the evidence, it offers little in the way of an explanation for the physics underlying the measurements, the explanations being left to the speculations of the observer.

Concerning our present understand of electron dynamics, it is worth noting a quote from Grandy [2, p.367]:

> It is rather remarkable that the modern concept of electrodynamics is not quite 100 years old and yet still does not rest firmly upon uniformly accepted theoretical foundations. Maxwell's theory of the electromagnetic field is firmly ensconced in modern physics, to be sure, but the details of how charged particles are to be coupled to this field remain somewhat uncertain, despite the enormous advances in quantum electrodynamics over the past 45 years. Our theories remain mathematically ill-posed and mired in conceptual ambiguities which quantum mechanics has only moved to another arena rather than resolve. Fundamentally, we still do not understand just what is a charged particle.

An emerging theory of the vacuum state, the Planck vacuum (PV), may provide a way out of these conceptual ambiguities while increasing our understanding of the fundamental physics involved. What follows provides a brief review of the

[1] To be published in *Galilean Electrodynamics*.

[2] Merriam-Webster Online Dictionary, 2009. Paradigm: a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated.

PV theory to date as described in the twelve papers [3] through [14] enumerated chronologically in the references.

The PV theory derives Newton's gravitational constant G, Planck's (reduced) constant $\hbar$, and the fine structure constant α [4]:

$$G = \frac{e_*^2}{m_*^2} \tag{1}$$

$$\hbar = \frac{e_*^2}{c} \tag{2}$$

$$\alpha = \frac{e^2}{e_*^2} \tag{3}$$

where e_* is the bare electronic charge, m_* is the Planck mass, c is the speed of light, and e is the experimentally observed electronic charge. The PV from which these constants emerge is an omnipresent negative-energy vacuum state consisting of a degenerate collection of Planck particles (PP) which are characterized by the triad (e_*, m_*, r_*), where r_* $(= e_*^2/m_*c^2)$ is the PP Compton radius.

The Compton relation

$$r_c mc = \hbar \qquad \text{or} \qquad \lambda_c = \frac{h}{mc} \tag{4}$$

associates a Compton radius r_c $(= e_*^2/mc^2)$ or a Compton wavelength λ_c $(= 2\pi r_c)$ with the particle mass m, while the de Broglie relation

$$p = \frac{\hbar}{r_d} \tag{5}$$

relates the particle's relativistic momentum $(p = m\gamma v)$ to its de Broglie radius $r_d = r_c/\beta\gamma$, where $\beta = v/c$ and $\gamma = 1/\sqrt{1-\beta^2}$. The PV theory explains these relations [4][5] in terms of the magnitudes, mc^2/r and e_*^2/r^2, of the two distortion forces the particle exerts on the PV, the radius at which these two forces are equal being the Compton radius.

The string of Compton relations [5]

$$r_* m_* c = r_c mc = e_*^2/c \tag{6}$$

relate the PPs of the PV to the free-space elementary particles, where r_c is the Compton radius of any of the free particles, m is the particle mass, and r_* and m_* are the Compton radius and mass of the individual PPs making up the PV state. One of the e_*s in the product e_*^2 comes from the free particle and the other from the charge on the individual PPs.

The Compton relations (6) lead to the free-space permittivities [4]

$$\epsilon = \frac{1}{\mu} = \frac{e_*^2}{r_* m_* c^2} = \frac{e_*^2}{r_c mc^2} = 1 \tag{7}$$

showing that the vacuum of free space and the PV are one and the same. Furthermore, the Coulomb force between two charges e can be expressed as

$$F_{el} = \frac{e^2}{r^2} = \alpha \frac{e_*^2}{r^2} \tag{8}$$

showing the fine structure constant α to be closely related to the PV, or free-space, polarizability.

The Heisenberg uncertainty relations

$$\Delta p \cdot \Delta q \geq \frac{\hbar}{2} = \frac{e_*^2/c}{2} \tag{9}$$

where p and q correspond to any two canonically conjugate operators, remain a wave-particle-duality mystery in the current paradigm. The PV theory explains these relations in the following manner: the so-called free particle interacts continually with the invisible PV continuum; as this continuum, like any continuum, can support wavelike disturbances, the reaction of the PV to the particle perturbations produces a wavelike reaction in the particle; so (9), which is currently ascribed to the particle as a single entity, is actually a common-sense reaction of a perturbed continuum acting on the free particle.

The gravitational equations of Newton and Einstein transform from the current paradigm to the new paradigm in the following way [10][9]:

$$F_{gr} = -\frac{mMG}{r^2} = \frac{(-mc^2/r)(-Mc^2/r)}{-m_* c^2/r_*} \tag{10}$$

and

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \qquad \rightarrow \qquad \frac{G_{\mu\nu}/6}{1/r_*^2} = \frac{T_{\mu\nu}}{\rho_* c^2} \tag{11}$$

where c^4/G $(= m_* c^2/r_*)$ and $1/r_*^2$ are the ultimate curvature force and Gaussian curvature sustainable by the PV, and ρ_* $(= m_*/(4\pi r_*^3/3))$ is the Planck-particle mass density of the PV. The final equation in (11) implies that the Einstein field equations are physically associated with the curvature of the PV state.

The quantum vacuum [15][5] consists of an electromagnetic (photon) component and a massive-particle ($k_c = 1/r_c$) component. The energy densities of the two components transform from paradigm to paradigm as (with $k_{c*} = \sqrt{\pi}/r_*$)

$$\frac{c\hbar}{2\pi^2} \int_0^{k_{c*}} k^3 dk \qquad \rightarrow \qquad \frac{1}{8} \frac{e_*^2/r_*}{r_*^3} = \frac{1}{8} \frac{m_* c^2}{r_*^3} \tag{12}$$

for the photon component, and

$$\frac{c\hbar}{4\pi^2} \int_0^{k_{c*}} k^2 \left(k_c^2 + k^2\right)^{1/2} dk \qquad \rightarrow \qquad \frac{1}{16} \frac{e_*^2/r_*}{r_*^3} = \frac{1}{16} \frac{m_* c^2}{r_*^3} \tag{13}$$

for the massive-particle component, demonstrating that the quantum-vacuum densities and the mass-energy density ($\sim m_* c^2/r_*^3$) of the PPs in the PV are related.

The following is a list of additional conclusions drawn from the PV theory. The details leading to these conclusions are left to the references.

- Special relativity and the Lorentz transformation can be explained in terms of point charges interacting with the PV [4].
- The Einstein field equations and the Schwarzschild equations can be explained in terms of point masses (or effective point masses) interacting with the PV [4].
- The Compton relations and the Planck constant in (6) are the result of equating the curvature-force perturbation (mc^2/r) and the polarization-force perturbation (e_*^2/r^2) the free particle exerts on the PV [4]. Thus the role that $\hbar$ ($= e_*^2/c$) plays as an indicator of quantum effects is less mysterious in the new paradigm, being the result of *two* particle perturbations (mass and charge) acting on the PV simultaneously.
- The quantum vacuum is a free-space phenomenon of non-propagating zero-point fields whose source is the collection of charged PPs in the PV [5][6]. The energy spectra of the photon and massive-particle components of the quantum vacuum are truncated ($k_{c*} \neq \infty$) because of the graininess ($r_* \neq 0$) of the PV. It follows that the PV can be considered as a continuum only for intervals larger than ten Planck lengths ($10r_*$) or thereabouts.
- The neutrino appears to be a "particle" that travels within the PV [7]. As such it is more a phonon-like disturbance than a true particle.
- Black holes appear to be a limiting case of other types of "holes" that connect free space to the PV [8], perhaps allowing energy from the PV to "leak" into and out of free space under certain conditions.
- It is argued in [9] that the cosmological expansion is due to the expansion of the PV from which the visible universe is derived, rather than the expansion dynamics usually assumed to take place within the visible universe itself [16].
- The Einstein field equations are valid where time and space differentials are an order of magnitude or so greater than r_*/c and r_* respectively; and where the n-ratio $n_r \equiv (mc^2/r)/(m_*c^2/r_*) < 1$, with some caution being exercised when applying the equations in the region where $0.5 < n_r < 1$ [10].
- A very rough heuristic model for an active galactic nucleus is presented in [12] that sheds some intuitive light on the Einstein equations and the phenomenon itself.

- The reaction of an accelerated point electron to its own radiation is still somewhat of a mystery. An early (circa 1938) indication by Dirac that this so-called 'self force' may be due to charged sources other than the electron itself is examined in [13]. The conclusion is that the radiation reaction force may be due to the reaction of the PV to perturbations from the accelerated electron.

- Finally, a massless-point-charge model for the electron is presented in [14] as a partial answer to the Grandy quote at the beginning of the present paper.

This paper is an updated and expanded version of an earlier paper [17] concerned with the paradigm shift in fundamental physics. It represents a summary of the initial phase of the PV theory, the phase intended to demonstrate that the present theory can explain the body of current-day mathematical physics.

References

[1] S. Weinberg, "The Search for Unity: Notes for a History of Quantum Field Theory," Daedalus 106, 17, 1977.

[2] W.T. Grandy Jr., *Relativistic Quantum Mechanics of Leptons and Fields*, (Kluwer Academic Publishers, Dordrecht—London, 1991).

[3] W.C. Daywitt, "A Model for Davies' Universal Superforce," Galilean Electrodynamics, Sept./Oct. 83, 2006. In this reference the Planck particle and the Planck vacuum are referred to as the super-particle and super-particle vacuum respectively.

[4] W.C. Daywitt, "The Planck vacuum," Progress in Physics, v. 1, 20, 2009.

[5] W.C. Daywitt, "The Source of the Quantum Vacuum," Progress in Physics, v. 1, 27, 2009.

[6] W.C. Daywitt, "The Apparent Lack of Lorentz Invariance in Zero-Point Fields with Truncated Spectra," Progress in Physics, v. 1, 51, 2009.

[7] W.C. Daywitt, "The Neutrino: Evidence of a Negative-Energy Vacuum State," Progress in Physics, v. 2, 3, 2009.

[8] W.C. Daywitt, "Black Holes and Quantum Gravity from a Planck Vacuum Perspective," Progress in Physics, v. 2, 6, 2009.

[9] W.C. Daywitt "A Planck Vacuum Cosmology," Progress in Physics, v. 2, 52, 2009.

[10] W.C. Daywitt, "Limits to the Validity of the Einstein Field Equations and General Relativity from the Viewpoint of the Negative-Energy Planck Vacuum State," Progress in Physics, v. 3, 27, 2009.

[11] W.C. Daywitt, "The Planck Vacuum and the Schwarzschild Metrics," Progress in Physics, v. 3, 30, 2009.

[12] W.C. Daywitt, "A Heuristic Model for the Active Galactic Nucleus Based on the Planck Vacuum Theory," Progress in Physics, v. 3, 41, 2009.

[13] W.C. Daywitt, "The Radiation Reaction of a Point Electron as a Planck Vacuum Response Phenomenon," Progress in Physics, v. 2, 15, 2010.

[14] W.C. Daywitt, "A Massless-Point-Charge Model for the Electron," Progress in Physics, v. 2, 17, 2010.

[15] P.W. Milonni, *The Quantum Vacuum—an Introduction to Quantum Electrodynamics*, (Academic Press, New York, 1994).

[16] J.V. Narlikar, *An Introduction to Cosmology*, Third edition, (Cambridge Univ. Press, Cambridge, UK, 2002).

[17] W.C. Daywitt, "A New Paradigm: From Quantum Fields to the Planck Vacuum," Progress in Physics, v. 1, L9, 2010.