

# The Heisenberg Uncertainty Principle in the Planck Vacuum Theory

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**Abstract**—This paper derives the Heisenberg Uncertainty Principle from the Planck vacuum (PV) state that consists of a degenerate collection of nonrelativistic Planck particle (PP) cores. The mechanism leading to this result is the quantization of the Planck action associated with the PP energies. The reduced Planck constant itself is closely connected to the spin coefficient of the PP, the proton, and the electron cores.

**Index Terms**—Heisenberg Uncertainty Principle, Planck Particle Spin, Planck Vacuum State.

## I. INTRODUCTION

THE spacetime in the PV theory is a quasi-continuum consisting of a continuum pervaded by a degenerate collection of PP cores. Also the theory supports a 7-dimensional (7D) spacetime that consists of two 4-dimensional (4D) spacetimes, an observed 4D spacetime that contains the particles and an unobserved 4D spacetime that contains the antiparticles. The separate 4D spacetimes prevent the particles and antiparticles from annihilating one another.

The theoretical foundation [1] [2] [3] [4] of the PV theory rests upon the unification of the Einstein, Newton, and Coulomb superforces:

$$\frac{c^4}{G} \left( = \frac{m_* c^2}{r_*} \right) = \frac{m_*^2 G}{r_*^2} = \frac{e_*^2}{r_*^2} \rightarrow r_* m_* c = \frac{e_*^2}{c} \quad (= \hbar) \quad (1)$$

where the ratio  $c^4/G$  is the curvature superforce that appears in the Einstein field equations.  $G$  is Newton’s gravitational constant,  $c$  is the speed of light,  $m_*$  and  $r_*$  are the Planck mass and length respectively [5, p.1234], and  $e_*$  is the massless bare (or coupling) charge. The fine structure constant is given by the ratio  $\alpha \equiv e^2/e_*^2$ , where  $e$  is the observed electronic charge magnitude. The ratio  $e_*^2/c$  to the right of the arrow is the spin coefficient for the PP, the proton, and the electron cores, where  $\hbar$  is the reduced Planck constant.

The  $e_*^2$  in (1) is the squared coupling charge, where one of the  $e_*$ s belongs to the PP core ( $\pm e_*, m_*$ ) under consideration, and the other charge belongs to any one of the remaining PP cores making up the degenerate PV state. The product  $e_*^2 = (\pm e_*)^2$  implies that both the PP and its antiparticle contribute to the PV oscillator density.

The PP cores ( $\pm e_*, m_*$ ) in the PV are spinors that distort their surroundings with the force

$$F_*(r) = \frac{(\pm e_*)^2}{r^2} - \frac{m_* m_* G}{r_* r}$$

$$= \frac{e_*^2}{r^2} - \frac{m_* c^2}{r} = -\frac{m_* c^2}{r} \left( 1 - \frac{r_*}{r} \right) \quad \text{for } r \geq r_* \quad (2)$$

whose vanishing at  $r_*$  defines every spinor in the PV state. That vanishing also defines the Compton (coupling) radius

$$r_* = \frac{e_*^2/c}{m_* c} \quad (3)$$

of the spinor. Since the spinors have a mass energy equaling  $m_* c^2$ , they are at least nineteen orders-of-magnitude more energetic than the electron or proton cores. Thus the forces involved in the dynamics concerning the electron and proton cores have no effect on the PP spinors. On the other hand, the spin of the electron and proton cores is born in the PV-state spin coefficient ( $e_*^2/c$ ) of (3). And finally, the PV in (1) is a universal vacuum state in which the spinors are part of that cosmic whole.

Section II derives the basic quantum oscillator energy (18) by quantizing the Planck action associated with the corresponding classical, nonrelativistic energy equation (12). Section III discusses coordinate uncertainty.

## II. PLANCK PARTICLE OSCILLATOR

The vanishing of the force in (2) can be used to derive the harmonic oscillator equations for the PP core. For small  $x/r_*$  with the core ( $\pm e_*, m_*$ ) at  $r = r_*$ :

$$\begin{aligned} F_*(x+r_*) &= \frac{e_*^2}{(x+r_*)^2} - \frac{m_* c^2}{x+r_*} = \frac{e_*^2/r_*^2}{(1+x/r_*)^2} - \frac{m_* c^2/r_*}{1+x/r_*} \\ &\approx -2 \frac{e_*^2}{r_*^2} \frac{x}{r_*} + \frac{m_* c^2}{r_*} \frac{x}{r_*} = -\frac{e_*^2}{r_*^2} \frac{x}{r_*} = -\frac{m_* c^2}{r_*} \frac{x}{r_*} \quad (4) \end{aligned}$$

( $\mathbf{x} = x\hat{\mathbf{r}}$ ) where the equality to the right of the arrow in (1) is used in the calculation.

Equation (4) yields the oscillator force

$$\begin{aligned} -K_* x &= -\frac{e_*^2}{r_*^2} \frac{x}{r_*} = -\frac{m_* c^2}{r_*} \frac{x}{r_*} \\ &= -\frac{e_*^2}{r_*^3} x = -\frac{m_* c^2}{r_*^2} x \quad (5) \end{aligned}$$

that defines the “spring constant”  $K_*$ , and leads to the harmonic oscillator equation

$$m_* \ddot{x} = -K_* x = -\frac{m_* c^2}{r_*^2} x \quad (6)$$

or

$$\ddot{x} = -\frac{K_*}{m_*} x = -\omega_*^2 x \quad (7)$$

where

$$\omega_* = \left(\frac{K_*}{m_*}\right)^{1/2} = \frac{c}{r_*} = \frac{1}{t_*} = \frac{m_*c^2}{e_*^2/c} \quad (8)$$

and  $t_*$  ( $= r_*/c$ ) is the Planck time [5, p.1233]. The final ratio on the right represents the PP mass energy divided by its spin coefficient  $e_*^2/c$ . From the PV equation in (1),

$$\hbar = \frac{e_*^2}{c} = r_* \cdot m_*c = \frac{r_*}{c} \cdot m_*c^2 = t_* \cdot m_*c^2 [\text{erg.sec.}] \quad (9)$$

is the Planck-quantum angular momentum.

The solution to (7) [6, p.208] used here is

$$x = x_0 \sin \omega_* t \quad (10)$$

$$\dot{x} = \omega_* x_0 \cos \omega_* t. \quad (11)$$

The oscillator energy corresponding to (4)-(11) is

$$\begin{aligned} u_* &= \frac{m_* \dot{x}^2}{2} + \frac{K_* x^2}{2} \\ &= \frac{m_* \omega_*^2 x_0^2}{2} (\cos^2 \omega_* t + \sin^2 \omega_* t) = \frac{m_* \omega_*^2 x_0^2}{2} \\ &= m_* c^2 \frac{x_0^2}{2r_*^2} = \hbar \omega_* \frac{x_0^2}{2r_*^2} = \frac{\hbar}{2} \omega_* \frac{x_0^2}{r_*^2} = A \omega_* \end{aligned} \quad (12)$$

where

$$A = \frac{\hbar x_0^2}{2 r_*^2}. \quad (13)$$

(The separate PP cores within the degenerate PV state are confined to spheres of diameter no larger than about  $2r_*$ . Thus the PPs in the PV state are nonrelativistic and the nonrelativistic equation (12) is appropriate.)

The quantization of the Planck action (13) then takes the form

$$A_n = \frac{\hbar x_n^2}{2 r_*^2} \quad (14)$$

for  $n=(0, 1, 2, \dots)$ , leading to the differences

$$\overbrace{A_n - A_{n-1}}^{\hbar/2} = \frac{\hbar}{2} \left( \frac{x_n^2 - x_{n-1}^2}{r_*^2} \right) \quad (15)$$

yielding

$$\left( \frac{x_n^2 - x_{n-1}^2}{r_*^2} \right) = 1 \quad (16)$$

for the PV coordinate-differentials. If the PV spacetime were a continuum, then  $\hbar=0$  and the coordinate-differentials vanish—it is the pervasion of this continuum by the PP cores that leads to the PV coordinate uncertainty and to  $\hbar \neq 0$ .

Equation (16) can be solved for  $x_n^2/r_*^2$  or  $x_n^2/2r_*^2$  in a straightforward iterative manner (Appendix A) and leads to

$$\frac{x_n^2}{2r_*^2} = \frac{1}{2} \frac{x_0^2}{r_*^2} + n = \frac{1}{2} + n \quad (17)$$

where it is natural to set  $x_0 = r_*$ , as it is at the Compton radius  $r_*$  in (2) that the PP oscillations (7) take place. Substituting (17) into (12), and using (1), then yields

$$(u_*)_n = \left(\frac{1}{2} + n\right) \hbar \omega_* = \left(\frac{1}{2} + n\right) \frac{e_*^2}{r_*} \quad (18)$$

whose zero-point ( $n = 0$ ) solution is

$$(u_*)_0 = \frac{\hbar \omega_*}{2} = \frac{e_*^2/r_*}{2}. \quad (19)$$

### III. CONCLUSIONS AND COMMENTS

Examining the PP oscillations from the PV theory leads to six interesting conclusions:

1. From (9), the Planck quantum is now a well defined quantity

$$\hbar = m_*c^2 \cdot t_* [\text{erg.sec.}] \quad (20)$$

2. The spin coefficient ( $e_*^2/c$ ) for the electron and proton cores has its source in the PV state (see (3)).

3. The quantum action from (13) is

$$A = \frac{\hbar x_0^2}{2 r_*^2} = \frac{\hbar}{2} \quad (21)$$

where it is noted that the 2 in the denominator comes from the fact that the PPs of the PV state are nonrelativistic.

4. The zero-point energy spectrum from (18) is

$$n=(0, 1, 2, \dots) : \quad \left(\frac{1}{2} + n\right) \hbar \omega_* = \left(\frac{1}{2} + n\right) \frac{e_*^2}{r_*} \quad (22)$$

where the quantity

$$\left(\frac{1}{2} + n\right) \quad (23)$$

is associated with the quantum state but is not explained in the open literature.

5. Equations (15) and (16) with Appendix A

$$\overbrace{A_n - A_{n-1}}^{\hbar/2} = \frac{\hbar}{2} \left( \frac{x_n^2 - x_{n-1}^2}{r_*^2} \right) = \frac{\hbar}{2} \quad (24)$$

lead to the Heisenberg uncertainty principle

$$\delta A_n = A_n - A_{n-1} = \frac{\hbar}{2} \quad (25)$$

where again the 2 comes from the 2 in the nonrelativistic energy of (12).

6. The PPs in the PV state do not interact with one another because the vacuum state is configured so that  $r \geq r_*$ , while the PP coupling forces vanish at  $r = r_*$ .

#### APPENDIX A

#### ITERATIVE SOLUTION

For  $n=(0, 1, 2, \dots)$ , (16) leads to

$$\frac{x_n^2 - x_{n-1}^2}{r_*^2} = 1 \quad (A_n)$$

$$\frac{x_{n-1}^2 - x_{n-2}^2}{r_*^2} = 1 \quad (A_{n-1})$$

$$\dots \dots \dots \frac{x_2^2 - x_1^2}{r_*^2} = 1 \quad (A_2)$$

$$\frac{x_1^2 - x_0^2}{r_*^2} = 1. \quad (A_1)$$

Summing equations  $A_n$  through  $A_1$  then yields

$$\frac{x_n^2 - x_0^2}{r_*^2} = n \quad \text{or} \quad x_n^2 = x_0^2 + r_*^2 n = r_*^2 (1 + n) \quad (A'_n)$$

for the total PV coordinate-differential.

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