The Planck Vacuum Source of the Cosmic Microwave Background Radiation

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This paper argues that the isotropic cosmic microwave background (CMB) radiation has its source in the charged quantum oscillators of the quasi-continuous Planck vacuum (PV) state. Calculations trace the cosmic nature of the radiation to the omnipresent Planck particle oscillators which are the physical embodiment of the hypothetical circa 1914 Planck oscillators.

[Reference — Daywitt W.C., The Planck Vacuum Source of the Cosmic Microwave Background Radiation. To be published in the Galilean Electrodynamics journal.]

1 Introduction

The theoretical foundation [1] [2] of the PV theory rests upon the unification of the Coulomb, Newton, and curvature ($c^4/G = m_* c^2/r_*$) forces. From that framework the following calculations have evolved, providing experimental validation of the theory as implied by the common-sense derivation of the CMB radiation equation to be derived in what follows. In the curvature force defined here, c is the speed of light and G is Newton's gravitational constant; with m_* and r_* defined below.

The invisible, omnipresent PV state consists of a quasi-continuum in which a countable infinity of Planck particles are uniformly distributed, where the particle separation is of the order of one Planck length r_*. This vacuum state is permeated by a primordial zero-point field, the same stochastic field that is responsible for the mass of the Planck particle and the masses of the free-space elementary particles [3] [4].

Section 2 derives the basic quantum oscillator equation (19) associated with the particle/PV force that the Planck particles exert on the PV state. Since the particles are identical and distinguishable, they can be represented statistically by the Boltzmann distribution. Correspondingly, this section presents a concise and transparent derivation that makes the quantum nature of the PV state self-evident. This derivation provides a physical model for the hypothetical 1914 derivation of the Planck oscillator [5].

Section 3 derives the thermodynamic extension (24) of the basic Planck particle oscillator (19). This extension connects the charged, thermodynamic nature of the oscillator with the heat radiation in its vicinity.

Section 4 ties up some loose ends and relates the CMB radiation curve to the omnipresent PV state.

In what follows, the 'Planck particle oscillator' refers to the present PV oscillator, while the 'Planck oscillator' refers to the hypothetical 1914 Planck oscillator.

2 Planck Particle Oscillator

The PV state [1] [2] is loosely defined as a quasi continuous degenerate collection of Planck particles $(-e_*, m_*)$ each of which is characterized by the Compton relation

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

where $r_* \,(= e_*^2/m_* c^2)$ is the Planck particle Compton radius, e_* is the massless bare charge, m_* is the Planck particle mass which results from the point charge $(-e_*)$ being driven by the zero-point electric field [3] [4], and $\hbar$ is the reduced Planck constant. The radius r_* and mass m_* are equal in magnitude to the Planck length and mass respectively [6, p.1234]. The quasi-continuous nature of the PV is due to the separated Planck particles that populate the PV state.

The Compton relation (1) is related to the vanishing force $F_*(r_*) = 0$, where

$$F_*(r) = \frac{e_*^2}{r^2} - \frac{m_* c^2}{r} \tag{2}$$

is the particle/PV force the separate Planck particles exert on the PV as a whole. The first and second terms represent respectively the Coulomb and gravitational forces the particle exerts on the PV at a radius r from the particle [1] [2]. The vanishing of the force at the Planck particle Compton radius r_*, where the two force components in (2) cancel each other, anticipates the oscillations derived below.

The energy density of the PV particles is roughly

$$2\frac{e_*^2/r_*}{4\pi r_*^3/3} = 2\frac{m_* c^2}{4\pi r_*^3/3} \tag{3}$$

where the factor 2 accounts for the equal charge and mass contributions (e_*^2/r_* and $m_* c^2$) to the energy. The random zero point energy, or agitation energy of the Planck particles permeating the vacuum, is not included in (3).

Due to the degenerate nature of the PV state the Planck particles do not exhibit a macroscopic motion with respect to one another, although they do exhibit a strong microscopic random motion that is related to their zero point agitation and their corresponding masses m_*.

The vanishing of (2) at $r = r_*$ can be used to derive a harmonic oscillator equation for the Planck particle and the force it exerts on the PV state: for small x/r_* with $(-e_*, m_*)$ at $r = 0$,

$$\frac{e_*^2}{(x+r_*)^2} - \frac{m_* c^2}{x+r_*} = \frac{e_*^2/r_*^2}{(1+x/r_*)^2} - \frac{m_* c^2/r_*}{1+x/r_*} \tag{4}$$

reduces to the oscillator force

$$-K_* x = -\frac{e_*^2}{r_*^3} x = -\frac{m_* c^2}{r_*^2} x \tag{5}$$

($\mathbf{x} = x\widehat{\mathbf{r}}$) that defines K_*, and leads to the harmonic oscillator equation

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

or

$$\ddot{x} = -\frac{K_*}{m_*} x = -\omega^2 x \tag{7}$$

where

$$\omega = \frac{c}{r_*} = \frac{1}{t_*} \tag{8}$$

and t_* $(= r_*/c)$ is the Planck time [6, p.1233].

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

$$x = x_0 \sin \omega t \tag{9}$$

$$\dot{x} = \omega x_0 \cos \omega t \tag{10}$$

$$x^2 + \left(\frac{\dot{x}}{\omega}\right)^2 = x_0^2 \tag{11}$$

where (11), in which the time has been eliminated, defines the possible orbits (for various x_0s) in the phase space defined by (11). These orbits are ellipses of semi-axes x_0 and $m_* \omega x_0$, where $\omega^2 = K_*/m_*$.

The oscillator energy corresponding to (5)-(11) is

$$u_* = \frac{m_* \dot{x}^2}{2} + \frac{K_* x^2}{2} = \frac{m_* \omega^2 x_0^2}{2} \left(\cos^2 \omega t + \sin^2 \omega t\right) \tag{12}$$

$$= \frac{m_* \omega^2 x_0^2}{2} = m_* c^2 \frac{x_0^2}{2 r_*^2} = A\nu \tag{13}$$

using (1) and (8) in (13), where $\omega = 2\pi\nu$ leads to

$$A = \pi \cdot x_0 \cdot m_* \omega x_0 = h \frac{x_0^2}{2 r_*^2}\,, \tag{14}$$

the area enclosed by the ellipses associated with (11).

The quantization of the "action area" (14) then takes the form

$$A_n = h \frac{x_n^2}{2 r_*^2} \tag{15}$$

where

$$A_{n+1} - A_n = h \left(\frac{x_{n+1}^2 - x_n^2}{2 r_*^2}\right) \tag{16}$$

for $n = (0, 1, 2, \cdots)$. If the PV were a continuum, the x_{n+1}^2 and x_n^2 would be equal and (16) would vanish. The Planck quantization [5, p.139], however, equates (16) to the Planck quantum-constant h, leading to

$$\left(\frac{x_{n+1}^2 - x_n^2}{2 r_*^2}\right) = 1\,. \tag{17}$$

This can be solved for x_n^2 in a straightforward iterative manner and leads to

$$\frac{x_n^2}{2 r_*^2} = \frac{1}{2} \frac{x_0^2}{r_*^2} + n = \frac{1}{2} + n \tag{18}$$

where it is natural to set $x_0 = r_*$, as it is at the Compton radius r_* that the Planck particle oscillations (6) take place. Substituting (18) into (15), and multiplying by ν, then yields

$$A_n \nu = \left(\frac{1}{2} + n\right) h\nu \tag{19}$$

for the quantized energy levels of the Planck particle oscillator.

The quantized energy levels in (19) represent the core of the quantum oscillator; while the oscillator charge $(-e_*)$ and its interaction with the heat radiation surrounding the charge leads, in thermodynamic equilibrium, to the thermodynamic extension (24) of the oscillator. As the Planck particle oscillators are omnipresent, this process takes place on a cosmic scale.

The spectral frequency ν in (19) is usually assumed to run from zero to infinity. It will be seen in Section 4, however, that the spectral frequency is bandwidth limited.

The Planck particle oscillators derived here are assumed to be real physical oscillators that exist within the invisible PV state outlined above.

3 Thermodynamic Oscillator

From (19) and $u_i = ih\nu$ $(i = 0, 1, 2, \cdots)$, the thermodynamic occupation numbers for u_i are given by the Boltzmann formulas [7, p.209]

$$N_i = N_0 e^{-ih\nu/kT} \tag{20}$$

and

$$N = N_0 \sum_{i=0}^{\infty} e^{-ih\nu/kT} = \frac{N_0}{1 - e^{-h\nu/kT}}\,. \tag{21}$$

Differentiating both sides of equation (21) with respect to $(1/kT)$ leads to the identity

$$N_0 \sum ih\nu e^{-ih\nu/kT} = \frac{N_0 h\nu e^{-h\nu/kT}}{(1-e^{-h\nu/kT})^2} \tag{22}$$

where the left hand side of (22) is just the thermodynamic energy U–U_0. Then substituting for N_0 from (21) on the right of (22) yields

$$U - \frac{Nh\nu}{2} = \frac{Nh\nu}{e^{h\nu/kT}-1} \tag{23}$$

where the zero-point energy term on the left comes from the first term on the right of (19). For the single Planck particle oscillator, (23) leads to

$$u(\nu,T) = \frac{h\nu}{2} + \frac{h\nu}{e^{h\nu/kT}-1}\,. \tag{24}$$

To reiterate, both oscillator energies (19) and (24) owe their existence to the vanishing of the particle/PV force (2) at the Planck particle Compton radius r_*.

4 Comments and Conclusions

The zero point energy of the thermodynamic oscillator is often discarded [8, p.349] because its integral over the half-open interval $\nu = [0,\infty)$ diverges. Puthoff has shown [3] [4], however, that the integral has an upper cutoff frequency $[0,\nu_*]$; so the integral of the zero point energy is finite:

$$\int_0^{\nu_*} u(\nu,0)d\nu = \int_0^{\nu_*} \frac{h\nu}{2} d\nu = \frac{\pi e_*^2}{c}\int_0^{\nu_*} \nu d\nu$$
$$= \frac{\pi e_*^2 \nu_*^2}{2c} = \frac{1}{8}\frac{m_* c^2}{t_*} \tag{25}$$

where

$$\nu_* = \frac{ck_*}{2\pi} = \frac{c}{2\pi}\frac{\sqrt{\pi}}{r_*} \tag{26}$$

and t_* is the Planck time. The cutoff wavenumber from the Puthoff calculations is $k_* (= \sqrt{\pi}/r_*)$.

The quantum nature of the oscillator energy levels in (19) is often introduced in an ad hoc manner [7, p.209] [8, p.345], where in the present paper it is derived directly from the oscillator phase-space equation (11).

The mean energy [7, p.215] of the oscillator in (24), applied to the leakage from an isothermal cavity, is

$$\overline{u}_\nu = \frac{8\pi\nu^2}{c^3}\frac{h\nu}{e^{h\nu/kT}-1} \tag{27}$$

where the first ratio is the density of states 'per unit volume per unit frequency' within the cavity. This result corresponds to the Planck blackbody radiation equation [5, p.168].

Applying the previous calculations to an astrophysical system leads to the brightness (intensity) expression [6, p.73] for the blackbody spectrum

$$B_\nu(T) = \frac{2\nu^2}{c^2}\frac{h\nu}{e^{h\nu/kT}-1} \tag{28}$$

with the units 'energy per unit time per unit surface area per unit solid angle' in the frequency range between ν and $\nu + d\nu$. For $T = 2.725$ kelvin, (28) yields the experimental CMB radiation curve [6, p.1167]. In conclusion then, the calculations in Sections 2-4 suggest that the omnipresent (cosmic) nature of the PV state is the source of this brightness energy density.

The derivation of the CMB radiation presented here represents a significant alternative to the highly involved derivation presented in the Big Bang theory [6, 1057].

References

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