Emissions with Zero Radiation Pressure

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(Dated: 12 December 2000)

Abstract

The Dynamic Theory provides a manifold of 5 dimensions; space, time, and mass density. The gauge field equations in the 5-D manifold lead to the prediction that the energy density is proportional to the sum of the squares of the three transverse wave components. However, the radiation pressure is predicted to be proportional to the sum of the squares of the electric and magnetic components and the negative of the square of the new transverse component. Weyl's quantum principle provides the logical connection, for which Einstein searched in vein, between a photon's wave and particle properties. Putting these two theoretical requirements together leads to non-zero emissions when the radiation pressure vanishes and these emissions must obey Planck's radiation law.

I. RADIATION ENERGY AND PRESSURE IN THE DYNAMIC THEORY

The five dimensional gauge wave equations leads to an energy density for transverse waves given by[1] $\xi = \frac{1}{8\pi}\left[\bar{E}\bullet\bar{E}+\bar{B}\bullet\bar{B}+\bar{V}\bullet\bar{V}\right]$ while the radiation pressure is given by $\rho = \frac{1}{8\pi}\left[\bar{E}\bullet\bar{E}+\bar{B}\bullet\bar{B}-\bar{V}\bullet\bar{V}\right]$. For wave solutions of the form $\bar{E}(\bar{x},t,\gamma) = \bar{E}_o sin(\bar{k}\bullet\bar{x} - \omega t + k_4\gamma) = \bar{E}_o sin 2\pi\left(\frac{x}{\gamma} - vt + \frac{\gamma}{\eta}\right)$, it may be shown that $\bar{B} = \frac{\bar{k}c\otimes\bar{E}}{2\pi v}$ and $\bar{V} = -\frac{a_o c}{\eta 2\pi v}$ and $k^2c^2 = \mu\varepsilon\omega^2 - a_o^2c^2k_4\left(k_4 + \frac{\partial \ln\mu}{\partial\gamma}\right)$. This leads to the situation that for vanishing radiation pressure, $p = 0$, the radiation energy density does not vanish, but is given by $\xi = \frac{1}{8\pi}2(\bar{V}\bullet\bar{V})$.

The wave solutions may be used to determine the ratio of the radiation pressure to the energy density, which is $\frac{p}{\xi} = 1 - \frac{a_o^2c^2k_4^2}{\omega^2}$. By taking the data from the Nichols and Hull experiments, we find the value of $a_o ck_4 \approx 4.1\times10^{13}$ sec^{-1} when $\lambda = 550$ nanometers. From this expression for the ratio one may see that at zero radiation pressure $a_o ck_4 = \omega^2$.

II. LIGHT QUANTA

The concept of a photon started with Einstein's light quanta[2]. The concept has been the subject of many articles since 1905. The name "photon" was first introduced by Lewis 21 years later[3]. However, both Planck's[4] and Einstein's derivations of the famous relation between energy and frequency, $\varepsilon = hv$, came from studies of radiation in thermal equilibrium with a system described by statistical thermodynamics. Planck quantized the equilibrium energy U of an oscillator while Einstein quantized the entropy density per unit volume. In 1917 Einstein wrote, "The properties of elementary processes required by [his momentum fluctuation relation] make it seem almost inevitable to formulate a truly quantized theory of radiation."[5] Einstein was not, and never would be, satisfied with his and others inability to obtain such a theory. In 1924, after the experimental evidence of the Compton Effect provided proof of the quantization of light, he wrote, "There are therefore now two theories of light, both indispensable, and-as one must admit today despite twenty years of tremendous effort on the part of theoretical physicists-without any logical connection"[6].

Weyl's quantum principle may be used to derive Maxwell's electromagnetic field equations[7]. These, in turn, may be used to derive the electromagnetic wave equations. At the same time the quantum principle requires that the gauge potentials be quantized since $\int N_j \phi_j dx^j = 2\pi i N$ where $i = \sqrt{-1}$ and there is no summation over the j's. The radial electrostatic dependence may be investigated by considering N_o to be nonzero and $N_x = N_y = N_z = 0$. The concept of a photon, as a particle, is one that is electrically neutral. The wave description allows the discussion of polarization such that an electromagnetic wave traveling along the x axis may have its electric field directed along the y axis. Therefore, consider $N_o = N_x = N_z = 0$. The quantum principle requires that the y component of the gauge (vector) potential to be quantized, as $\phi_y = NB \cos 2\pi \left(\frac{x}{\lambda} - vt\right)$ where the dependence upon x and t was chosen to be sure that the electric field, given by $E_y(x,t) = \frac{\partial \phi_y(x,t)}{\partial (ct)} = \frac{NBv}{c^2} \sin 2\pi \left(\frac{x}{\lambda} - vt\right)$, satisfies the wave equations. This expression may be used to find the average value of the Poynting vector, or $I = \left(\frac{1}{\mu_o}\right) \langle E^2 \rangle$. The average value of the square of electric field is given by $\langle E^2(x,t) \rangle = \dfrac{N^2 B^2 v^2}{c^3} \displaystyle\int_{t=0}^{t=\frac{1}{v}} \sin^2 \left(\frac{x}{\lambda} - vt\right) dt = \dfrac{N^2 B^2 v}{2c^2}$.

Therefore, $I = \left(\frac{N^2 B^2}{2\mu_o h c^3}\right) v$. Now a quantum of light for which $N = 1$ would have an energy flow of $I = hv$ when $B = \sqrt{2\mu_o h c^3}$. Einstein's energy relation, for a single light quantum passing through a unit area, is then $\varepsilon = hv$.

III. ZERO RADIATION PRESSURE EMISSIONS

Equating the zero radiation pressure energy density with the average value of the Poynting vector for a quantum of light, with the quantum number, N set to unity, produces $\xi_{01} = \frac{1}{8\pi} 2 \left(\bar{V_{01}} \bullet \bar{V_{01}}\right) = hv$ as the energy density associated with a single light quanta with zero radiation pressure. For additional light quanta, with zero pressure, the total energy density takes on values of $\xi_{01} = 0,\ 1hv,\ 2hv,\ 3hv, \ldots$ which is precisely the behavior of Planck's black body radiation.

Determining the average total energy of the zero radiation pressure emission, as a function of the frequency, v, may then be done using Planck's black body formula, or

$\xi_o(v) = \frac{hv}{e^{hv/kT}-1} = \frac{1}{4\pi}\bar{V}_o \bullet \bar{V}_o = \frac{1}{4\pi}\left(\frac{-\omega}{a_o ck4}\right)^2 \bar{E}_o \bullet \bar{E}_o = \frac{1}{4\pi}\bar{E}_o \bullet \bar{E}_o$ where the subscript denotes the zero radiation pressure condition.

Though we now have shown that the zero radiation pressure emissions must obey the blackbody radiation laws, better insight may be gained by considering the phase of the wave solution, or

$$\phi = 2\pi\left(\frac{x}{\lambda} - vt + \frac{\gamma}{\eta}\right).$$

When the phase is constant in time, the phase velocity must satisfy $v_{ph} = \lambda\left(v - \frac{\dot{\gamma}}{\eta}\right)$. Now define, $v_{ph}(\dot{\gamma} = 0) \equiv c$, $\quad \dot{\gamma}(v_{ph} = 0) \equiv a_o c$, and $\frac{\partial \ln \mu}{\partial \gamma} \equiv A$. When the expression for μ is $\mu = 1 + \frac{D\gamma}{T}$, the log derivative becomes

$$\frac{\partial \ln \mu}{\partial \gamma} = \frac{\left(1 + \frac{1}{\beta T}\right)}{\left(\gamma + \frac{T}{D}\right)}$$

where β is the thermal expansion coefficient. Notice that for vanishing mass density the log derivative vanishes with D.

IV. CONCLUSIONS

The five dimensional manifold of the Dynamic Theory requires that the radiation pressure vanish while the radiation energy density is still finite. A photon may be defined as a gauge vector potential with the quantum number set to unity and which satisfies the wave equation. Further, the light quanta comes from Weyl's quantum principle which also provides the basis for radiation and needs no connection to statistics or thermodynamics. Weyl's quantum principle provides the logical connection that Einstein was trying to find. At the same time this connection between the wave and particle aspects of the photon require that the radiation at zero radiation pressure obey Planck's black body radiation formula. Therefore, any requirement for the radiation pressure to vanish is a requirement for zero pressure black body radiation.

If empty space has no method of supporting a finite pressure, then the Dynamic Theory requires that there exist a zero radiation pressure within the empty space. This appears to be the same situation found experimentally with respect to the cosmic background radiation. Could they be the same?

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