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The Photon and the Quantum Enigma

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Abstract

We model the Photon as a space lattice oscillation, in a plane perpendicular to its line of propagation. This propagation is at the light velocity c . This plane is vertical or horizontal or rotating clockwise or anti-clockwise. This oscillation occupies a finite space volume of a defined shape, structure and size. Papers [1] and [2] model electromagnetism as the geometrodynamics of space; we show that the elastic space lattice oscillating displacement vector is the oscillating electric field, pointing in the opposite direction. For simplicity we ignore the magnetic field. We also show that our photons and ground state photons - the photoms, condense when they are in phase and disperse when in anti-phase. This feature explains the double slit experiment, both for an ensemble of photons (classical EM wave) and single photons. It dispels the need for attributing a dualistic nature to single photons that arrive at the screen one at a time.

Key Words: Photons, Electromagnetism, Geometrodynamics, Spacetime

1 Introduction

The reading of papers [1], [2] and [3] is a must, otherwise the following statements will be considered an absurdity.

We contend that the photon is a confined oscillating dipole with its field. This dipole is an oscillation of the bivalent elementary charges, which in the pair production process are converted into the stable bivalent elementary charges of the electron and positron (as it is for other particles). **The photon in our theory holds all the basic features that appear in all the other elementary particles.**

We further contend that EM waves are ensembles of closely packed photons that oscillate in phase and hence are classical waves. Similarly ensembles of closely packed ground state photons - photoms – as we call them, oscillating in phase are also classical waves. As we show, photons and photoms condense when they are in phase and disperse when in anti-phase. These features dispel, as we explain, the need to attribute a dualistic nature to photons.

In modern literature [4] [5] [6] the photon is considered a wavepacket, but its shape, structure and size are not discussed.

We remind the reader that GDM stands for the “Geometrodynamic Model of Reality”- our new theory of the foundations of physics, see [2].

2 The GDM Model of the Photon

Paper [1] shows that contracted space is positive charge and dilated space is negative charge. It also shows that the electric field \mathbf{E} is proportional to \mathbf{u} , the Elastic Displacement Vector of the elastic space lattice. \mathbf{E} is defined as $\mathbf{E} = -H\mathbf{u}$, and points in the opposite direction to \mathbf{u} .

Fig. (1) shows an oscillating cylinder-like photon passing in front of us to the right, with a velocity c and cycle time T . At the moment $t = 0$, Fig. (1a), we see a cylinder of space with no strain and stress; each square represents a group of space cells (the following process is

related to each and every space cell). At $t = 1/4 \cdot T$, Fig. (1b), the space in the cylinder becomes dilated below the line of propagation (the middle) and contracted above it. The displacement vector, in the figure, points upwards all the way. The electrical field vector is in the opposite direction. At $t = 1/2 \cdot T$, Fig. (1c), we are facing the same situation as in Fig. (1a). At $t = 3/4 \cdot T$, Fig. (1d), the displacement vector reverses its direction and the electrical field points up. At $t = T$, Fig. (1e), the cycle is completed.

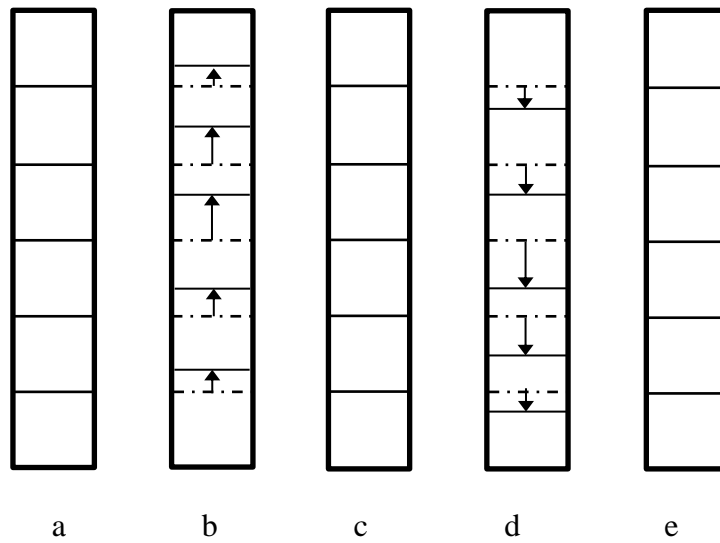


Fig. (1) The Photon's Oscillating Space Lattice

At $t = 1/4 \cdot T$, Fig. (1b), space cells below the line of propagation (the middle) are dilated and those above it are contracted, and the electric field points downwards. At $t = 3/4 \cdot T$, Fig. (1d), the cells below are contracted and those above are dilated, and the electric field points upwards. But contracted space and dilated space are the bivalent electric charges [1]. Thus the GDM space vibrational photon, as described, is an oscillating electric dipole with its electric field. This dipole and its field, as we show, are confined in a finite volume of space and the oscillating charges are the elementary electric charges.

3 The Spatial Size r_e of the Photon Energy

The fine structure constant α , where Q is the **elementary charge**, is:

$$\alpha = Q^2 / \hbar c \quad (1)$$

From (1) we get: $\hbar c = Q^2 / \alpha \rightarrow 2\pi\hbar c / \lambda = 2\pi Q^2 / \alpha \lambda \rightarrow \hbar\omega = 2\pi Q^2 / \lambda \alpha \rightarrow$

$$\hbar\omega = 2Q^2 / 2 r_e \quad (2)$$

where the photon energy is $\hbar\omega$ and r_e is defined as:

$$r_e = \alpha / 2\pi \cdot \lambda \quad (3)$$

As if the energy of the photon is “concentrated” in two “spheres” of the bivalent elementary charge Q with a radius r_e .

The factor 2 in the numerator of equation (2) is accounted for the energy of contraction (one “sphere”) and that of dilation (other “sphere”). We relate to r_e as the “radius” of the “cylinder”, which contains the two “spheres”.

4 The Oscillation of the Center of Energy of the Photon

For a spring with a constant K and mass M :

$y = y_0 \sin \omega t \quad v = \omega y_0 \cos \omega t \quad a = -\omega^2 y_0 \sin \omega t$, where the axis y is perpendicular to the line of propagation.

$$U_k = 1/2 M v^2 = 1/2 M \omega^2 y_0^2 \cos^2 \omega t \quad U_p = 1/2 K y^2 = 1/2 K y_0^2 \sin^2 \omega t$$

$$U = U_k + U_p = \text{constant}$$

$$U = U_k(\max) = U_p(\max) = M \omega^2 y_0^2 = K y_0^2 \quad \omega = \sqrt{K/M} \quad (4)$$

Since U is a constant we are allowed to replace M , see [3], in the above equations (4), by

$M = U/c^2$, which gives:

$$U = M \omega^2 y_0^2 = U/c^2 \omega^2 y_0^2$$

Hence $y_0 \omega = c$, but $c = \lambda/(2\pi\omega)$ and the maximum amplitude of the center of energy is:

$$y_0 = \lambda/2\pi \quad (5)$$

We denote y_0 as R_e and relate to it as half the “cylinder height”. Note that (3) and (5) give:

$$r_e/R_e = \alpha \quad (6)$$

This is the **same ratio**, as it is for the radii of the electron [3] (their sizes are different). From the geometry of both the electron and the photon it seems that this ratio determines the probability for the photon to interact with the electron. Hence $j = -\sqrt{\alpha} = -0.08542455$ is the probability amplitude of the QED Junction, Coupling, which is “... one of the greatest damn mysteries of physics: a magic number”; Feynman [7] in his own words.

Note that **the contraction or dilation move at the same velocity c , as the propagation does**, and hence the maximum possible half height of the disturbance is $H = c \cdot 1/4T = 1/4 \cdot \lambda$, whereas as (5) shows: $R_e = 1/2\pi \cdot \lambda$.

5 Photon Energy and the Planck Constant \hbar

Using (4) and (5) we get $U = K \lambda^2/2\pi^2$ where K is an attribute of space similar to the K of a spring. If the “Space Spring Constant K ” is **a function of ω only** we guess that it can be:

$$K = M\omega^2 = (U/c^2)\omega^2 = \hbar\omega^3 / c^2$$

where \hbar , **not yet identified**, is a constant of proportionality.

Necessarily $U = \hbar\omega$ where \hbar becomes the known quantum constant.

Thus a classical functionality of $K(\omega) \propto \omega^3$ leads to the basic quantum mechanical result.

6 The Photon's Volume

Taking the “cylinder height” as $2R_e$, gives for the maximum of the oscillatory volume:

$$V_{\text{Photon}} = \pi r_e^2 2R_e = \alpha^2/8\pi^2 \cdot \lambda^3 = 6.75 \cdot 10^{-7} \cdot \lambda^3 \text{cm}^3 \quad (7)$$

The shorter is λ , the more compact is the photon.

For $\lambda = 500\text{nm}$ we get: $V_{\text{Photon}} = 6.75 \cdot 10^{-7} \cdot \lambda^3 \sim 8 \cdot 10^{-20} \text{cm}^3$.

7 The Photon Spin

The photon spin L , for a circular polarized photon, is its linear momentum $P = U/c$ times its radius of rotation $R_e = \lambda/2\pi$, see (5), $L = PR_e = U/c \cdot \lambda/2\pi$ but $U = \hbar\omega$. Hence the known result:

$$L = \hbar \quad (8)$$

8 Photoms - the Ground State Photons

QED, [6], attributes to a photon in its ground state one half of the energy, half of the momentum, and half of the spin. To distinguish a photon from a ground state photon, we name it a **Photom** (a photon at the bottom is a photom). In the GDM, however, there are two types of photoms.

The Positive Photom: This photom, as Fig. (2) shows, is an oscillating contraction of space (positive charge), close to the line of propagation. This oscillation is in a plane or in a rotating plane, around the line of propagation.

The Negative Photom: This photom, as Fig. (3) shows, is an oscillating dilation of space (negative charge) close to the line of propagation. This oscillation is in a plane or in a rotating plane, around the line of propagation.

These photoms are the split of the photon in Fig. (1). The GDM considers them as the pair of

an electron and positron of the Dirac Sea, and vacuum polarization is due to them. This way we dispel the need for a separate ground state (vacuum state) for the electromagnetic field and that for the electron and positron field (Dirac sea).

Fig. (2) shows our cylinder-like photom passing in front of us to the right, with a velocity c . At the moment $t = 0$, Fig. (2a), we see a cylinder of space with no strain and stress; each square represents a group of space cells (this process is related to each and every space cell). At $t = 1/4 \cdot T$, Fig. (2b), the space in the cylinder becomes contracted above, and close to, the line of propagation (the middle). The electrical field vector points opposite to the displacement vector, shown in the figure. At $t = 1/2 \cdot T$, Fig. (2c), we face the same situation as in Fig. (2a). At $t = 3/4 \cdot T$, Fig. (2d), the displacement reverses its direction and the electrical field points down. At $t = T$, Fig. (2e), the cycle is completed.

Note that we do not know the exact shape of the photon or the photom. All we know, at this stage, is their geometric and dynamic features. This is the reason why we use terms like cylinder-like.

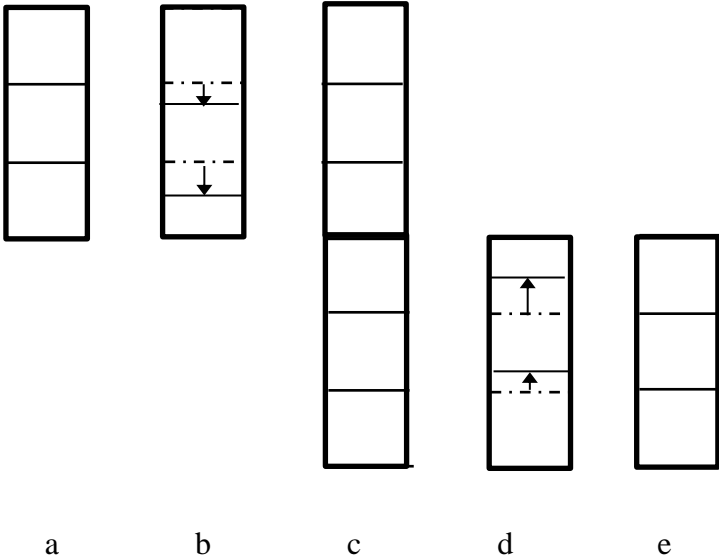


Fig. (2) The Positive Photom

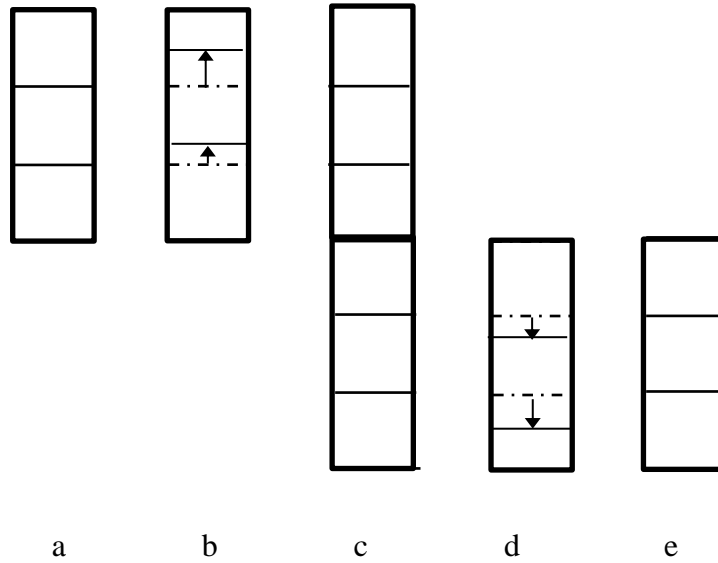


Fig. (3) The Negative Photom

Figure (3) shows our cylinder-like photom passing in front of us to the right, with a velocity c . At the moment $t = 0$, Fig. (3a), we see a cylinder of space with no strain and stress; each square represents a group of space cells (this process is related to each and every space cell). At $t = 1/4 \cdot T$, Fig. (3b), the space in the cylinder becomes dilated above, and close to, the line of propagation (the middle). The electrical field vector points opposite to the displacement vector, shown in the figure. At $t = 1/2 \cdot T$, Fig. (3c), we face the same situation as in, Fig. (3a). At $t = 3/4 \cdot T$, Fig. (3d), the displacement reverses its direction and the electrical field points up. At $t = T$, Fig. (3e), the cycle is completed.

9 Spatial Density of Photoms

The spatial density of an ensemble of photoms of a given λ and a bandwidth $d\lambda$, see [6], is:

$n(v) = 8\pi v^2/c^3 \cdot dv$ but $v=c/\lambda$ and $dv=c/\lambda^2 \cdot d\lambda$ hence:

$$n(\lambda) = 8\pi/\lambda^4 \cdot d\lambda \quad (9)$$

For photoms of $\lambda = 500\text{nm}$ and a bandwidth $d\lambda = 0.5\text{nm}$ the spatial density is:

$n(\lambda) \sim 2 \cdot 10^{11}$ photoms per cubic centimeter.

Note that a one joule laser pulse, of $\lambda = 500\text{nm}$ contains $\sim 2.5 \cdot 10^{18}$ photons.

10 Light Velocity and Red/Blue Shift in a Gravitational Field

General Relativity shows that light velocity is slower close to a star than at a distance from it [3] [8]. As a result, a falling photon in a gravitational field gains linear momentum ($P = U/c$). In order to retain its angular momentum ($L = P \cdot R_e$), it has to reduce its $R_e = \lambda/2\pi$, see [2], hence the blue shift. And in climbing the gravitational field, it will be red shifted.

11 Condensation and Dispersion

Fig. (4), shows a symbolic space lattice, which is like a 3D fisherman's net. Imagine that each vertical plane, in Fig. (4), going into the page, is a plane in which a photon or a photom are moving. If two adjacent photons or photoms of the same frequency oscillate in anti-phase side by side they stretch the lattice horizontally and move apart to ease the tension. The result is dispersion - a reduced spatial density of the photons or photoms. If, however, they oscillate in phase, they move together to ease the tension and the result is condensation - higher density. A similar situation occurs if they move one below or above the other.

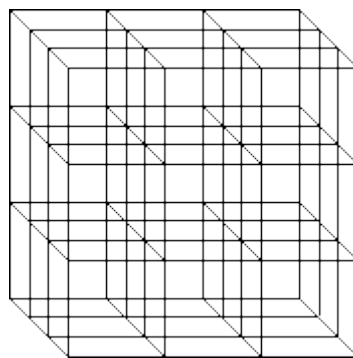


Fig. (4) Coupled Photoms and Coupled Photons

12 No Dualistic Nature

In this section we dispel the need for attributing a dualistic nature to photons.

12.1 Interference with Classical Waves – Ensembles of Photons

Photons or photoms, of the same wavelength, when they are in phase and closely packed, they move as a classical wave. Let a wave front, of such a classical wave, hit the double slit; if the photons or photoms, which are coming from the two slits and hit the screen, are in phase (on the screen) they create maxima zones on the screen, and minima if out of phase. In other words; intensity is reduced in zones of destructive interference whereas in zones of constructive interference intensity is enhanced. Photons and photoms entering these zones, however, are neither annihilated nor created and the total energy is conserved. No annihilation or creation takes place, only a spatial displacement of the particles that result in a reduction in their density (intensity) in one zone and an increase in their density (intensity) in the other.

12.2 Interference with Individual Photons

There is a body of both experimental and theoretical work that shows how the vacuum state of the electromagnetic field (photoms) induces “spontaneous” emission [6]. Thus, the basic state is that of a single photon plus a single photom. When one photom, out of the many that construct a wave front of photoms with a frequency that matches a transition in an excited atom (in the source), hits the excited atom it has a probability to induce the emission in phase of a photon. The probability of the photon to hit a certain spot on the screen is thus the classical probability of the inducing photom to arrive at this same spot. Hence, the many, one at a time, photon accumulation effect is the interference pattern.

This dispels the need for attributing a dualistic nature to photons and solves the collapse issue of the “wavefunction” (although there is no such thing for a photon). Note that the width and

the height of the slits, as well as the distance between them, comply with our understanding of the photon and photom, and the interference experiment.

In the year 2011 it was shown [9] in a “Weak- Experiment” [10] that a single photon, in the Double Slit experiment, goes all the way from the source to the screen through only one slit.

The photon follows a trajectory known as the D. Bohm trajectory [11].

Our “mechanism” by which the photon is “guided” is also relevant to other elementary particles, atoms, molecules and even microscopic bodies.

13 On EM Waves

Waves we encounter in nature are, most of the time, spherical waves rather than plane waves. However, far from a radiator, a spherical wave appears to be approximately a plane wave. Far from the radiator the electrical field of the wave \mathbf{E} decreases like $1/r$ and hence its intensity I , which is proportional to \mathbf{E}^2 decreases as $1/r^2$. Thus the classical approach complies with the quantum approach. In this case, the intensity at a far distance r depends on the number of photons that are crossing a unit area and hence the dependence on $1/r^2$.

14 Summary

The GDM photon has a finite volume $V_{\text{photon}} = 6.75 \cdot 10^{-7} \cdot \lambda^3 \text{cm}^3$. This photon is a confined oscillating dipole of the bivalent elementary charges with their fields.

Note that our discussion is based on the GDM, which is a new approach to the fundamentals of physics in general, and electromagnetism in particular.

The GDM photon owns all the attributes necessary to be converted, directly or indirectly, to each and every one of the other elementary particles.

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