A Model of Photons Ground-State Photons and Dirac Sea

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A Model of Photons Ground-State Photons and Dirac Sea

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Abstract

A photon, according to Quantum Field Theory (QFT), is kind of an **excitation** of the electromagnetic field. This field resides in Space and follows its topology. This excitation is considered point-like and structureless, whereas in some books - a wavepacket. No one, however, modeled this wavepacket in such a way that enables us to relate to it as a stable particle. On the other hand, in our recent paper titled "The Double Slit Experiment Enigma – Resolved" we show that the photon is not a wave. So, what is it? We contend that **the Photon is** a **Space Lattice excitation**. This idea enables us to model the photon and its ground-state photon. For abbreviation of the long expression Ground-State Photon we have invented the name **Photom**, which will be used from now on. This idea, that the photon and the photom are Space Lattice excitations, explains their electromagnetic nature. This understanding reveals the essence of the Zero-Point Fluctuations, Space Polarization and that of Dirac Sea.

Key Words**:** Photon, Electromagnetism, Geometrodynamics, Quantum Field Theory, Dirac Sea

1 Introduction

1.1 Our Model of the Photon Photom and Dirac Sea in a Nutshell

We consider Space to be a lattice. As such we model the **Photon** to be a **space lattice cells oscillation**. This oscillation is in a plane perpendicular to the line of propagation of its oscillation. This propagation, of the oscillation to the adjacent cells on the line of propagation, is at the light velocity c. The oscillation is vertical or horizontal to the line of propagation or rotating clockwise or anti-clockwise. This **single frequency oscillation**, which overcomes the

frequency ambiguity of a wavepacket, occupies a finite space volume of a defined shape, structure and size. An ensemble of many photons **in phase** moving together is an **electromagnetic wave**.

According to QFT the Photom's energy, spin and linear momentum are **half** of those of the photon. This means that they are actually the basic kind of oscillations of the space lattice. These oscillations are of two kinds: contraction (named **Eve**) and dilation (named **Adam**). The photon is the combination of these two Eve and Adam Photoms. Note that we model the **Graviton** elsewhere as a combination of four such photoms. Note also that according to QFT there is **only one** type of a Photom. The Zero Point Fluctuations of the vacuum (space), are thus the "gas" of photoms. Here comes a surprise. According to my theory "Electromagnetism is space Geometrodynamics" [1] [2] [3] [4] contracted space is positive charge whereas dilated space is negative charge, see Appendix A. We explain elsewhere that these oscillating charges, of the photoms, are the origins of the elementary electric charges. Hence this "gas" of photoms is the **Dirac Sea**. This charged "gas" of photoms is also the origin of the Vacuum (space) Polarization phenomenon, see Appendix B.

1.2 The Photon Cannot Be a Wavepacket

In modern literature [5] [6] [7] the photon is considered a wavepacket, but its shape, structure and size are not discussed. The idea is that some degree of localization can be realized by superposing states of different frequencies in such a way that there is some destructive interference outside a limited spatial range. These "packets" cannot have a defined quantized energy, only their components that evolve independently. Thus, the packet is unstable and cannot retain its "original form".

1.3 The Photon Cannot Be a Wave

In our paper [8]: "The Double Slit Experiment Enigma – Resolved" we dispel the need to attribute a dualistic nature to single photons that arrive, in a double slit experiment, at the

screen one at a time. Interference is explained in a novel way based on known and accepted physics. The photon, being an excitation of the electromagnetic field, is regarded as a particle of a defined size, and **not a wave**.

1.4 The Photon and Photom are Excitations of the Electromagnetic Field (In a unified reality these Excitations are of Space Itself)

The photon and photom according to Quantum Field Theory (QFT) are excitations of the electromagnetic field, that resides in Space and follows its topology. Hence, a vibration of space is a vibration of the electromagnetic field and vice versa. **Gravitational waves are vibrations of space and indeed they move at the velocity of light.** In our discussion here you can consider the electromagnetic field and space as different entities, but can also adopt our idea [1] that they are the same, see Appendix A.

2 Space

2.1 Space as a Lattice

We consider Space to be a lattice - to have a cellular structure. Considering space as a continuum is not prohibitive but problematic. Attributing a cellular structure (a lattice) to space explains its Hubble expansion, its elasticity (see 2.2) and introduces a cut-off in the wavelength of the vacuum-state spectrum of vibrations. Without this cut-off, infinite energy densities arise. The need for a cut-off is addressed by Sakharov [9] and Misner et al [10]. The Bekenstein Bound [11] sets a limit to the information available about the other side of the horizon of a black hole. Smolin [12] argues that: "*There is no way to reconcile this with the view that space is continuous for that implies that each finite volume can contain an infinite amount of information*". A review, relevant to our discussion, appears in a paper by Amelino-Camelia [13].

Note, that we **do not** know anything about the structure or substance of the space lattice.

Space density is defined as the number of space cells in a unit of volume.

2.2 The Elastic Space

We relate to space **not** as a passive static arena for fields and particles but as an active elastic entity. Physicists have different, sometimes conflicting, ideas about the physical meaning of the mathematical objects in their models. The mathematical objects of General Relativity, as an example, are n-dimensional manifolds in hyper-spaces with more dimensions than n. These are not necessarily the physical objects that General Relativity accounts for and n-dimensional manifolds can be equivalent to n-dimensional elastic spaces. This equivalence allows us to use General Relativity, and also relate to our own space as an elastic 3D space. Rindler [14] uses this equivalence to enable visualization of bent manifolds, whereas Steane [15] considers this equivalence to be a real option for a presentation of reality. Callahan [16], being very clear about this equivalence, declares: "…in physics we associate curvature with stretching rather than bending". After all, in General Relativity gravitational waves [17] are space waves and the attribution of elasticity to space is thus a must.

The deformation of space is the change in size of its cells. The terms positive deformation and negative deformation, around a point in space, are used to indicate that space cells grow or shrink, respectively, from this point outwards. Positive deformation is equivalent to positive curving and negative deformation to negative curving. This is discussed in [18] and [19].

Note, that the Metric, which is a solution of the GR field equation, expresses a deformed space.

3 The Photon and Photom as a space Lattice Oscillation

3.1 On Energy and Mass

Our Photon is an energetic particle, which moves at the speed of light. This is a massless particle. On the other hand, everybody is aware of the known relation:

U (Energy) = M (Mass)$\cdot c^2$ (Square of light velocity),

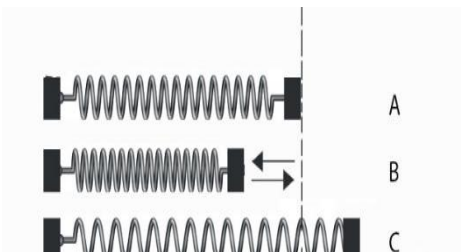
as if energy is always mass. This notion is wrong. Mass is nothing but energy, but energy is not always mass. Energy is mass, depends on the way it is "packed"- the way the particle is constructed. A "package of energy" that attributes to its energy inertia **(**namely you have to apply force in order to accelerate the "package"**)** is considered to have a mass. This means that mass is not fundamental and serves as a practical term only [20].

In classical mechanics if no force is applied, a body is at "rest" or moves on a straight line with a constant velocity. This is **Newton's first law**. In order to change the velocity, one has to apply a force F on the body to accelerate it - an acceleration a. The ratio: F/a = M defines the mass M. This is **Newton's second law**.

3.2 The Photon and Photoms Visualized as a Springs

Let us consider the simplest space vibrations as the oscillations of springs. Fig. (1B) shows a periodically contracted spring whereas Fig.(1C) shows a periodically stretched (dilated) spring. Fig. (1A) shows the state of no tension. Both the amplitude and the frequency of these springs can take any value. If they have the same frequency their energy of stretch equals that of contraction. If they are coupled, they will have the same frequency. The stretching and contracting are perpendicular to their vibrational transfer **motion, to neighbor cells.** A rotation of the vibrations along the line of propagation attributes to them the spin.

Fig. (2) presents the **Photon** as a particle which is composed of these two elementary vibrations of a group of space cells, similar to two coupled springs. They vibrate at the same frequency and with the same phase; when one group is stretched the other is contracted. Since they rotate, after each half cycle they are in an upside-down position. This rotation is the photon's spin.



Eve

Adam

Fig. (1) Space "Springs"

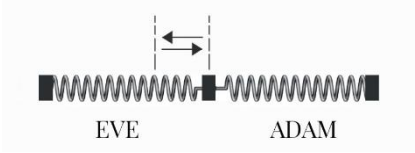


Fig. (2) The Photon as" Springs" (1B) Eve and (1C) Adam

Note that **a photon** or **a photom** are the oscillation of a group of cells.

Note also that both the propagation of the contraction or dilation and the perpendicular linear propagation of the oscillation in space are at the same velocity c.

3.3 Photoms - the Ground State Photons

QED, [6], attributes to a photon in its ground state one half of the energy, half of the linear 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 our theory however, there are two types of photoms.

The Positive Photom - Eve: This photom, as Fig. (3) 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 - Adam: This photom, as Fig. (4) 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. (2). The GDM considers them as the pair of

an electron and positron of the Dirac Sea, and vacuum polarization is due to them, see Appendix A and B. 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. (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·T, Fig. (3b), 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·T, Fig. (3c), we face the same situation as in Fig. (3a). At t = 3/4·T, Fig. (3d), the displacement reverses its direction and the electrical field points down. At t = T, Fig. (3e), 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 Figure (4) shows our cylinder-like photom passing in front of us to the right, with a velocity c. At the moment t = 0, Fig. (4a), 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·T, Fig. (4b), 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·T, Fig. (4c), we face the same situation as in, Fig. (4a). At t = 3/4·T, Fig. (4d), the displacement reverses its direction and the electrical field points up. At t = T, Fig. (4e), the cycle is completed.

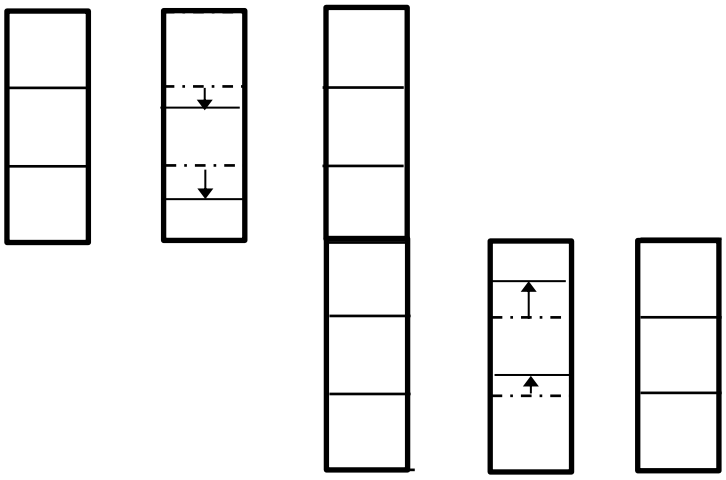


Fig. (3) The Positive Photom Eve

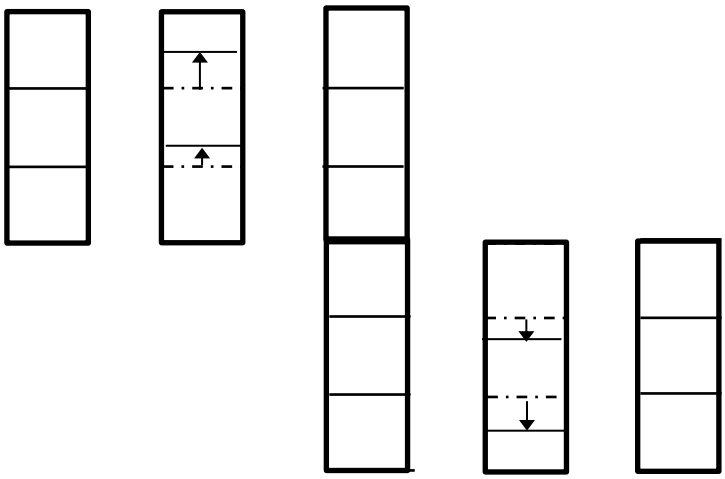


Fig. (4) The Negative Photom Adam

3.4 Spatial Density of Photoms

The spatial density of an ensemble of photoms of a given λ and a bandwidth dλ, see [6] [7], is:

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

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

For photoms of λ = 500nm and a bandwidth dλ = 0.5nm the spatial density is:

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

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

4 The Linearly Polarized Photon as the Photom Eve and the Photom Adam on the Same Line

Fig. (5) shows an oscillating, cylinder-like, photon passing in front of us to the right (Black arrow in Fig. (5)), with a velocity c and cycle time T. At the moment t = 0, Fig. (5a), we see a cylinder of a group of cells with no strain and stress; each square represents part of the group of space cells.

At t = 1/4·T, Fig. (5b), the space in the cylinder becomes dilated below the line of propagation (Black arrow in Fig. (5)) and contracted above it. The displacement vector, in the figure, points upwards all the way. At t = 1/2·T, Fig. (5c), we are facing the same situation as in Fig. (5a). At t = 3/4·T, Fig. (5d), the displacement vector reverses its direction. At t = T, Fig. (5e), the cycle is completed.

At t =1/4·T, Fig. (5b), part of the group of space cells below the line of propagation (the middle) is dilated and the part above it is contracted. At t = 3/4·T, Fig. (5d), the part of the group of space cells below is contracted and the part above is dilated.

Note that the Photon is actually the combination of the Photoms Eve and Adam oscillating on both sides of the line of propagation.

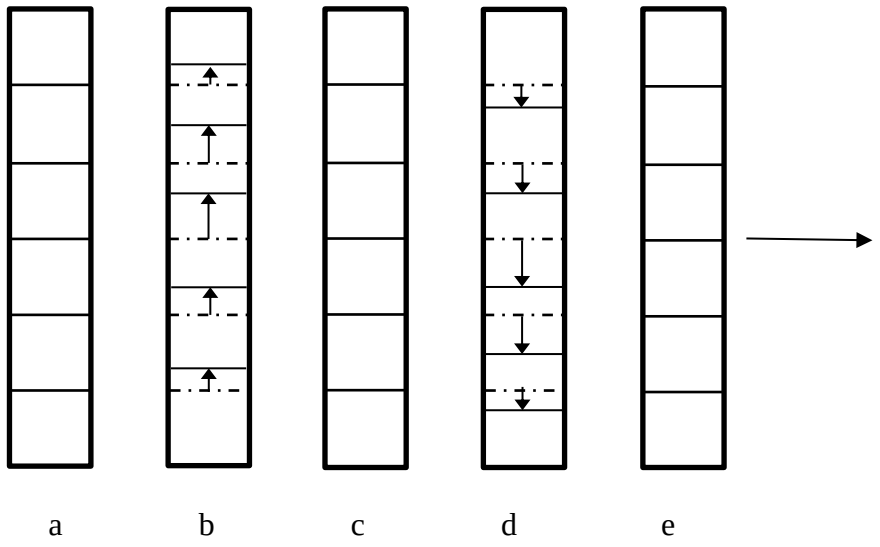


Fig. (5) The Photon's Oscillating Space Lattice

5 The Length of Dilation and Contraction of the "Springy" Photom

The **Photon and the photom** are massless particles, in other words none of them have inertia in the direction of motion (propagation). Mass is merely a practical term used to express inertia, due to energy, in the direction of motion (propagation). This, however, does not prevent us from attributing inertia, to the energy of the photon and photom, in the direction of oscillation perpendicular to the direction of motion (propagation). This justifies our following analysis. The above contention is based on our new understanding of Inertia and Mass, which is out of the scope of this paper [20].

For a **Spring** with a constant K and mass M the change in length, velocity and acceleration are:

$y = y_0 \mathrm{Sin}\omega t \qquad v = \omega y_0 \mathrm{Cos}\omega t \qquad a = -\omega^2 y_0 \mathrm{Sin}\omega t$

Note that y_0 is the length of the maximum contraction or the maximum dilation and **not the length** Y of the spring.

For the analogical photom y is perpendicular to the line of propagation. And the energy for the contracted "spring" as well as for the dilated "spring" is:

$U_k = 1/2\ Mv^2 = 1/2M\ \omega^2 y_0^2\ Cos^2\omega t \quad U_p = 1/2Ky^2 = 1/2\ Ky_0^2\ Sin^2\omega t$

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

$U = U_k(max) = U_p(max) = 1/2\ M\ \omega^2 y_0$ (1)

or

$U = U_k(max) = U_p(max) = 1/2Ky_0^2$ (2)

For this kind of vibration U is a constant. Hence, we can attribute to it inertia $M = U/c^2$ and equation (1) becomes: $U = 1/2\ M\ \omega^2 y_0^2 = 1/2\ U/c^2\ \omega^2 y_0^2$ or $1 = 1/2c^2\ \omega^2 y_0^2$

Hence $2c^2 = \omega^2 y_0^2$ or $2^{1/2}\ c = y_0\ \omega$

but $c = \lambda \cdot \omega / 2\pi$ and the maximum change of the spatial distance is thus:

$y_0 = \lambda / (2^{1/2} \cdot \pi) = 0.225\ \lambda$ (3)

Note, that this is a result of taking $M = U/c^2$. For the **massless** photon (see chapter 3.1), which is a construction of two photoms, the combined length of oscillation of contraction and dilation is $2\ y_0$

Now we know the amount of contraction or dilation but not the length Y of the springy photom and the 2Y of the photon. Based on the length of the focal zone of single photons [21], we guess that the order of magnitude of Y is λ for the photom and $2\ \lambda$ for the photon. The exact value of Y will be derived in chapter **6.** The volume of the photon, however, is determined also by its **width (diameter?).** The minimum possible width is of course the dimension of a single space cell. The photon/photom is thus kind of a linear

contracting/dilating **string**, as it is in String Theory but with a different and much simpler formalism.

Note that the photoms Eve and Adam are attracted to each other because they are the osculatory opposite "elementary electrical charges" [1] [19].

Note also that a photon can be created in empty space (vacuum). This phenomenon was reported in the paper titled "Resonant cavity photon creation via the dynamical Casimir effect" [22].

6 Constant K of the "Springy" Space and the Quantization of Energy

Using (2) and (3) we get for the energy U the expression

$$U = K \lambda^2/4\pi^2 \qquad (4)$$

where K is the mechanical **spring constant.**

Inserting U = 1/2 ħω $= \hbar \pi c/\lambda$ in (4) gives:

$K = (4 \pi^3 \hbar) \cdot 1/\lambda^3$ Hence our interesting result for **The Constant K of the "Springy" Space**:

$$K(\lambda) \propto 1/\lambda^3 \qquad (5)$$

We can also **reverse** our argument and say: **If** (5) is **a classical attribute of space** than necessarily its vibrational energy is **quantized.** It is **U = 1/2 ħω** for a photom and **U = ħω** for a photon. This simple derivation of (5) leads to the understanding that **Quantum behavior of energy is rooted in a classical attribute of space.**

7 The Circular Polarized Photon

This photon is constructed of two photoms at right angles to each other and oscillating with a 90-degree phase difference. The energy of each photom is spread along its length Y.

In this case, however, we can relate to the oscillating energy as if it is located a distance ½Y from the center (the point of the photoms touch). The 90-degree phase difference in the oscillations means that the energy is rotating around the center and hence attributing to the constructed photon angular momentum L. As we know:

$L = MvR$

The linear tangential momentum is Mv and the radius of rotation is R

In our case $M = U/c^2$, v = c and R = ½Y We know that $L = \hbar$ and $U = 1/2\ \hbar\ \omega$ hence:

$\hbar = U/c^2\ c\ ½Y = 1/2\ \hbar\ \omega/c\ 1/2Y$ or

$Y = 4\ c/\ \omega = 4/2\pi\ \lambda = 2/\pi\ \lambda$

and hence the **linear polarized photon length** (see chapter 5) is:

$2Y = 4/\pi\ \lambda$ (6)

8 A Remark on Electromagnetic 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 **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 $1/r^2$.

9 Summary

The photon and photom according to Quantum Field Theory (QFT) are excitations of the electromagnetic field, that resides in Space and follows its topology. Hence, a vibration of space

is a vibration of the electromagnetic field and vice versa. And indeed, gravitational waves are vibrations of space that move at the velocity of the “electromagnetic” light.

We show that the photon is a confined oscillating dipole of the potentially virtual bivalent elementary charges of its photoms with their fields.

The photon owns all the attributes necessary to be converted, as we show elsewhere, directly or indirectly in the Pair Production process, to each and every one of the other elementary particles. Hence, we should consider the “sea” of photoms as the Dirac Sea and the Zero-Point Fluctuations.

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Data available with the paper-The author declares that the data supporting the findings of this study are available within the paper.

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Appendix A On Electric Charge and its Field

In our Spacetime **GeometroDynamic Model** (**GDM**) of the physical reality a positive elementary electric charge and its field is a contracted zone of space, whereas a negative elementary electric charge and its field is a dilated zone of space [15]. In this model, of charge and its field, there is no physical separation between the particle and its field, and the integral of ρ over the entire space, for two bivalent elementary charges together, is zero. Relating to space as a lattice (cellular structure), we define Space Density ρ as the number of space cells per unit volume (denoted ρ_0 for space with no deformations). The electric field **E** is proportional to **u**, the Elastic Displacement Vector of the elastic space lattice. **E** is defined as **E** = -H**u**, and points in the opposite direction to **u,** where H is a constant of proportionality.

Based on this we define (postulate, invent) **Electric Charge Density** as:

$q = 1/4\pi \cdot (\rho - \rho_0)/\rho$ $[q] = 1$. This charge density is positive if $\rho > \rho_0$ and negative if $\rho < \rho_0$.

Electric charge, in a given zone of space τ, is then: $Q = \int_{\tau} q d\tau$ $[Q] = L^3$.

Our definition of electric charge density alone yields electrostatics, without any phenomenology, and together with the Lorentz Transformation - the entire **Maxwell theory**.

Thus, a space vibrational photon, as described, is an oscillating electric dipole with its electric field. This oscillating dipole and its field, as we show, **are confined in a finite volume of space** and the **single frequency** oscillating virtual charges are the potentially elementary electric charges. **Note** that the **photon** in our theory holds all the basic features that appear in all the other elementary particles.

Appendix B Space Polarization-The Polarization of the Vacuum

A scattering experiment, conducted in the TRISTAN accelerator in Japan in 1997, found that the closer electrons get to each other, the field they sense is larger than expected. The explanation, given by Koltick (1997), was that in the immediate vicinity of the electron the creation and annihilation of pairs of electrons and positrons screen the charge of the electron by polarization, see Fig. (B1). This is the **Polarization of the Vacuum**. My explanation is somewhat different.

Photoms can create space polarization. ADAM particles surround a positive charge and EVE particles adhere to their backs, see Fig. (B1), hence, space acts like a dielectric media and screens the positive charge.

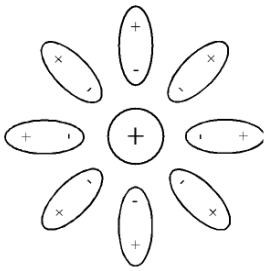

Fig. (B1) The "Net" Charge (Tristan Accelerator Japan 1997)

Thus, from a distance the charge will appear as carrying a smaller charge. If we approach the charge through the screen, the closer, we get the larger the charge will appear.

Based on this understanding we can dispel the need for virtual creation and annihilation of electron-positron pairs.