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Zero Point Energy and the Dirac Equation

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Abstract

Zero Point Energy (ZPE) describes the random electromagnetic oscillations that are left in the vacuum after all other energy has been removed. One way to explain this is by means of the uncertainty principle of quantum physics, which implies that it is impossible to have a zero energy condition.

In this article, the ZPE is explained by using a novel description of the graviton. This is based on the behavior of photons in a gravitational field, leading to a new definition of the graviton. In effect, gravitons behave as if they have charge and magnetic effects.

These are referred to as negative color charge, positive color charge and magnetic color. From this, it can be shown that a photon is made of color charges and magnetic color. This definition of the structure of a photon then leads to an explanation of how the vacuum produces Zero Point Energy (ZPE).

Zero Point Energy and Dirac Equation

Keywords: Zero point energy, Dirac equation, Hawking radiation, graviton, photon, pair production, color-charge, magnetism color, photon, vacuum and Higgs

Contents;

1 Introduction

Zero Point Energy (ZPE), or vacuum fluctuation energy, are terms used to describe the random electromagnetic oscillations that are left in a vacuum after all other energy has been removed.

The concept of zero-point energy was first proposed by Albert Einstein and Otto Stern in 1913, and was originally called "residual energy" or Nullpunktsenergie. All quantum mechanical systems have a zero point energy. The term arises commonly in reference to the ground state of the quantum harmonic oscillator and its null oscillations.

In cosmology, the vacuum energy is taken by many to be the origin of the cosmological constant. Experimentally, the zero-point energy of the vacuum leads directly to the Casimir effect[1], and is directly observable in nanoscale devices.

One way to explain this is by means of the uncertainty principle of quantum physics, which implies that it is impossible to have a zero energy condition.

In this article, an attempt has been made according to the concept of gravitational blue shift, to take the Mössbauer effect, Pound-Rebka experiments and the interaction between gravity and the photon into consideration from a Higgs field point of view[2].

Blue shift and the Mössbauer effect indicate clearly that three different Higgs bosons cause increasing photon mass when they have electromagnetic specifications. This generalizes color charge from the nuclear regime to the photon. This new view of color charge means that we can redefine the graviton and electromagnetic energy.

Gravitons behave like charged particles and in the interaction between gravity and the photon, gravitons convert to negative and positive color charges and magnetic color. These color charges and magnetic color form electromagnetic energy and electromagnetic energy then converts to matter and anti-matter such as charged particles.

2 The Photon in a gravitational field

Looking at the behavior of a photon in a gravitational field can help resolve vacuum energy. The fields around a "ray of light" are electromagnetic waves, not static fields. The electromagnetic field generated by a photon is much stronger than the associated gravitational field.

When a photon is falling in a gravitational field, its energy (mass) increases. According to $W=\Delta mc^2$, the force of gravity performs work on the photon, so the mass (energy) of the photon increases.

However, the energy of a photon depends on its electric and magnetic fields. Therefore, one part of the work done by gravity converts to electrical energy and the other part converts to magnetic energy. How can the Higgs boson show how particles acquire mass? Moreover, according to the Higgs boson, what happens to the blue shift?

3 Color-charges and color-magnetism

The change of frequency of a photon in a gravitational field has been demonstrated by the Pound-Rebka experiment. When a photon falls in a gravitational field, it acquires energy equal to $E=\Delta mc^2$ which separates into three parts; one part behaves like a positive electric field and another part behaves like a negative electric field. These neutralize each other in the structure of the photon (a photon itself is neutral) and the third part behaves like a magnetic field.

In quantum mechanical theory, every field is quantized. In addition, force is described as energy per distance shown by:

$$F = -\frac{dU}{dx} \qquad (1)$$

If we consider this equation from the aspect of quantum mechanics, a graviton enters into the structure of a photon, carrying gravitational force. As a result, a graviton disappears and the energy of the photon increases.

Similarly, Red Shift has the opposite effect. As a photon escapes from a gravitational field, its frequency shifts to red and its energy converts to gravitons. How can we describe this interaction between photons and gravitons on a sub-quantum scale such as in the structure of a photon?

Another consideration is virtual particles, implied by the uncertainty principle in the form:

$$\Delta E \Delta t \geq \hbar \,,\; \hbar = \frac{h}{2\pi} \qquad (2)$$

In the vacuum, one or more particles with energy ΔE above the vacuum may be created for a short time Δt. So, any analysis of the ZPE should be able to explain this particle production and even Hawking radiation in a strong gravitational field such as that of a black hole. To do this, the best way is to use the Dirac equation, which originally demonstrated the possibility of a particle pair, that is, a particle and anti-particle.

The relationship between energy and momentum for a massless particles is given by;

$$\langle E \rangle = \langle |P| \rangle \, c \qquad (3)$$

Now it is possible to change the definition of the rest mass of a particle. As we know, some particles such as photons are never seen at rest in any reference frame.

According to relativity however, they do have mass that derives from their energy. For example, a photon has a mass given by:

$$E = mc^2 = h\nu \;\Rightarrow\; m = \frac{h\nu}{c^2} \qquad (4)$$

So, there are two kinds of particles in physics;

- Some particles like the photon move only with the speed of light c, in all inertial reference frames. Let’s call this kind the NR particles or Never at Rest condition particles.

- Other particles like the electron aways move with speed $v<c$ in all inertial reference frames, they have a rest mass, and could be called PNZRM particles or Particles of Non Zero Rest Mass.

According the above definition, photons and gravitons are NR particles, while electrons and protons are PNZRM particles.

Zero Point Energy and Dirac Equation

Suppose a photon with NR mass m and energy $E = h\nu$ falls toward the earth relative to an inertial reference frame on the surface. Its frequency increases from ν to ν', and a large number of gravitons enter into the structure of the photon such that $\Delta\nu=\nu'-\nu$. The problem is; how many gravitons enter into a photon to provide the least possible photon energy change (minimum $\Delta\nu$)?

Now, according to this argument, in order to calculate the number of gravitons involved in $\Delta\nu$ and to explain their properties, suppose a photon with frequency ν is formed of n_1 elements, and with a frequency ν' it contains n_2 elements. These elements are not the same, because they exhibit different properties. Let us propose a 1×4 matrix $[A \ \ B \ \ C \ \ D]$.

Now we need to calculate A, B, C and D so that they satisfy the properties of a photon. When gravity works on a photon, gravitons enter into the photon and the intensity of its electric field increases.

The photon has no electrical effect; therefore A and B must carry electric field around the photon with opposite effect. So, according to the relative intensity of electric and magnetic fields $E=cB$, we can write;

$$A=cH^{+}, \quad B=cH^{-}, \qquad \text{c is the speed of light}$$

Here H^{+} is positive color-charge and H^{-} is negative color-charge. In addition, in the above relation c is a mathematical constant that relates E and B in electromagnetism. So, let us show $c=\kappa$. Then the above relation becomes:

$$A=\kappa H^{+}, \quad B=\kappa H^{-}, \qquad \kappa \text{ is a mathematical constant}$$

When a large count of H^{+} enters into a photon, the intensity of its positive electric field increases. According to the Maxwell equations, the intensity of its magnetic field increases as well.

Also, element C must carry a magnetic effect around the positive color-charges and the same applies to the D element for the negative color-charges. Therefore, C and D are the same but with opposite direction. So, according to the relationship between the intensity of electric and magnetic fields, we can write;

$$C=H^{m}, \quad D=-H^{m}$$

Then the matrix $[A \ \ B \ \ C \ \ D]$ takes the following form, here named the CPH matrix;

$$[CPH] = \left[\kappa H^{+} \quad \kappa H^{-} \quad H^{m} \quad H^{m} \right] \qquad (5)$$

According to the above expression, we are now able to define the least magnitude of a photon. A photon of minute energy contains some positive color-charges H^{+}, negative color-charges H^{-}, right rotation color-magnetism H^{m} and left rotation color-magnetism $-H^{m}$ as shown in the CPH matrix (relation 5). This very small energy can be express as the following;

$$\text{Minute electromagnetic energy } = (2\kappa + 2)E_{CPH} \qquad (6)$$

Note; the energy of a CPH (E_{CPH}) is defined later in relation (8).

The argument is now in a position to offer some supportable propositions about the photon and a new definition of the graviton.

4 Gravitons

Many physicists believe the graviton does not exist, at least not in the simplistic manner in which it usually envisioned. Superficially speaking, quantum gravity using the gauge interaction of a spin-2 field (graviton) fails to work the way that the photon and other gauge bosons do.

Maxwell's equations always admit a spin-1, linear wave, but Einstein's equations rarely admit a spin-2, linear wave, and when they do it is not exact.

However, in the present article the photon is made of gravitons. To resolve this, we need to continue with the definition of CPH and the Principle of CPH and then return to properties of a graviton.

5 Definition of a CPH

What is a CPH? It is the Creative Particle of Higgs, or, CPH is an existence unit of nature. In other words, everything is made of CPH. Therefore, a CPH is appropriately referred to as the unit of nature, although this not meant to be a “particle” as this concept has been traditionally referred to in physics.

A CPH is a NR particle of a kind nonethess, with a constant NR mass m_{CPH}, that moves with a constant magnitude speed of $|V_{CPH}| > |c|$ in any inertial reference frame, where c is the speed of light.

According to the mass-energy relation, the NR mass of a CPH is defined relative a to photon's NR mass by;

$$m_{CPH} < m = \frac{h\nu}{c^2} \ \forall \ \nu \qquad (7)$$

And the relationship between energy and momentum for the NR mass CPH is given by;

$$\langle E_{CPH} \rangle = \langle |P_{CPH}| \rangle \ V_{CPH} = \text{constant} \qquad (8)$$

Relation (8) shows that the energy of every CPH is constant in any interaction between two (or more) CPH. So, given $|V_{CPH}|$ cannot alter, they must take on spin to conserve the total energy.

In other words, in any inertial reference frame and Cartesian components;

$$|V_{CPH}(x)| + |V_{CPH}(y)| + |V_{CPH}(z)| = |V_{CPH}| \ , \ \text{CPH has no spin} \qquad (9)$$

$$|V_{CPH}(x)| + |V_{CPH}(y)| + |V_{CPH}(z)| < |V_{CPH}| \ , \ \text{CPH has spin} \qquad (10)$$

When a CPH has spin, it is called a graviton

Simply, a lone graviton without spin is a CPH.

When;

$$|V_{CPH}(x)| + |V_{CPH}(y)| + |V_{CPH}(z)| \geq c \qquad (11)$$

there is no difference between bosons and fermions. In this case, a CPH carries gravitational force and behaves like a fermion. Therefore, there are color-charges, only.

When;

$|V_{CPH}(x)|+|V_{CPH}(y)|+|V_{CPH}(z)| \le c$, the magnetic effect appears.

For particles like electrons or quarks;

$$|V_{CPH}(x)|+|V_{CPH}(y)|+|V_{CPH}(z)|<c \qquad (12)$$

Other bosons also occur. For example, reconsider pair production. Before pair production, there is a photon only. After pair production there is an electron, positron and a virtual photon (boson) that carries electromagnetic force. So, we can write:

$$|V_{CPH}(y)|+|V_{CPH}(z)|<c \qquad (13)$$

Spontaneous Symmetry Breaking has occurred.

Accordingly, a CPH with spin is called a graviton, so space is full of CPH. Increasing density of CPH in space causes their separation to decrease until they feel and absorb each other.

Suppose two CPH are moving in the x-axis direction and absorb each other, such that their paths change without decreasing the magnitude of V_{CPH}. According to relation (8), we are able to construct an operator $R_z(\Delta\varphi)$, which rotates a CPH by an angle $\Delta\varphi$ about the x-axis (toward z-axis or y-axis) in position space. Also, we can construct $T_z(\Delta\varphi)$ which rotates the CPH by $\Delta\varphi$ about the x-axis in spin space. We would expect such an operator to take the form;

$$T_z(\Delta\varphi) = \exp(-\frac{i s_z \Delta\varphi}{\hbar}) \qquad (14)$$

Thus, according to this expression, two interacting CPH rotate each other, but they cannot have same direction of spin. They spin in opposite directions. If positive color-charge has up spin, then negative color-charge must take on down spin.

6 Principle of the CPH theory

CPH is a unit of minuscule energy with a constant NR mass (m_{CPH}) that moves with a constant magnitude of speed such that $|V_{CPH}| > |c|$, in all inertial reference frames.

Any interaction between CPH and other existing particles represents a moment of inertia **I** where the magnitude of V_{CPH} $($or$|V_{CPH}|)$ is constant and never changes. Therefore,

$$\nabla |V_{CPH}| = 0 \text{ in all inertial reference frames and any space}$$

Based on the principal of CPH, a CPH has two types of energy generated by its movement within its inertial frame. One is translational and the other is spin. In physics, we represent energy summation (both kinetic and potential) by a Hamiltonian equation and energy difference by a LaGrangian. Therefore, in the case of CPH, we use a Hamiltonian to describe the summation of energy generated by translation and spin as follows:

$$E_{CPH} = T + S \qquad (15)$$

Where T is translational and S is spin energy of a CPH respectively. Since the speed and mass of CPH are constant, then $E_{CPH} = \text{constant}$. CPH produces energy and energy produces Matter and Anti-Matter. In fact, everything has been formed of CPH.

7 CPH and the Cyclic group

As explained in section 3, gravitons in interaction with each other convert to color-charges and color-magnetism. In addition, when a CPH has spin, it is calling a graviton. Therefore, we can define a cyclic group for electric field that is generated by gravitons.

So, $G<g>$ given by;

$$G\langle g\rangle = \{nH^{+}, nH^{-} \mid n \in Z\} \qquad (16)$$

Suppose 2n color-charges ($n\,H^{+}$ and $n\,H^{-}$) combine and move in space. There are two electric fields with opposite sign in that space. About each such field a magnetic field forms, produced by gravitons. According to the signs of these fields, the direction of this magnetism is different, so their elements are same. Therefore, there is a cyclic group given by:

$$G\langle g\rangle=\{kH^{m} \mid k \in Z\} \qquad (17)$$

According to the above group and the CPH matrix (relation 5), we can explain zero point energy.

8 Zero Point Energy

Space is full of gravitons. Gravitons interact with each other and convert to color-charges. Interaction between gravitons depends on their density $\rho(g)$ in a given volume. Energy production is given by:

$$E = \iiint_V \rho(g)\,dx\,dy\,dz \qquad (18)$$

According to the above expression, we are able to explain the mechanism of ZPE. Some gravitons with the same NR mass m_{CPH} convert to color-charges, and two electric fields form. These fields neutralize each other. However, positive color-charges repel each other, and the same action applies to the negative color-charges.

Therefore, when the intensity of color-charges grows, about each field (negative and positive fields) a magnetic field forms. This magnetic field maintains the electric field. This mechanism is explainable by the Larmor radius (gyroradius or cyclotron radius) given by;

$$r_g = \frac{mv_{\perp}}{|q|B} \qquad (19)$$

Where r_g is the gyroradius, m is the mass of the charged particle, $v_\perp$ is the velocity component perpendicular to the direction of the magnetic field, q is the charge of the particle, and B is the constant magnetic field.

This defines the radius of circular motion of a charged particle in the presence of a uniform magnetic field. When color-charges change in the structure of a photon, then magnetic-color changes too. Therefore the electric fields do not decay in the structure of a photon.

In general, a photon has been formed of two parts;

1- A large number of negative color charges and magnetic color. Magnetic color maintains color charges in a tube-like distribution, so negative magnetic color forms an appropriate negative electric field. In addition, the same happens for positive electric field in the opposite sense. So it is now possible to demonstrate the least possible negative color charges with their magnetic color by $\lhd$, so that;

$$\lhd = (\kappa H^{-}, -H^{m}) \qquad (20)$$

2- Similarly to the above; positive color charges with their magnetic color can be shown by $\rhd$, so that;

$$\rhd = (\kappa H^{+}, +H^{m}) \qquad (21)$$

The signs (+and -) of $(+H^{m}), (-H^{m})$ depend on the direction of movement around the color charges. In fact, there is a kind of magnetic color in the structure of a photon. Therefore, generally, a photon is given by;

$$n\left|\lhd\right\rangle + n\left|\rhd\right\rangle = \left|E\right\rangle \qquad (22)$$

In the quantum mechanics of any general field, plane waves of specific spin can always be written in terms of photons with a simple spin state and a general spatial wave function. Thus the fundamental entity, the photon, can be considered quite generally to be a plane wave with a circularly polarized spin component (Any field can be built from these basic ingredients).

For simplicity, consider a photon traveling in the x direction, or consider the direction of the photon as choosing the coordinate axis so that x points along the photon's momentum vector. Every element in the photon (relation 22) moves with linear speed in the same direction as the photon.

The Dirac equation results for total energy is given by;

$$E^2 = \left(\alpha_0 mc^2 + \sum_{j=1}^{3} \alpha_j cp_j \right)^2 \qquad (23)$$

Comparing relationship (22) with equation (23), the energy equation can now be written as;

$$E^2 = \left(n\left|\lhd\right\rangle + n\left|\rhd\right\rangle \right)^2 \qquad (24)$$

The roots of relations (23) and (24), are given by;

$$E_- = -\sqrt{\alpha_0 m_0 c^2 + \sum_{j=1}^{3} \alpha_j cp_j} = n \lhd = n(\kappa H^-, -H^m) \qquad (25)$$

$$E_+ = +\sqrt{\alpha_0 m_0 c^2 + \sum_{j=1}^{3} \alpha_j cp_j} = n \rhd = n(\kappa H^+, +H^m) \qquad (26)$$

In pair production, relation (25) defines an electron and relation (26) defines a positron. We saw that a photon (γ -ray) produces two charged particles, an electron and positron with negative and positive charges. Before production, we have two electric and two magnetic fields. After production, there are two particles with electric field and two weak magnetic fields around them.

This phenomenon shows that an electric field has no charge effect when formed of two kinds of color-charge, namely negative color-charge and positive color-charge. Moreover, in pair production, negative color-charges combine with each other to make a negatively charged particle, and positive color-charges combine with each other to make a positively charged particle. The magnetic colors with different direction move around the electron and positron. Consider relations (25) and (26), given by;

$$E_{-}=n \lhd = n(\kappa H^{-}, -H^{m})$$
$$E_{+}=n \rhd = n(\kappa H^{+}, +H^{m})$$

The pair annihilate each other to form energy. In addition, there is no electric effect around the photons, so;

$$n \lhd + n \rhd = \gamma + \gamma \qquad (27)$$

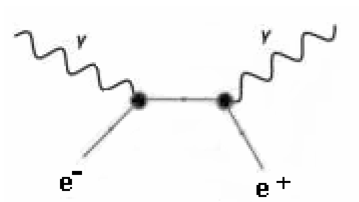

Fig1: annihilation of a particle pair

In this process, each particle (electron and positron) decomposes to two parts. Each part of the electron combines with each part of the positron and converts to quantum energy (see figure1). This phenomenon shows that the electron is divisible.

Physicists use this phenomenon as a way to confirm the mass-energy equation $E=mc^2$, but in fact, there is another important concept inherent in pair annihilation since;

$$n \lhd + n \rhd = (\frac{n}{2} \lhd + \frac{n}{2} \rhd) + (\frac{n}{2} \lhd + \frac{n}{2} \rhd) = \gamma + \gamma \qquad (28)$$

These photons are neutral and they carry two electric and magnetic fields. This phenomenon is acceptable only where two opposite charged particles separate and recombine again.

9 Hawking Radiation

In a simplified version of the explanation, Hawking predicted that energy fluctuations from the vacuum cause the generation of particle-antiparticle pairs near the event horizon of a black hole. One of the particles falls into the black hole while the other escapes before they have an opportunity to annihilate each other. The net result is that to someone viewing the black hole, it would appear that a particle has been emitted.

How is Hawking radiation explainable by the equation for the ZPE? To resolve this problem, there are three aspects of a black hole to consider;

- The density of gravitons is extremely high around a black hole.
- Gravitons convert to photons readily.
- The Dirac equation shows how photons produce matter and anti-matter.

According to the above expression, the space around a black hole produces high-energy photons whose energy is enough for pair production.

In a black hole situation, n becomes large, so E^2 (relation 24) is comparable to the total mass of a particle and anti-particle. This process does not need to take into account the time factor that the uncertainty principle dictates in relation (2). So, pair production is a common occurence around a black hole.

Summary;

According to this article we have generalized color charge from the nuclear regime to the photon. This new view of color charge means that we can redefine the graviton and electromagnetic energy. Gravitons behave like charged particles and in the interaction between gravity and the photon, gravitons convert to negative and positive color charges and magnetic color. These color charges and magnetic color form electromagnetic energy. Electromagnetic energy converts to matter and anti-matter as charged particles. Space is full of gravitons. Gravitons interact with each other and convert to color-charges. These color charges and magnetic color form electromagnetic energy.

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Refrences;

1- Richard Cushman. and Wilberd van der Kallen. (2005). *'A new interpretation for the mass of a classical relativistic particle'*, Elsevier Journal, Physics Letters Volume 24, Issue 3, May 2006, Pages 230-234

2- Ravindran V. (2006) *'Higher-order threshold effects to inclusive processes in QCD'*, Elsevier Journal, Physics Letters B, Available online 11 July 2006

Perelstein M. (2006) *'Little Higgs models and their phenomenology'*, Elsevier

3- Journal, Progress in Particle and Nuclear Physics, Available online June 2006

4- Gupta G. P. and. Lal K. C. (1971) *'On the equivalence of gravitational red shift and temperature shift in the Mssbauer effect'*, Elsevier Journal, Physics Letters A Volume 36, Issue 5, September 1971, Pages 421-422

5 - Peter S. Riseborough, E-book, Advanced Quantum Mechanics March 14, 2007

6- Stefan Waner, E-book, Introduction to Differential Geometry & General Relativity

4th Printing January 2005

7- http://www.daviddarling.info/encyclopedia/C/Casimir.html

8- * advanced string theory http://superstringtheory.com/basics/basic3a.html

9- F. Smarandache, V. Christianto, Fu Yuhua, R. Khrapko, J. Hutchison, E-book, Unfolding the Labyrinth: Open Problems in Physics, (University of Microfilm International)

---

[1] - Casimir, H. G. B. "On the attraction between two perfectly conducting plates." *Proc. Con. Ned. Akad. van Wetensch* B51 (7): 793-796 (1948).
[2] - General relativity forces Masataka Mizushima Department of Physics, University of Colorado, Boulder, CO 80309, USA November 2004. 30 November 2005-15 December 2005, Pages e369-e378