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A Visualization of the Higgs Effect to Explore the Origin of Cosmic Rays and Dark Energy Based on the Photon As An Electric Dipole

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Abstract This study presents a novel analogy for the Higgs mass-generation mechanism, based on the hypothesis of the photon as an electric dipole in combined motions, a rotation and a linear uniform motion perpendicular to its rotational axis. Within this framework, photon interaction occurs through two distinct chemical bonding modes: a side-by-side (π-bond) or a head-to-tail (σ-bond) configuration, resulting in the formation of a quadrupole. The subsequent collision of these quadrupoles with ambient photons and their resulting decomposition provides a theoretical visualization for the production of cosmic rays. Furthermore, this chemical bonding analysis identifies specific candidates for dark matter and dark energy, effectively integrating mass generation, cosmic ray origins, and dark energy into a unified model of photon interaction. By deriving matter's mass-generation mechanism from these interactions, the study concludes that mass is inherently quantized, mirroring the fundamental quantization of energy

Keywords: *Electrical Dipole, Quadrupole, Higgs Particle, Higgs Effect, Mass Generation, Photon Molecule, Cosmic Rays, Proton, Neutron, Electron, Positron, Dark matter, Dark Energy*

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1. Introduction

The history of modern physics is marked by three major pillars that explain how the universe works: how particles acquire mass (matter), where the high-speed cosmic messengers (cosmic rays) come from, and why the mysterious force (dark energy) driving the universe apart exists.

For much of the 20th century, physicists faced a crisis: the Standard Model [1] required fundamental particles, such as the W^+, W^- and Z^0 bosons to be massless, yet experiments clearly showed they had relatively large masses. If there were no Higgs field, particles would not have the mass. Giving mass to a particle is referred to as the Higgs effect which adds mass to any particle that interacts with the field. The Higgs field is a field of energy which is thought to be everywhere in the universe. The field is accompanied by the Higgs boson.

The breakthrough Higgs effect was first developed in 1964 by three independent teams, Francois Englert [2], Peter Higgs [3], and Gerald Garalink [4], based on the Gauge Theory [5,6,7]. The particles that acquire mass not by containing the field but by interacting with it in a similar way to an object moving through molasses, will become slower and heavier when passing through the molasses. The discovery of the Higgs particle at CERN's large Hadron Collider on October 8, 2013 tentatively confirmed the Higgs mechanism.

In 1896 Henri Becquerel [8] discovered radioactivity, after which it was generally believed that atmospheric electricity, or ionization of the air, was the result of the radiation [9] by the radioactive elements in the ground of the Earth. The increasing ionization rates at heights above the ground could be interpreted as the absorption of ionizing radiation by the air [10]. With the invention of electrometers by Theodor Wulf [11] in 1910, which made it possible for accurate measurements of the radioactivity underwater and at higher altitude.

In 1912 Domenico Pacini [12] concluded atmospheric radiation must be due to sources other than the radioactivity of the Earth based on the observation of less radioactivity underwater 3 meters from the surface than ionization over lake or over the sea. In 1912 Victor Hess [13] found that the ionization to an altitude of 5300 meters increased to twice the rate at ground level, which enabled him to draw the conclusion that radiation levels *increased* with altitude and radiation of very high penetrating power enters from high above extraterrestrial space into our atmosphere. In 1913-1914, Werner Kolhöster [14,15] confirmed Hess's conclusion by measuring the ionization rate at an altitude of 9 km.

Cosmic rays are high-energy particles. According to the current theoretical explanation, of primary cosmic rays originating from outside the Solar system [16] in the

Milky Way [17] and from distant galaxies [18], 99% are the bare nuclei of Hydrogen atoms and Helium atoms [19], about 1% are electrons. Of the nuclei, about 90% are simple protons (Hydrogen nuclei) while 9% are alpha particles(Helium Nuclei). A very small portion are stable anti-particles such as positrons and antiprotons. Of secondary cosmic rays, are the Pions produced by primary cosmic particles colliding with the molecules in the atmosphere [20].

If gravity is attractive, the expansion of the universe should be slowing down. However, in the late 1990s, astronomers found the opposite. The two Supernova Search teams, Type Ia Supernova [21] and Supernova Cosmology Project [22] noticed that the distant galaxies were moving away faster than they should be or were accelerating [23]. In cosmology and astronomy, Dark Energy is a proposed form of energy causing this acceleration. It acts like a repulsive force inherent to the vacuum of space itself. It drives the accelerating expansion of the universe and slows the rate of structure formation [24].

The evidence for dark energy is not direct, but comes from the three independent sources: distance measurements and their relation to redshift, the theoretical need for some type of additional energy to form the observational flat universe, and the measurements of large-scale wave patterns of mass density in the universe. If the Lambda-CDM model [25] is correct, Dark energy will dominate the universe, contributing 68% of the total energy in the present observable universe while dark matter and ordinary matter contribute 27% and 5% respectively [26,27,28]. Up to now, the exact nature of dark energy is still a mystery. It remains in the realm of speculation and exploration.

It seems these three major pillars are totally different physical realms, there is nothing to do with one another. Our present work will apply the similar Higgs interaction effect to the two photons to correlate the mass generation, the source of cosmic rays, and dark energy based on the hypothesis of the photon as an electrical dipole.

2. Theory Deduction

2.1. Mass Generation through Higgs Effect

Recently we developed a theory that the photon is an electrical dipole, the trajectory of its electrical spinvector tip in combined motions is an electromagnetic wave [29], and its four wave components of the dipole satisfy the Dirac equation [30]. The spinvector is defined as a vector in rotation and in translation with its translational direction perpendicular to its rotating axis. The spinvector is illustrated as Figure 1, the negative pole as a black dot and the positive pole as red dot.

For each pole of the photon, there are two rotational directions, clockwise (right) or counterclockwise direction(left). If we assume the wave on z axis and define the wave function of the negative pole as positive ψ, then the wave function of the positive pole must be negative ψ, because the phase difference between two poles is π. The four-wave components of the photon are illustrated and Figure 2, the wave in black represents the negative pole in clockwise rotation (ψ_{+R}), and the wave in green as its rotation in counterclockwise direction (ψ_{+L}); while the wave in red as the positive pole in clockwise rotation(ψ_{-R}), and the wave in blue as its rotation in counterclockwise direction (ψ_{-L}).

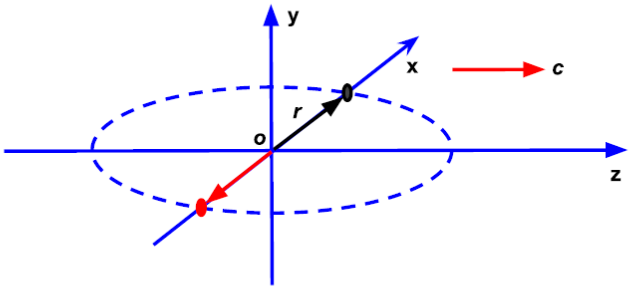

Figure 1. The photon as a dipole in combined motions

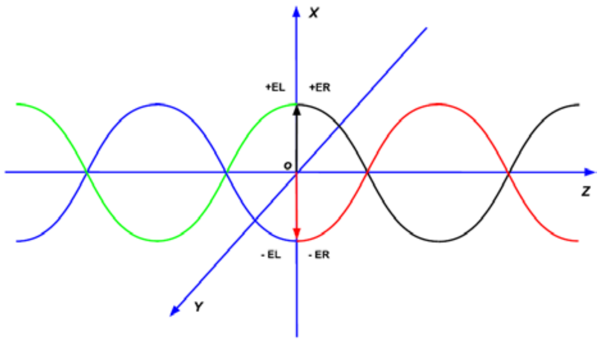

Figure 2. The four-wave components of the photon as a dipole in combined motions

According to Higgs field theory of mass generation, two real scalar field φ_1, φ_2 of spin-one particles and a real vector field A_μ interact to generate mass. Herewith we will apply Higgs field theory to two force-carrying photons. Their field ϕ_1, ϕ_2 interact through the electromagnetic vector field A_μ. The Lagrangian density of the interactions between them will be described as:

$$\mathcal{L} = \frac{1}{2}(\mathcal{D}\phi_1)^2 + \frac{1}{2}(\mathcal{D}\phi_2)^2 - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} - V\left(\phi_1^2 + \phi_2^2\right) \quad \text{Eq. 1.}$$

Where

$$\mathcal{D}_\mu\phi_1 = \partial_\mu\phi_1 - gA_\mu\phi_2$$

$$\mathcal{D}_\mu\phi_2 = \partial_\mu\phi_2 - gA_\mu\phi_1$$

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

g is a dimensionless coupling constant. $\mathcal{L}$ is invariant under simultaneous gauge transformations of the first kind on $\phi_1 \pm i\ \phi_2$ and of the second kind on A_μ. Suppose that $V'\left(\phi_0^2\right) = 0$, and $V''\left(\phi_0^2\right) > 0$; then spontaneous breakdown of U(1) symmetry occurs. If we treat $\Delta\phi_1$, $\Delta\phi_2$ and A_μ as small quantities, the further equations are derived from Equation 1 for the vacuum expectation solution when $\phi_1(x)=0$, $\phi_2(x)=\phi_0$:

$$\partial^{\mu}\left[\partial_{\mu}(\Delta\phi_1)-g\phi_0A_{\mu}\right]=0 \qquad \text{Eq. 2.}$$

$$\partial_{\nu}F^{\mu\nu}=g\phi_0\left[\partial^{\mu}(\Delta\phi_1)-g\phi_0A_{\mu}\right] \qquad \text{Eq. 3.}$$

$$[\partial^2-4\phi_0^2V''(\phi_0^2)](\Delta\phi_2)=0 \qquad \text{Eq. 4.}$$

Equation 4 describes scalar waves whose quanta have mass $2\phi_0\left[V''(\phi_0^2)\right]^{1/2}$.

With the introduction of new variables,

$B_{\mu}=A_{\mu}-(g\phi_0)^{-1}\partial_{\mu}(\Delta\phi_1)$

$G_{\mu\nu}=\partial_{\mu}B_{\nu}-\partial_{\nu}B_{\mu}=F_{\mu\nu}$

Equation 2 and 3 will be transformed into Equation 5,

$\partial_{\mu}B^{\mu}=0$; $\partial_{\nu}G^{\mu\nu}+g^2\phi_0^2B^{\mu}=0$. Eq. 5.

The Equation 5 describes the vector waves whose quanta have mass $g\phi_0$.

In our previous work [30,31], we struggled about the photons' motion mode to bond together as a photon molecule. Now we will visualize the mass generation process based on the chemical bond mechanism and force analysis to explain the reaction process between two photons. Figure 3 describes a side by side mode when two photons approach together with zero phase difference, so with net repulsive forces (both electric and magnetic).

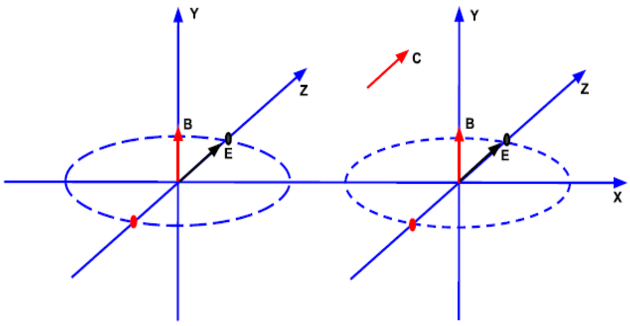

Figure 3. Two photons approaching as side by side mode with net repulsive force

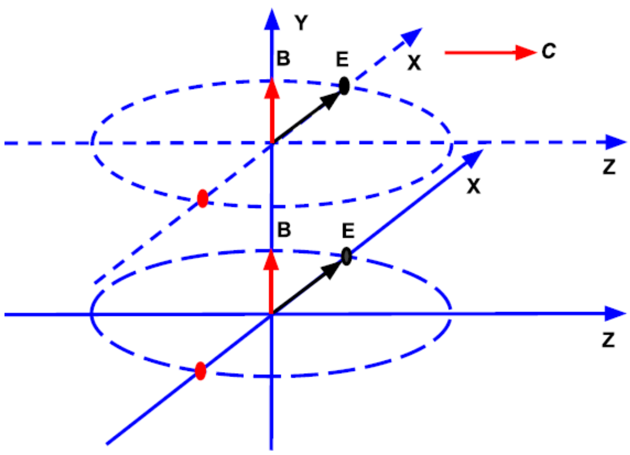

Figure 4. Two photons approaching as head to tail mode with net repulsive force

Figure 4 describes a head to tail mode when two photons approach together with zero phase difference, thus with net repulsive forces (repulsive electric force but attractive magnetic force). Either of these approaching modes will not bond the two photons together.

While Figure 5 describes a side by side mode when two photons approach together with π phase difference, so with net attractive forces (both electric and magnetic). The attractive action is similar to chemical π bond.

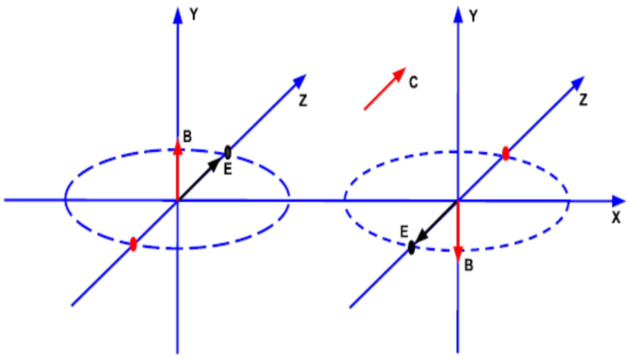

Figure 5. Two photons approaching as side by side mode with π bond

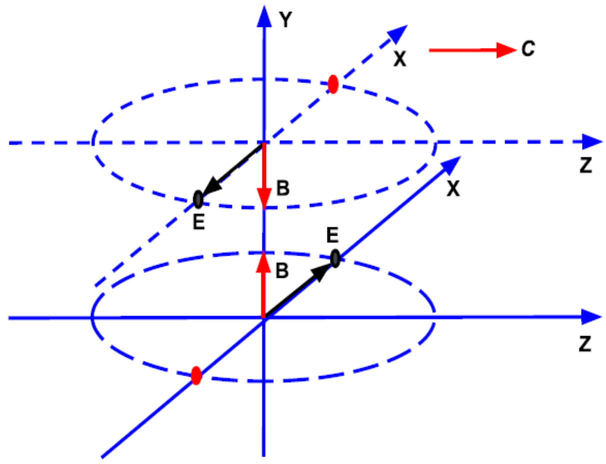

Figure 6. Two photons approaching as head to tail mode with σ bond

And Figure 6 describes a head to tail mode when two photons approach together with π phase difference, therefore with net attractive forces (strong electric attractive and weak magnetic repulsive). The attractive action is similar to chemical σ bond. Both of these approaching modes will bond the two photons as a quadrupole or a photon molecule.

For the σ bond quadrupole, the attractive electric force and the repulsive magnetic force are constant when the two dipoles are balanced at some distance, as a consequence the net bond force is a constant force as long as the two photons rotate in the same direction. However for the π bond quadrupole, the magnitude of attractive electric force is varying due to the rotation of the photons, therefore the magnitude of attractive magnetic force varies as the electric force changes. And the net bond force forms a periodically vibrating force. In order to simplify the illustration, we will describe the σ bond quadrupole as Figure 7, and describe the π bond quadrupole as Figure 8, both of them are with a disk-like structure (shape).

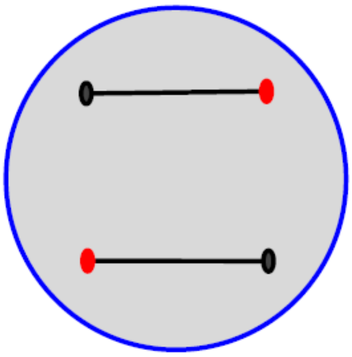

Figure 7. σ bond quadrupole

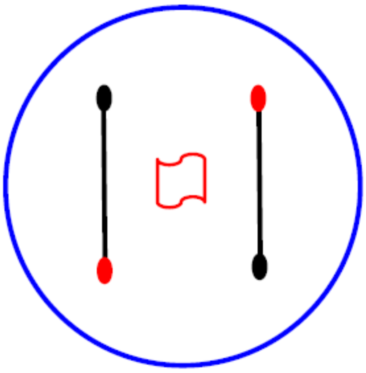

Figure 8. π bond quadrupole

According to classical physics, the two photons are bonded together with an attractive force no matter as σ bond or as π bond, therefore the system(two photons) increases the potential energy (V) between them. Due to the energy conservation, the system has to decrease the kinetic energy to conserve the constant total energy as Equation 6. As a consequence, the system must decrease the motion speed from c to v as the mass generation. If we assume the motion mass of the photon as m_p, based on our previous work the total kinetic energy of the photon is the sum of its translational kinetic energy and its rotational kinetic energy, then the total rest mass (m) of the disk generated from the two photons through the bonding mechanism still in translation and rotation will be expressed as Equation 7, the net acquired mass as Equation 8.

$$2m_p c^2 = \left(\frac{1}{2}mv^2 + \frac{1}{4}mv^2\right) + V \qquad \text{Eq. 6}$$

$$m = \frac{8m_p c^2 - 4V}{3v^2} \qquad \text{Eq. 7}$$

$$\Delta m = m - 2m_p = \frac{8m_p c^2 - 6m_p v^2 - 4V}{3v^2} \qquad \text{Eq. 8}$$

2.2. The Source of Cosmic Rays

Based on the force analysis, we realize that the π bond quadrupole is relatively unstable compared to the σ bond quadrupole. It is vulnerable to collide or attack by the surrounding photons. The proposed collision results will be illustrated as Figure 9 and Equation 9 to form Proton and Neutron, the massless photon with dot-line circle, the massive particles with solid-line circle. The positive charges of the Proton are exposed to outside, and the negative charges of the neutron are embedded into its mass body.

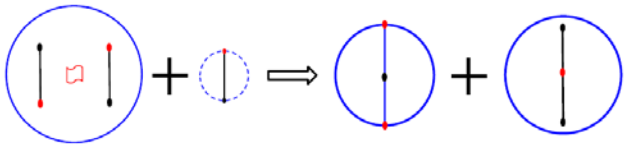

Figure 9. The collision of π bond quadrupole with Photon

$$Quadrupole + Dipole = Proton + Neutron \qquad \text{Eq. 9}$$

The Neutron would be further collided by surrounding photons to form one Proton, two Electrons and one electron neutrino as Figure 10 and Equation 10.

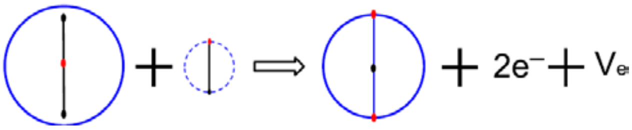

Figure 10. The collision of Neutron with Photon

$$Neutron + Dipole = Proton + 2Electron + Neutrino \qquad \text{Eq. 10}$$

And the unstable π bond quadrupole would decompose to form Proton and Antiproton as described as Figure 11/Equation 11 and Figure 12/Equation 12.

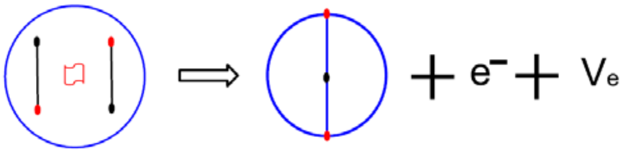

Figure 11. The π bond quadrupole decomposes into Proton

$$Quadrupole = Proton + Electron + Electron\ Neutrino \qquad \text{Eq. 11}$$

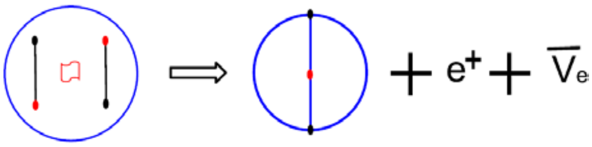

Figure 12. The π bond quadrupole decomposes into Antiproton

$$Quadrupole = Antiproton + Positron + Positron\ Neutrino \qquad \text{Eq. 12}$$

$$e^+ + e^- = \gamma \qquad \text{Eq. 13}$$

$$2Proton(P) + 2Neutron(N) = \alpha\ Particle \qquad \text{Eq. 14}$$

All the above Figures and Equations will elucidate and interpret the composition of the Primary Cosmic rays. But we need to explain something about the structure of Proton and Neutron. From the perspective of static electrical theory, our proposed structure of the Proton is equivalent to the classical Proton as Figure 13, but with diametric electric vectors corresponding to four-wave components of the Dirac Equation.

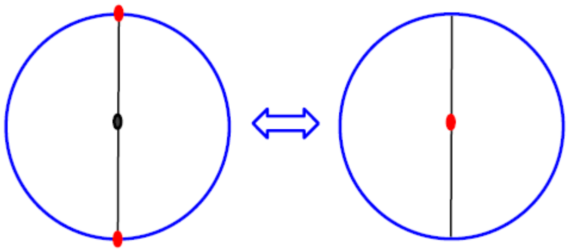

Figure 13. The proposed structure of the Proton

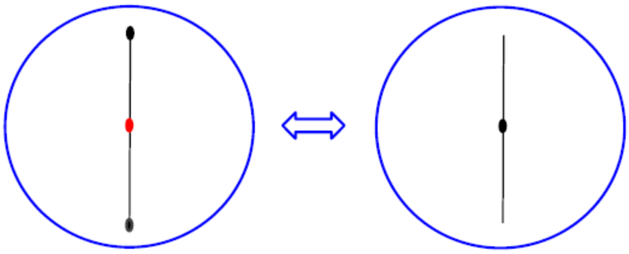

Figure 14. The proposed structure of the Neutron

For our proposed structure of the Neutron as Figure 14, because the electric charge is embedded in the mass, and the mass body shall be electrically insulative, which will explain why the neutron doesn't show electric property but has magnetic moment in rotation and has diametric electric vectors corresponding to four-wave components of the Dirac Equation.

As to the Electron and Positron, we suppose they all have the same structure of diametric vectors as Proton and Neutron as Figure 15 due to some unknown mechanism, corresponding to four-wave components of the Dirac Equation.

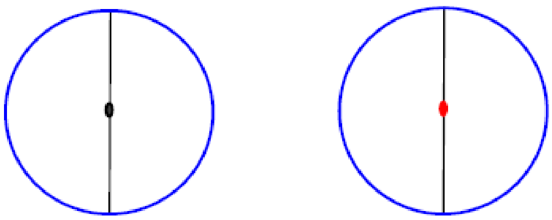

Figure 15. The structure of Electron and Positron with diametric vectors

2.3. The Candidate of Dark Matter and Dark Energy

One of the candidate of the dark matter is the σ bond quadrupole. It has constant bond force and its mass is denser and more uniform than the π bond quadrupole. Another candidate of the dark matter is a kind of condensed π bond quadrupole. We suppose the mass density of π bond quadrupole depends on the initial distance between the photons, the farther the sparser mass density, the closer the higher density. The mass body becomes denser and stickier as the distance changes just like the phase change (condensation process) of the matter from vapor to liquid and to solid. When the mass body turns too dense or sticky enough, it prevents the electric charges from moving closer or rotating within the mass body, finally the condensed quadrupole turns into dark matter as Figure 16 and loses both the electric and the magnetic properties.

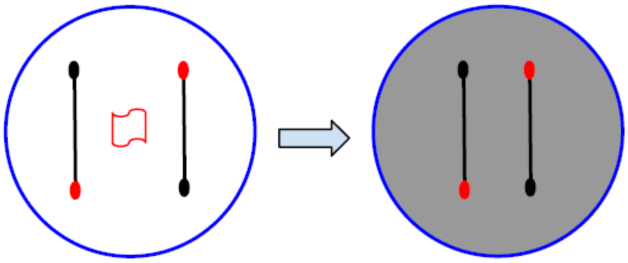

Figure 16. The quadrupole turns into dark matter

When we check the formation of π bond quadrupole, we realize that in another scenario if the initial distance is very much close while the attractive force is strong enough, there is a high chance for the photons to annihilate charges into some kind of energy as Figure 17 and lose the interaction capability with electromagnetism. If that is the case, we believe this energy is the dark energy we are looking for in the universe.

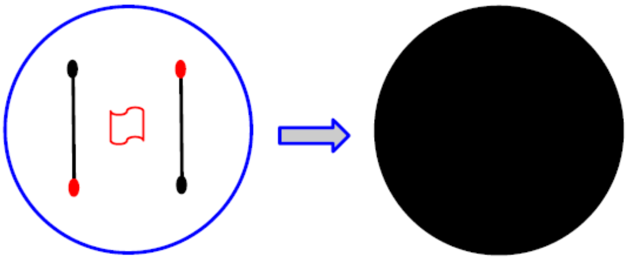

Figure 17. The annihilation of the photons into dark energy

3. Discussions

The bonding process of quadrupole formation and the subsequent generation of protons and neutrons suggest that fractionally charged quarks and antiquarks do not exist independently. Instead, quarks and antiquarks appear to carry a single integer charge, appearing primarily as fragmented products of protons or neutrons.

Dark matter is an invisible, hypothetical form of matter that does not interact with light or any other form of electromagnetic radiation. Its existence is inferred from robust observational evidence, including galaxy rotation curves [32], galaxy clusters [33], and gravitational lensing [34].

Current theoretical frameworks classify dark matter into three primary categories based on its velocity and thermal history: cold, warm, and hot [35]. Regarding its composition, numerous hypotheses exist. Potential candidates include light bosons—such as QCD axions or axion-like particles—as well as neutrinos, supersymmetric particles, or Weakly Interacting Massive Particles (WIMPs) [36,37]. Our proposed candidates, the σ-bond quadrupole and condensed π-bond quadrupole, are based on the bonding processes of photons, aligning with current wave-like coupling axions [38] or "dark photon" hypotheses.

Up to now whether observing atmospheric lightning discharges or electron-positron annihilation, the resulting products—such as lightning or gamma radiation—manifest as electric dipoles. This suggests that while mass is annihilated in these processes, the electric charge persists. Conversely, in photon annihilation, it is the electric charge itself that is annihilated. Consequently, we propose defining the energy released from the annihilation of charges (photons) as "dark energy", while the energy derived from mass annihilation constitutes "normal matter energy" with the photon serving as the primary product.

In particle physics, the photon is defined as having zero charge. However, our model proposes that the photon is an electric dipole. Under this framework, Equation 13 remains consistent with the principle of charge conservation. Consequently, the standard Feynman diagram [39] for electron-positron annihilation must be modified to reflect this feature of dipole structure, rather than the simple creation of a neutral gauge boson.

Building on the hypothesis of the photon as an electric dipole, our previous work [30] derived the total kinetic energy ($E_{TK} = m_p c^2$) as the sum of translational and rotational kinetic energy through classical kinematics. This aligns with Simulik's application [40] of the massless Dirac equation and with Simulik-Bondar's derivation [41] of the formula for a photon mass in media which is partially based on Schwinger's derivation [42] of $E = mc^2$ from Maxwell's equations in a vacuum. While Einstein's special relativity defines the energy of a static object as Equation 15:

$$E = mc^2 \quad \text{. Eq. 15}$$

We integrate Planck's principle of quantization by proposing that the photon itself is the basic energy quantum. Given that energy is a scalar with additive properties, the energy of any macroscopic object can be viewed as the accumulation of vast quantities of photons—analogous to how raindrops converge into streams and eventually oceans. By representing an object's mass as m_o and a photon's motion mass as m_p, we arrive at Equation 16:

$$E = m_o c^2 = N m_p c^2$$

$$m_o = N m_p \quad \text{Eq. 16}$$

This suggests that mass is quantized, with the photon's motion mass serving as the fundamental quantum. Consequently, an object's mass measures the number of photons it contains, implying that fundamental particles like protons, neutrons, and electrons are ultimately decomposed from quadrupoles formed through photon interactions, or that the photon(dipole) is the precursor to the quadrupole formation, creating a clear hierarchy as below:

$$\begin{aligned} &Photon(Dipole) \\ &\rightarrow Quadrupole(Photon\ Molecule) \\ &\rightarrow Matter(Fundamental\ particles) \end{aligned}$$

4. Conclusion

Based on the exploration of the chemical bonding processes between two photons, it becomes evident that applying the Higgs effect to photon-photon interactions via electromagnetic forces provides a compelling theoretical framework to the mass generation. The formation of a π -bond quadrupole facilitates the transition of energy into fundamental particles with mass, a mechanism that offers a novel explanation for the origin of cosmic rays within our solar system and identifies the π -bond quadrupole as the high potential physical identity of the Higgs particle.

This proposed internal configuration for protons and neutrons aligns with current empirical observations in particle physics, while simultaneously necessitating a critical re-evaluation of the existence of fractionally charged quarks and antiquarks. Furthermore, the integration of dark matter and dark energy into this model provides a directed pathway for cosmological exploration, potentially resolving Olbers' Paradox (the dark night sky instead of a bright night sky). Ultimately, mass generation through photon interaction leads to the fundamental conclusion that mass is quantized, echoing the established quantization of energy.

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