

On the Motions of the Photon as an Electric Dipole and the Exploration of the Origin of Mass and Gravitation-Spinvector Motion III

Zhonglin BO*

DuPont China Technical Center, 600 Cailun Road, Shanghai 201203, P.R. China

*Corresponding author: bill.b.bo@dupont.com

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Abstract In this research we propose a special motion of the photon as an electric dipole, a rotating vector in uniform linear motion termed as a “spinvector”. This proposal accounts for the intrinsic particle-wave duality of the photon. The unique kinematics of the photon explained by this spinvector can comprehensively address all aspects of electromagnetic wave theory, including various phenomena such as different light polarizations and the redshift of light when subjected to an external magnetic field, either along the wave direction or perpendicular to the oscillation direction of its electric field. Furthermore, this work provides a direct explanation for the Faraday effect as the result of the Lorentz force from an external magnetic field along the wave's propagation direction. Exploring the theory of the spinvector in motion suggests potential reactions where photons could form molecular structures or polymers. Additionally, we propose the graviton as a special photon, with one of its electric poles serving as the rotation center.

Keywords: photon, particle-wave duality, electromagnetic wave, polarization, spinvector motion, graviton, gravitation, mass origin, red-shift, spinvector mechanics

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1. Introduction

In physics the term of light means electromagnetic radiation of any wavelength, no matter visible or not [1,2]. According to this definition, gamma rays, X-rays, microwaves, and radio waves are the primary types of light in physical science. The main properties of light are intensity, propagation speed, wave frequency or spectrum and polarization. The speed of light in vacuum has the same value c , about 3×10^8 m/s, it is one of the fundamental constants of nature [3]. As electromagnetic radiation, light propagates by massless elementary particles named as photons which represents the quanta of electromagnetic field and can be analyzed as both waves and particles. The study of light is one of the most important research areas in modern physics.

The first wave theory of light was proposed by René Descartes in 1637 [4], he published a theory of the refraction of light by analogy with the behavior of sound waves. He assumed that light behaved like a wave and concluded that refraction could be explained by the speed of light in different media.

The particle theory of light could be traced back to Isaac Newton. In 1675 he postulated that light was composed of particles which were emitted in all directions from a source. One of Newton's arguments against the

Descartes' wave nature of light was that light travelled only in straight lines, while waves were known to always bend around obstacles. Newton's theory could explain the reflection of light but could only explain refraction with the assumption that light accelerated upon entering a denser medium due to the greater gravitational pull. In 1704 Newton published his final theory in his *Optics*. His scientific reputation helped the particle theory of light to prevail during the eighteenth century.

In 1678 Christiaan Huygens [5] worked out a mathematical wave theory of light. Then in 1690 he published his wave theory in his *Treatise on Light* and proposed that light was emitted in all directions as a series of waves. The wave theory predicted that light waves could interfere with each other like sound waves which was proved by Thomas Young with famous double-slit interference experiment. Young also proposed that different colors were caused by different wavelengths of light and explained color vision in terms of three-colored receptors in the eye. In 1816 André-Marie Ampère supported Augustin-Jean Fresnel to form an idea that the polarization of light can be explained by the wave theory if light were a transverse wave [6].

In 1845 Michael Faraday discovered that the plane of polarization of linearly polarized light is rotated when the light rays travel along the magnetic field direction in the presence of a transparent dielectric, an effect now known as Faraday effect [7].

Faraday's work inspired James Clerk Maxwell to study electromagnetic radiation and light. Maxwell discovered that self-propagating electromagnetic waves would travel through space at a constant speed, which happened to be equal to the previously measured speed of light. From this, Maxwell concluded that light was a form of electromagnetic radiation. In 1873, he published *A Treatise on Electricity and Magnetism*, which contained a full mathematical description of the behavior of electric and magnetic fields, still known as Maxwell's equations[8].

In 1900 When Max Planck attempting to explain black-body radiation, suggested that although light was a wave, these waves could gain or lose energy only in finite amounts related to their frequency. Planck called these "lumps" of light energy "quanta". In 1905, Albert Einstein used the idea of light quanta to explain the photoelectric effect and suggested that these light quanta had a "real" existence. In 1923 Arthur Holly Compton showed that the wavelength shift seen when low intensity X-rays scattered from electrons (so called Compton scattering) could be explained by a particle-theory of X-rays, but not a wave theory. In 1926 Gilbert N. Lewis named these light quanta particles, the photons [9,10].

Based on the further great work of Max Planck, Albert Einstein, Louis de Broglie, Niels Bohr, Erwin Schrodinger and many other physicists, current Quantum Mechanics theory holds that all particles such as photons, electrons, and atoms [11,12] exhibit a particle-wave nature of duality.

Although the use of the wave-particle duality has worked astonishingly well in modern physics, the unquestionable meaning or undisputable interpretation of intrinsic duality has not been satisfactorily resolved, especially on why the photon as a particle behaves the property of a wave, on why the photon propagates as an electromagnetic wave and on how the photon is impacted by the external magnetic field.

We try to explain these phenomena with our theory of spinvector in motion, the special kinematics, or dynamics of the photon as an electric dipole, and to explore the other intrinsic natures of the photon.

2. Theory Deduction

2.1. Particle-Wave Duality

From pure mathematic and classical physics point of view, we all know that a wave motion is a combination of an oscillation or a vibration and a uniform linear motion, the direction of the oscillation is perpendicular to the direction of its linear motion. And according to the classical wave theory, an oscillation or a vibration can be treated as a rotation of a vector [13]. In other words, an oscillation moving in uniform linear motion perpendicular to its oscillation will produce a wave, equivalently a rotating vector in uniform linear motion will form a wave. Typically a rotating vector is generated by the spin of an object, to make it simple we just call this rotating vector a spinvector. The feature of spinvector in motion and the trajectory of its vector head are illustrated in Figure 1 and 2.

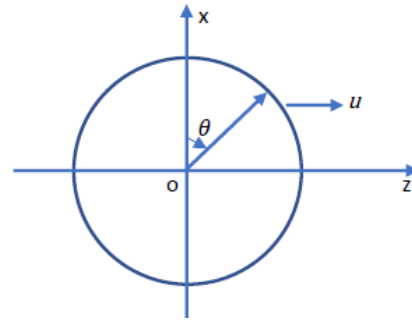


Figure 1. A spinvector in uniform linear motion

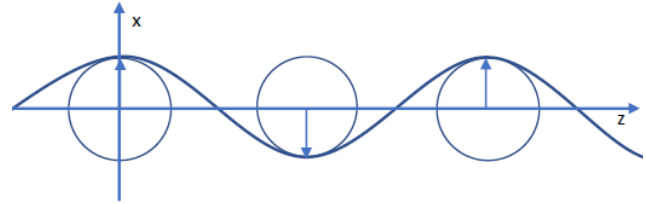


Figure 2. The trajectory of the vector head of a spinvector in motion

The wave equation of a spinvector in uniform linear motion will follow the classical wave Equation 1, if the spinvector rotates with y axis as a rotating axis and the wave propagandas in z axis direction, ψ, x as the wave function, A as the wave amplitude, ω as the rotation angular frequency of the spinvector, and u as the wave speed.

$$\psi = x = A \cos\left(\frac{\omega z}{u} - \omega t\right) \quad \text{Eq. 1}$$

Suppose a photon is a mechanic particle, an electric dipole consisting of a positive charge, a negative charge, and supposing a virtual, massless, and electrically insulating string connecting the two different charges, if the dipole is on the x axis with its middle of the string located on the origin of the coordinate as Figure 3.

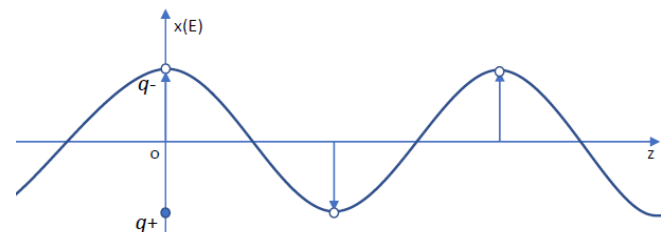


Figure 3. The trajectory of the vector head of a spinvector of the photon

If the dipole spins with y axis as a rotating axis while traveling in a uniform linear motion at speed of $u = c$ along the z axis, and if we only take the negative electric pole into consideration, negative pole as a massless mass-point and a vector head, then the wave equation of the spinvector of the negative pole of the dipole will be as Equation 2:

$$\psi = A \cos\left(\frac{\omega z}{c} - \omega t\right) \quad \text{Eq. 2}$$

$$\frac{\partial \psi}{\partial z} = -\frac{A\omega}{c} \sin\left(\frac{\omega z}{c} - \omega t\right)$$

$$\frac{\partial^2 \psi}{\partial z^2} = -\frac{A\omega^2}{c^2} \cos\left(\frac{\omega z}{c} - \omega t\right)$$

$$\frac{\partial^2 \psi}{\partial t^2} = -A\omega^2 \cos\left(\frac{\omega z}{c} - \omega t\right)$$

$$\frac{\partial^2 \psi}{\partial z^2} = \frac{1}{c^2} \frac{\partial^2 \psi}{\partial t^2}$$

$$\frac{\partial^2 \psi}{\partial z^2} - \frac{1}{c^2} \frac{\partial^2 \psi}{\partial t^2} = 0 \quad \text{Eq. 3}$$

Equation 3 is the typical equation of the light plane wave. It means that if a spinvector travels at uniform linear speed of c , the trajectory of the vector head of the dipole(photon) is just the light wave. Or each spinvector of the photon shall have the same wave features as the photon's.

According to Einstein's special relativity[14], a photon's energy follows the Equation 4, where m_0 is the rest mass of the photon, p is its momentum. While according to Einstein and Planck[15], a photon's energy follows the Equation 5, where h is the Planck constant, ν is its wave frequency.

$$E^2 = p^2 c^2 + m_0^2 c^4 \quad \text{Eq. 4}$$

$$E = h\nu \quad \text{Eq. 5}$$

Due to $m_0 = 0$, then from special relativity, the photon has momentum even though there is zero mass at rest.

$$E = pc = p \frac{\lambda}{T} = h\nu = \frac{h}{T}$$

$$p = \frac{h}{\lambda}$$

The photon momentum demonstrates that it has a relativistic mass as m_r

$$m_r = \frac{h\nu}{c^2} = \frac{h}{c\lambda} = \frac{h}{Tc^2}$$

Therefore, we can conclude that the positive charge and the negative charge of the dipole shall have half relativistic mass m_r or m too of the photon's relativistic mass during photon's motion, and because their wave motions have the same wave features as the photon's, such as: wavelength, wave frequency, and wave speed. Then the original Equation 2 for the negative pole of the photon can be modified as below:

$$\psi = A \cos\left(\frac{2\pi z}{Tc} - \frac{2\pi}{T} t\right) = A \cos\left(\frac{2\pi z}{\lambda} - \frac{2\pi}{T} t\right)$$

$$\psi = A \cos\left(\frac{2\pi pz}{h} - \frac{2\pi E}{h} t\right) = A \cos\left(\frac{pz - Et}{\hbar}\right)$$

Since in physics, we typically use exponent form to describe the wave motion. Thus

$$\psi = Ae^{\frac{i}{\hbar}(px - Et)}$$

$$-\hbar^2 \frac{\partial^2 \psi}{\partial x^2} = p^2 \psi ; i\hbar \frac{\partial \psi}{\partial t} = E\psi$$

Because there is electric potential energy existing between the positive pole and negative pole, the total energy for each pole will be:

$$E = KE + PE = \frac{p^2}{2m} + V$$

$$E\psi = \frac{p^2 \psi}{2m} + V\psi = -\frac{\hbar^2 \partial^2 \psi}{2m \partial x^2} + V\psi$$

$$\left(-\frac{\hbar^2 \partial^2 \psi}{2m \partial x^2}\right) + V\psi = E\psi$$

Finally, the spinvector of the photon shall have same wave equation as Schrodinger Equation as follows:

$$\hat{H}\psi = E\psi = i\hbar \frac{\partial \psi}{\partial t} \quad \text{Eq. 6}$$

where m is the relativistic mass of one of the photon's electric charge, V is its potential energy, $\hat{H}$ is the Hamiltonian operator.

The Equation 3 and 6 will explain why the photon's motion behaves as wave and why the photon has the particle-wave duality because of its spinvector in motion.

2.2. Electromagnetic Wave

Now let's take the electric property of the dipole into consideration, initially the dipole is on the x axis with its center located at the origin of the coordinate, and the distance between two poles is $d = 2r$, when at rest the electric field at the middle point of the dipole is E_{x0} as Figure 4(a).

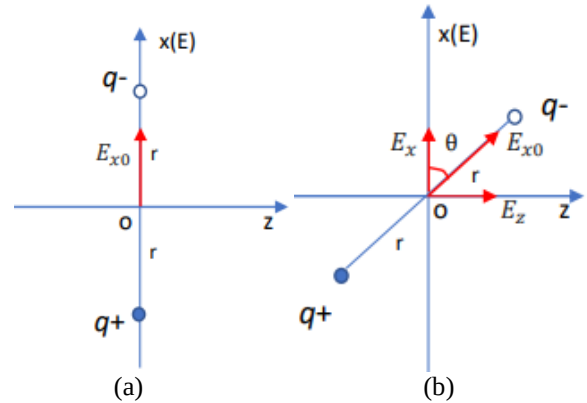


Figure 4. The electric field at the center of the dipole

Each of the positive charge and negative charge equally contributes to the total electric field with the electric field vector points to the $x+$ direction.

$$\begin{aligned} E_{x0} &= E_{(-)} + E_{(+)} \\ &= \frac{q}{4\pi\epsilon_0 r^2} + \frac{q}{4\pi\epsilon_0 r^2} = \frac{2q}{\pi\epsilon_0 d^2} \end{aligned}$$

If the dipole rotates with axis y as the rotation axis in clockwise direction. Its total magnitude of the electric

field will not change, just keep as E_{x0} during the dipole's rotation, but the electric field vector is rotating during the dipole's rotation. When the constant electric vector rotates, it looks like the electric field oscillates on the x axis, with its component on x axis varying as the rotation angle changing as Figure 4(b) and as Equation 7.

$$E_x = \frac{2q\cos\theta}{\pi\epsilon_0 d^2} = E_{x0}\cos\theta \quad \text{Eq. 7}$$

If we keep the dipole rotating while moving in a linear uniform way at speed c along the z axis. The electric field wave along z axis will be generated as Equation 8.

$$E_x = E_{x0} \cos\left(\frac{\omega z}{c} - \omega t\right) \quad \text{Eq. 8}$$

Since we only focus on the vibration of the electric field on the x axis direction, and we are only interested in the electric wave due to the vibration in linear uniform motion. We will assign the magnitude of the electric field on the x axis as the total electric field interested. And if we consider the magnitude relationship between electric field and magnetic field, $E = cB$ [16], in electromagnetic wave theory, and because they always oscillate in perpendicular directions. Then the magnetic wave equation induced by the motion of the electric vector of the dipole will be as Equation 9, B_{y0} as the amplitude of the magnetic wave:

$$\begin{aligned} \frac{E_x}{c} &= \frac{E_{x0}}{c} \cos\left(\frac{\omega z}{c} - \omega t\right) \\ B_y &= B_{y0} \cos\left(\frac{\omega z}{c} - \omega t\right) \\ E &= E_x i + E_y j + E_z k = E_x i \\ B &= B_x i + B_y j + B_z k = B_y j \end{aligned} \quad \text{Eq. 9}$$

Thus

$$\begin{aligned} \frac{\partial E_x}{\partial z} &= -\frac{E_{x0}\omega}{c} \sin\left(\frac{\omega z}{c} - \omega t\right) \\ \frac{\partial B_y}{\partial z} &= -\frac{B_{y0}\omega}{c} \sin\left(\frac{\omega z}{c} - \omega t\right) \\ \frac{\partial E_x}{\partial t} &= E_{x0}\omega \sin\left(\frac{\omega z}{c} - \omega t\right) \\ \frac{\partial B_y}{\partial t} &= B_{y0}\omega \sin\left(\frac{\omega z}{c} - \omega t\right) \\ \frac{\partial^2 E_x}{\partial z^2} &= -\frac{E_{x0}\omega^2}{c^2} \cos\left(\frac{\omega z}{c} - \omega t\right) \\ \frac{\partial^2 B_y}{\partial z^2} &= -\frac{B_{y0}\omega^2}{c^2} \cos\left(\frac{\omega z}{c} - \omega t\right) \end{aligned}$$

$$\begin{aligned} \frac{\partial^2 E_x}{\partial t^2} &= -E_{x0}\omega^2 \cos\left(\frac{\omega z}{c} - \omega t\right) \\ \frac{\partial^2 B_y}{\partial t^2} &= -B_{y0}\omega^2 \cos\left(\frac{\omega z}{c} - \omega t\right) \end{aligned}$$

$$\frac{\partial^2 E_x}{\partial z^2} = \frac{1}{c^2} \frac{\partial^2 E_x}{\partial t^2}; \quad \frac{\partial^2 B_y}{\partial z^2} = \frac{1}{c^2} \frac{\partial^2 B_y}{\partial t^2}$$

$$\frac{\partial^2 E_x}{\partial z^2} - \frac{1}{c^2} \frac{\partial^2 E_x}{\partial t^2} = 0; \quad \frac{\partial^2 B_y}{\partial z^2} - \frac{1}{c^2} \frac{\partial^2 B_y}{\partial t^2} = 0 \quad \text{Eq. 10}$$

$$\frac{\partial E_x}{\partial z} = -\frac{1}{c} \frac{\partial E_x}{\partial t}; \quad \frac{\partial B_y}{\partial z} = -\frac{1}{c} \frac{\partial B_y}{\partial t}$$

$$\frac{\partial E_x}{\partial z} = -\frac{\partial B_y}{\partial t}; \quad \frac{\partial B_y}{\partial z} = -\frac{1}{c^2} \frac{\partial E_x}{\partial t}$$

If we take the divergence and curl for the electric field [17]

$$\begin{aligned} \nabla \cdot E &= \frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} + \frac{\partial E_z}{\partial z} \\ &= 0 + 0 + 0 = 0 \end{aligned}$$

$$\nabla \times E = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ E_x & E_y & E_z \end{vmatrix} = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ E_x & 0 & 0 \end{vmatrix}$$

$$\nabla \times E = \frac{\partial E_x}{\partial z} j$$

We can deduct the Equation 11 and 12 for the electric field during photon's spinvector in motion.

$$\nabla \cdot E = 0 \quad \text{Eq. 11}$$

$$\nabla \times E = \frac{\partial E_x}{\partial z} = -\frac{\partial B_y}{\partial t}$$

$$\nabla \times E = -\frac{\partial B}{\partial t} \quad \text{Eq. 12}$$

Similarly, if we take the divergence and curl for the magnetic field, we can get the Equation 13 and 14 for the magnetic field during the electric spinvector in motion.

$$\nabla \cdot B = \frac{\partial B_x}{\partial x} + \frac{\partial B_y}{\partial y} + \frac{\partial B_z}{\partial z} = 0$$

$$\nabla \cdot B = 0 \quad \text{Eq. 13}$$

$$\nabla \times B = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ B_x & B_y & B_z \end{vmatrix} = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 0 & B_y & 0 \end{vmatrix}$$

$$\nabla \times B = -\frac{\partial B_y}{\partial z} i$$

$$\nabla \times B = -\frac{\partial B_y}{\partial z} = \frac{1}{c^2} \frac{\partial E_x}{\partial t}$$

$$c^2 \nabla \times B = \frac{\partial E}{\partial t} \quad \text{Eq. 14}$$

Equation 10 indicates that both electric field and magnetic field during the dipole's motion have same form as Equation 3 of the light's plane wave. Equations 11-14 are the Maxwell's four Equations in full alignment with the electromagnetic wave theory for the photon traveling in vacuum. And the typical electromagnetic wave is illustrated as Figure 5 [18].

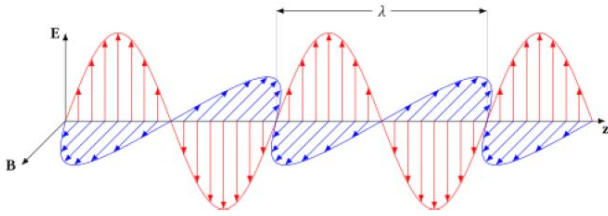


Figure 5. Typical electromagnetic waves of the spinvector of the photon

If we take the total electric field for the components on both x axis and z axis into account, then the magnetic field will still be on y axis as the only one component, because the electric field is on the rotating plane xoz , and the magnetic field is always perpendicular to the electric field.

$$E = E_x i + E_y j + E_z k = E_x i + E_z k = E_{x0}$$

$$B = B_x i + B_y j + B_z k = B_y j$$

$$\nabla \cdot E = \frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} + \frac{\partial E_z}{\partial z}$$

$$= 0 + 0 + \frac{\omega}{c} E_{x0} \cos\left(\frac{\omega z}{c} - \omega t\right)$$

$$= \frac{2\pi}{Tc} \frac{2q}{\pi \epsilon_0 d^2} \cos\left(\frac{\omega z}{c} - \omega t\right)$$

$$= \frac{q}{\epsilon_0 \lambda r^2} \cos\left(\frac{\omega z}{c} - \omega t\right)$$

Due to λr^2 is the volume of a square column containing the electromagnetic field in one of the wave cycles with the column length as λ , the square width as r .

$$V = \lambda r^2$$

If we define the charge density as ρ

$$\rho = \frac{q \cos\left(\frac{\omega z}{c} - \omega t\right)}{V}$$

Then

$$\nabla \cdot E = \frac{\rho}{\epsilon_0} \quad \text{Eq. 15}$$

While

$$\nabla \times E = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ E_x & 0 & E_z \end{vmatrix}$$

$$= \left(\frac{\partial E_x}{\partial z} - \frac{\partial E_z}{\partial x}\right) j = \left(\frac{\partial E_x}{\partial z} - 0\right) j$$

$$= \frac{\partial E_x}{\partial z} j$$

$$\nabla \times E = -\frac{\partial B}{\partial t} \quad \text{Eq. 16}$$

And the divergence and curl of the magnetic field will not change,

$$\nabla \cdot B = 0 \quad \text{Eq. 17}$$

$$\nabla \times B = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 0 & B_y & 0 \end{vmatrix}$$

$$\nabla \times B = -\frac{\partial B_y}{\partial z} i$$

$$c^2 \nabla \times B = \frac{\partial E_x}{\partial t}$$

Because during the photon's wave motion, there is no conductive current, J_c , or conventional current, J_v , there is only displacement current, J_d due to the motion of the point charges of the dipole. Then the displacement current is the total current during the photon's motion.

$$J = J_c + J_v + J_d$$

$$= 0 + 0 + J_d$$

And displacement current is direct proportional to the time derivative of the time-varying component of the electric field as follows [16]:

$$J_d = \epsilon_0 \frac{\partial E_x}{\partial t}$$

$$\frac{\partial E_x}{\partial t} = \frac{J_d}{\epsilon_0} = \frac{J}{\epsilon_0}$$

$$c^2 \nabla \times B = \frac{\partial E_x}{\partial t} = \frac{J}{\epsilon_0}$$

Since the electric field of the dipole is a constant, E_{x0} , So,

$$\frac{\partial E}{\partial t} = \frac{\partial E_{x0}}{\partial t} = 0$$

Finally

$$c^2 \nabla \times B = \frac{J}{\epsilon_0} + \frac{\partial E}{\partial t} \quad \text{Eq. 18}$$

From above deduction, we can conclude that the Maxwell four Equations are applicable to different scenarios for the photon as an electric dipole in spin and linear uniform motion, no matter we take the component of the electric field of the dipole on z axis into consideration or not. Equation 15 to 18 are Maxwell's famous four Equations for electromagnetic theory.

If we take the positive pole and negative pole into consideration separately instead of as a dipole and measure the magnitude of the electric field at negative pole and positive pole with its middle point as the zero reference. They shall be with same magnitude, but with opposite sign on the x axis. When the photon in wave motion, actually the electric field waves and the magnetic waves will be the standing waves as Figure 6 and Figure 7.

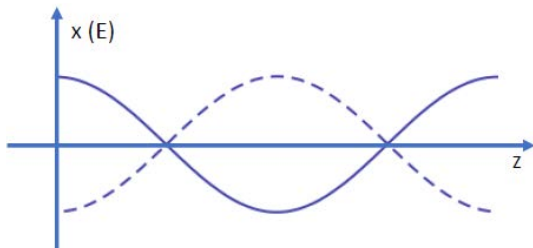


Figure 6. The actual standing electric waves of the photon

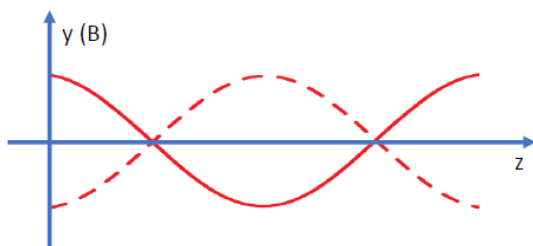


Figure 7. The actual standing magnetic waves of the photon

The fact that both the electromagnetic waves of the photon are the standing waves will explain why the

photon is neutral from electric and magnetic perspective even though it travels as electromagnetic wave, and it will not be changed the motion direction by external electric field or magnetic field at normal conditions.

2.3. Polarization

Polarization is a property of transverse waves which specifies the geometrical direction of the oscillations[19]. In a transverse wave, the direction of the oscillation is perpendicular to the propagating direction of the wave. Transverse waves which exhibit polarization include electromagnetic waves [20] such as light and radio waves, gravitational waves, and transverse sound waves in solids.

From the deduction of the spinvector in motion of the photon, it is apparent that the oscillation of the wave is perpendicular to its wave propagating direction. If the dipole is located on the x axis while spinning on the xoz plane, and travels along the z axis, when we observe the electric field amplitude from y axis without consideration of the linear motion, the trajectory of the spinvector head is the circle on the xoz plane as Figure 8(a); when we look at the electric field from z axis, the trajectory is just the oscillation on the x axis, described as Figure 8(b).

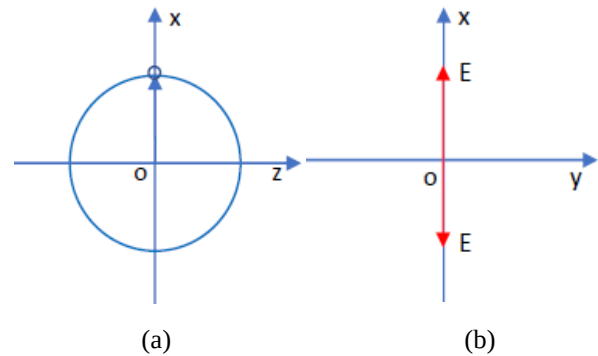


Figure 8. The oscillation of the spinvector observed from z axis

When the spinning plane of the spinvector rotates from xoz plane to yoz plane with angle θ as Figure 9,

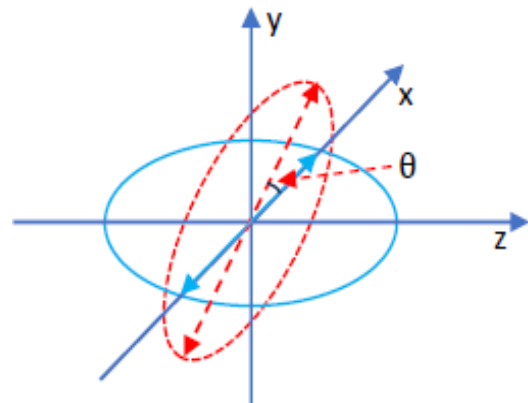


Figure 9. The spinning plane rotating from xoz plane to yoz plane

If we look at the electric field from the spinning plane, the electric field oscillation will cause polarization rotation as Figure 10(a); if we observe the electric field from the xoz plane or along the yoz, the trajectory will be an ellipse as Figure 10(b) because the oscillation amplitudes on x axis and y axis are different; When $\theta = \pi/2$, if we look at the electric field from z axis, the

trajectory will be an oscillation on the y axis; if we observe the electric field from x axis without the consideration of linear motion, the trajectory of the spinvector head is a circle again but on the yo z plane as Figure 10(c).

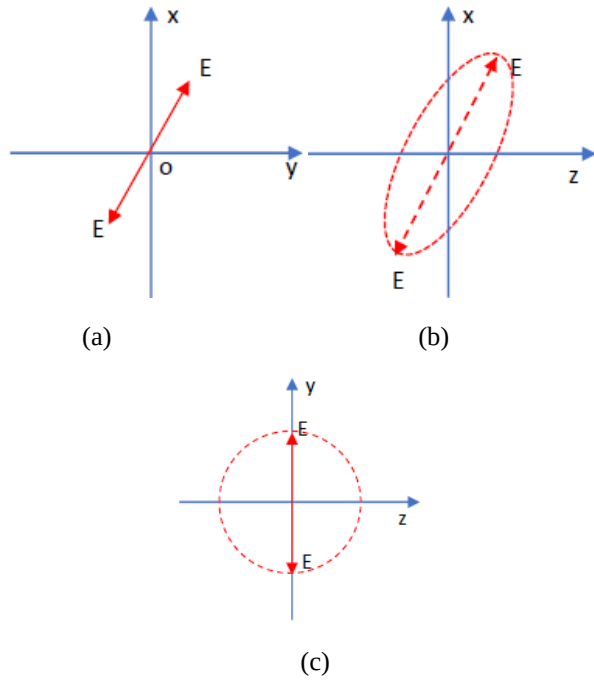


Figure 10. The oscillations of the spinvector observed from different axes

Before we provide the theoretical explanation why the polarization plane will rotate, let us review the Faraday effect first which refers to as the magneto-optic Faraday effect (MOFE) [21], a phenomenon causes a polarization rotation proportional to the projection of the magnetic field along the wave propagating direction of the photon, illustrated as Figure 11 [22].

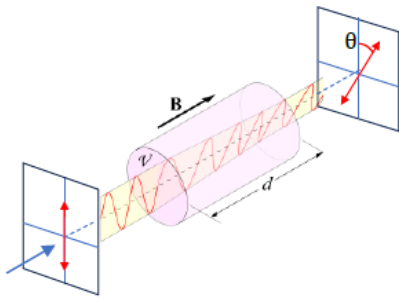


Figure 11. The polarization rotation due to external magnetic field

The relation between the rotation angle of the polarization, θ , and the magnetic field in a transparent material is as:

$$\theta = VBd$$

where v is the Verdet constant for the material, B is the magnetic flux density in the direction of propagation, d is the length of the path where the photon and the magnetic field interact. Apparently, as long as the B , or d changes, θ can be adjusted to between 0 and $\pi/2$ as necessary, if the $\theta = \pi/4$, then the rotating polarization can also be

viewed as the addition of a horizontally polarized wave on x axis and a vertically polarized wave with same amplitude on the y axis as described as Figure 12 [18].

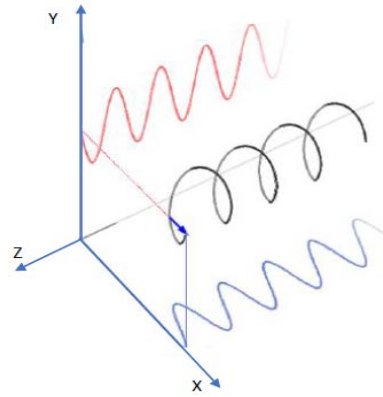


Figure 12. A rotated polarization as the linear addition of x and y components

Now let's check carefully what will happen when the spinvector entering into the magnetic field with direction same as the wave propagating direction along the z axis direction. If we take the negative electric pole into consideration, the spinning positions of the vector head on its rotation circle are P-M-V-N-P as Figure 13(a), the positions on its wave are P-M-V-N-P' as Figure 13(b).

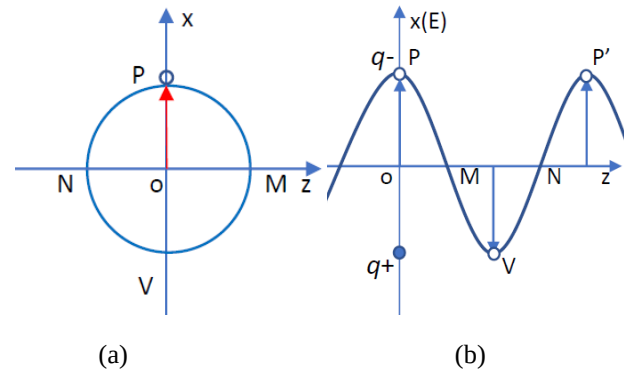


Figure 13. The position of one of photon's pole during its rotation and wave cycle

If we observe the spinvector motion from its back from $-z$ to $+z$ direction, the oscillation positions of the negative electric pole are P-M-V-N-P as Figure 14(a). When the negative pole enters into the magnetic field starting from position P, from oscillation perspective the next path of the negative electric pole will be PM, the downward (on x axis) vibration speed will change from zero (at P) to the maximum (at M), while the electric current direction will be upward MP, according to the left-hand rule, the pole will be exerted by a Lorentz force to the left (as Figure 14(b) on y axis), from zero (at P) to the maximum (at M'), as combination, the pole will be pulled down-left gradually to the position M with the maximum deviation as Figure 14(c), the solid line vibration; For the next vibration path MV, the downward vibration speed will vary from maximum (at M) to zero (at V) as Figure 14(a), the Lorentz force will change back from maximum (at M') to zero (at V) as Figure 14(b), while the pole will be pulled back up-right to position V as Figure 14(c). For the path VN, the vibration will turn the direction from downward

to upward as Figure 14(a), the electric current will turn to downward, the pole will be exerted a Lorentz force to the right, maximum at N' on the y axis as Figure 14(b), as result the pole will be pulled up-right from position V to N as Figure 14(c); And during the final path NP, the pole will be pulled back down-left to position P by the Lorentz force.

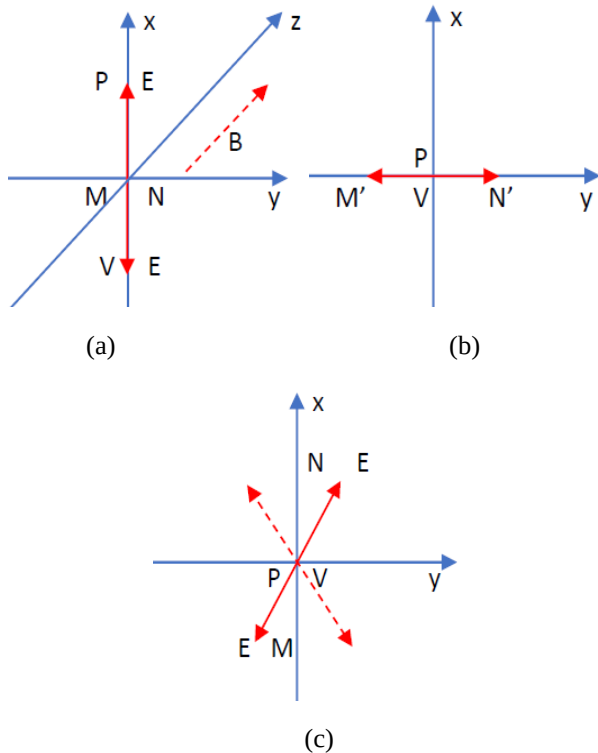


Fig. 14. A photon entering an external magnetic field in z direction

If a positive pole enters the magnetic field starting from position P, the same effect will happen, but with an opposite vibration deviation due to Lorentz force as Figure 14(c), the dash-line vibration. From above analysis, we can conclude that the intrinsic nature of the Faraday effect is simply attributed to the Lorentz force due to the external magnetic field at same direction during the photon's spinvector in motion along the wave propagating direction. The external magnetic field along the light wave direction causes the different type of polarization phenomena.

2.4. Exploration of the Mass Origin

In section 2.2 when we deduct the electromagnetic wave equations for the spinvector, if we take the negative and positive pole into consideration separately, we realize that the photon doesn't show any magnetic property during its motion. And when we developed the theory on photon bond [23] to form photon molecular or photon polymer, we should have excluded the motion mode of the photon with its middle of the dipole as rotation center. Based on this research work we will conclude that maybe only one pole of the dipole as the rotation center, then the motions of the photon will show magnetic property, described as Figure 15.

When the two photons rotating with same direction as Figure 16, an attractive magnetic force will be balanced by both repulsive forces of the electric dipole to form head to tail σ bond as a photon molecular.

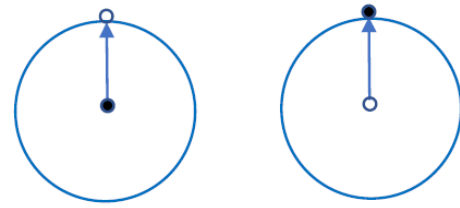


Figure 15. Different modes of rotation of the photon

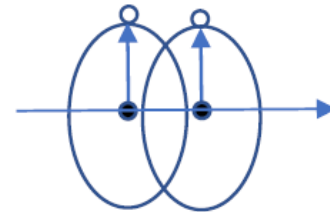


Figure 16. The σ bond between the two photons

When the two photons rotating on the same plane but with opposite direction as Figure 17, two attractive magnetic forces will be balanced by both repulsive forces of the electric dipole to form shoulder to shoulder π bond as a photon molecular. It seems the π bond will not be as stable as σ bond.



Figure 17. The π bond between the two photons

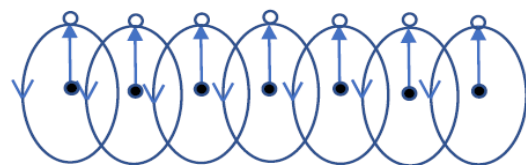


Figure 18. The polymerizations of the photons or poly-photon

When a lot of photons rotating with same direction as Figure 18, connected by σ bond, a photon polymer or poly-photon will be formed. The photon polymer will be the base material for all the elementary particles, the Higgs' particle.

3. Discussions

From the particle-wave deduction process, we all know that the wave can be generated due to the spinvector of the dipole while in linear uniform motion, or the wave can be formed by a moving oscillator (the photon). If such a photon is moving in some media, the photon as a moving oscillator will absolutely transfer its energy to the media particles. Some media particle waves will be generated accordingly by the photon as the media wave source. It is this theory of spinvector in motion that we used to explain

the experiment of double-slit interference by a single photon or a single electron [24].

During the theory deduction for the electromagnetic waves by an electric spinvector in motion, we intentionally focus on the vibration of electric field on x axis, while on the vibration of magnetic field on y axis. In fact, there are electric vector components on z axis.

$$E = E_x i + E_z k$$

$$= E_{x0} \cos\left(\frac{\omega z}{c} - \omega t\right) i + E_{x0} \sin\left(\frac{\omega z}{c} - \omega t\right) k$$

If we use exponent to describe the wave, the wave equation will be:

$$E = \frac{2q}{\pi \epsilon_0 d^2} e^{i\omega\left(\frac{z}{c} - t\right)} \quad \text{Eq. 19}$$

The real part is the component on x axis and the imaginary part is the component on z axis. From that perspective the electric wave of the light wave is not only a transverse wave, but also a longitudinal wave.

As to the spinvector, we specifically referred to the spinvector as an electric dipole (electric dipole). If there were a similar magnetic dipole (magnetic photon) existing, we would deduct an almost same theory of magnetoelectric waves.

We all know that static electric forces occur between any two particles with electric charge, causing an attraction between particles with opposite charges and repulsion between particles with the same charge. And we all know electromagnetism is an interaction that occurs between particles with electric charge via electromagnetic fields. The electromagnetic force is one of the four fundamental forces of nature. It is the dominant force in the interactions of atoms and molecules. That is only because that all the matters are composed of protons and electrons, the particles with electric charge in our known space-time.

The duality principle in mathematical logic is a theorem on the acceptability of mutual substitution of logical operations in the formulas of formal logical and logical objective languages. In the electromagnetic field theory, we realize there are several dualities between electricity and magnetism, such as the duality between static electric field and uniform electric field, the duality between static electric field and uniform magnetic field.

Since the magnetoelectric wave theory is possible from pure mathematic and theoretic perspective based on the magnetic spinvector in motion, we have enough reasons to postulate that there would be magnetic charges existing in some unknown space-time, somewhere in the universe, there would exist the magnetic dipole composed of magnetic monopoles. In that space-time all the matters must be composed of particles with magnetic charges (magnetic protons and magnetic electrons) same as our space-time, just as we proposed in our previous work [25]. There would be all set of equations based on magnetic field theory such as Gauss law, Static magnetic field force, Static magnetic field strength, magnetic Lorentz force, magnetic current, and Maxwell magnetic four Equations.

When an external magnetic field exerted along the light

wave propagating direction, if we look at the polarization in the direction from the photon source to the z axis, we will observe a circular polarization when the electric field vibration is turned from x axis to y axis. If the positive pole enters the magnetic field first, the circular polarization will be a left-handed circular polarization (LHCP); if the negative pole enters the magnetic field first, the polarization will be a Right-handed circular polarization (RHCP), illustrated as Figure 19 [26].

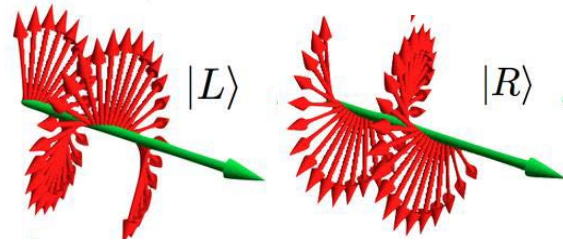


Figure 19. The left and right circular polarization

During the interpretation of Faraday Effect, we all know the external magnetic field is along the z axis direction. If we change the magnetic field direction from z axis to the direction of x axis, due to the magnetic direction parallel to the electric oscillation on the x axis, there will be no impact on polarization of the photon.

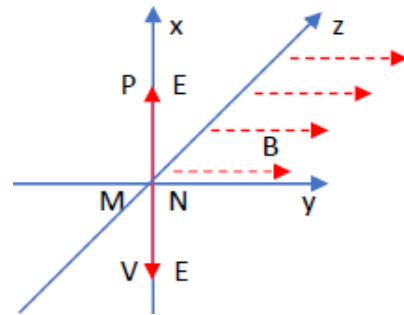


Figure 20. A photon entering an external magnetic field in y axis direction

But if we change the magnetic field direction from z axis to the y axis direction as Figure 20, and if the negative pole entering the magnetic field at position P, then the photon will be exerted a Lorentz force pushing forward in +z direction during its vibration path PV, and a Lorentz force pulling backward in -z direction during its vibration path VP. In other words, the photon will be experienced an accelerating, back to normal, slowing down, and back to normal cycle if the magnetic field is wide enough in wave propagating direction. But according to Einstein's special relativity, the photon's speed is a constant c. Since an acceleration in the wave cycle means a reduction of the wave cycle time, in order to keep speed as a constant, the compensation must be a shorter wavelength, a wave blueshift. In contrast to the photon pushed forward by extra Lorentz force, when pulled backward by extra Lorentz force, the effect of the force will result in a longer wavelength, a wave redshift. If the conclusion of universe expansion was based only on the light wave's redshift, further carefully investigation is necessary.

Now let's investigate why the electric dipole moves in a special way, spinning while in linear uniform motion. When an electric dipole in a uniform external electric field

it will always move as rotation due to the torque, or whenever the negative pole of the dipole occurs external perturbation, the negative always starts to move as rotation from the reference frame of the positive pole. If the negative pole rotates in the clockwise direction, it will induce the magnetic field at its surrounding with direction down into the y axis direction as Figure 21(a). As the pole moving, there is a Lorentz force to keep the negative pole rotating to the middle of the dipole or to the opposite pole. As a result, the positive pole will keep rotating to its dipole center in a counterclockwise direction or as the rotation center.

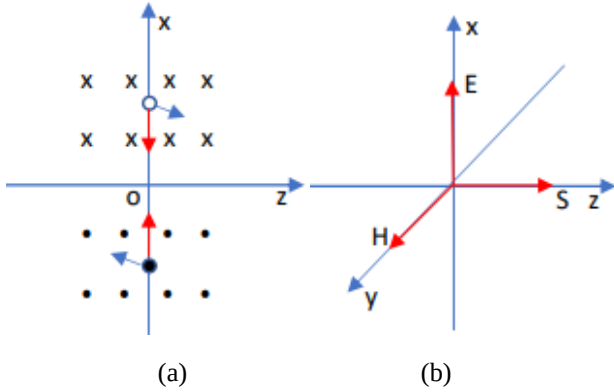


Figure 21. The logic of the photon's spin while in linear uniform motion

After the dipole spin, the rotating electric vector will induce magnetic field at y axis direction to form an electromagnetic field. According to the electromagnetic wave theory, the photon shall obtain a Poynting electromagnetic energy. The Poynting vector S as Figure 21(b) follows the Equation as below[27]:

$$S = E \times H = \epsilon_0 c^2 E \times B$$

$$S = \epsilon_0 c^2 E_{x0} \cos\left(\frac{\omega z}{c} - \omega t\right) \times \frac{E_{x0}}{c} \cos\left(\frac{\omega z}{c} - \omega t\right)$$

$$= \epsilon_0 c E_{x0}^2 \cos^2\left(\frac{\omega z}{c} - \omega t\right)$$

The Intensity or the average value of the S in one cycle will be equal to:

$$S_{av} = \frac{1}{2} \epsilon_0 c E_{x0}^2$$

While the energy flux density S_{en} of the electromagnetic field has the following relation:

$$S_{en} = \frac{\epsilon_0}{2} (E^2 + c^2 B^2)$$

$$= \frac{\epsilon_0}{2} \left[E_{x0}^2 \cos^2\left(\frac{\omega z}{c} - \omega t\right) + c^2 \frac{E_{x0}^2}{c^2} \cos^2\left(\frac{\omega z}{c} - \omega t\right) \right]$$

$$= \epsilon_0 E_{x0}^2 \cos^2\left(\frac{\omega z}{c} - \omega t\right)$$

And the average value of the S_{en} in one cycle will be equal to:

$$\bar{S}_{en} = \frac{1}{2} \epsilon_0 E_{x0}^2$$

Then the energy flux speed v_{en} at any time during the photon's motion will be:

$$v_{en} = \frac{S_{av}}{\bar{S}_{en}} = \frac{\frac{1}{2} \epsilon_0 c E_{x0}^2}{\frac{1}{2} \epsilon_0 E_{x0}^2}$$

$$= c$$

In other words, after the photon's spin, it obtains an energy or a momentum along the z axis direction, and it will move with a speed same as its energy flux speed, c . This is the intrinsic nature why the dipole always moves in a special way, spin while in a linear uniform motion.

During the exploration of mass origin, we focus on the magnetic force between the photons, now let's focus on a force existing within the dipole itself, the Coulomb's force as Figure 22.

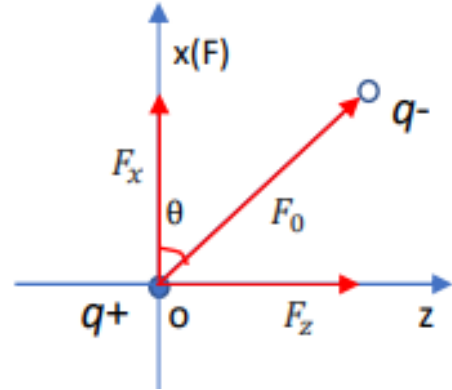


Figure 22. The force vector between two poles of the photon

$$F_0 = \frac{q^2}{4\pi\epsilon_0 d^2}$$

When the dipole rotates while in linear uniform motion, apparently there is a force vector existing, the force vector will form a force wave during the photon's motion with the equations as follows:

$$\psi_F = \frac{q^2}{4\pi\epsilon_0 d^2} e^{i\omega\left(\frac{z}{c} - t\right)} \quad \text{Eq. 20}$$

$$\psi_F = \frac{q^2}{4\pi\epsilon_0 d^2} e^{\frac{i(pz - Et)}{\hbar}} \quad \text{Eq. 21}$$

Or in the differential form and Schrodinger Equation:

$$\frac{\partial^2 \psi_F}{\partial z^2} - \frac{1}{c^2} \frac{\partial^2 \psi_F}{\partial t^2} = 0 \quad \text{Eq. 22}$$

$$\hat{H}\psi_F = E\psi_F = i\hbar \frac{\partial \psi_F}{\partial t} \quad \text{Eq. 23}$$

The force in the wave direction will be the imaginary part of its exponent expression:

$$F_z = F_0 \sin\left(\frac{\omega z}{c} - \omega t\right)$$

When an object A emits such a photon to another object B far away, and if the photon is absorbed by the object B, it seems there is a flying force tying the object A and B. From this perspective, this type of the photon is a graviton, and the total accumulation of the forces exerted by all the photons between two objects is the gravitation between the two objects. The intrinsic nature of the gravitation is a Coulomb's force or an electromagnetic force.

4. Conclusion

We propose that the photon is a mechanical particle as an electric dipole. By treating the photon as a mechanical vector that rotates while in uniform linear motion, we derived its motion equation based on classical wave theory. This motion equation, as a mechanical spinvector in motion, aligns with the plane wave equation of light. Additionally, using special relativity, we demonstrated that this motion equation is equivalent to the Schrodinger equation. Treating the photon as an electric spinvector, we found that its motion characteristics are fully consistent with Maxwell's four equations in electromagnetic theory.

Our deductions lead us to conclude that the hypothesis of the photon as an electric dipole is rational. The kinematics of the photon's spinvector can explain its particle-wave duality, elucidating why photons travel as electric spinvectors while propagating as electromagnetic waves. This unique motion of the photon also explains various polarization phenomena, such as polarization rotation, elliptical polarization, and circular polarization, when influenced by an external magnetic field along the wave motion.

Furthermore, we attribute the Faraday effect to the Lorentz force induced by an external magnetic field along the wave propagation direction. When the external field is applied perpendicular to the oscillation of the electric field of the spinvectors, we explain the occurrence of wave redshift or blueshift due to the Lorentz force, maintaining the constant speed of light as required by special relativity.

Regarding the hypothesis of special photons as gravitons, further research and experimentation are needed to verify their existence and their correlation with the mass of objects. Nonetheless, we are confident that our theory of spinvector mechanics, or spinvector in motion, will definitely be applied to many other areas of physics currently dominated by quantum mechanics, particularly in astronomy and cosmology, with continued development in the future.

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