Transluminal Energy Quantum Model of a Spin-¹/₂ Charged Photon Composing an Electron

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Abstract

A helically-circulating transluminal energy quantum model of an electrically charged spin- $\frac{1}{2}$ photon is proposed to compose an electron. When moving forward linearly, the spin- $\frac{1}{2}$ charged photon's helically-circulating energy quantum moves at $c\sqrt{2}$ with a forward helical angle of 45° and a helical radius of $R = \lambda / 4\pi$. The transluminal energy quantum makes two helical turns per wavelength of the spin- $\frac{1}{2}$ charged photon.

Key words: electron, photon, model, transluminal, electron-positron pair production

Introduction

Gauthier (1,2) proposed a model of a relativistic electron that is composed of a helically moving spin-¹/₂ charged photon that generates the de Broglie wavelength. Details of the energy and momentum structure of the spin-¹/₂ charged photon itself were not provided, only the size and shape of the helical trajectory of the spin-¹/₂ charged photon forming a relativistic electron, as well as the spin-¹/₂ charged photon's associated energy and momentum relations.

Gauthier (3) presented a transluminal energy quantum model of a spin-1 photon. This spin-1 photon model was then used to model a stationary electron composed of a double-looping charged photon-like object in order to get the correct electron spin and (pre QED) magnetic moment. But when the relativistic motion of an electron was later considered, it was realized that the circulating charged photon-like object should have spin-½ so that the electron model's spin would also match a real electron's spin-½ at highly relativistic velocities as well as when the electron is stationary.

This article presents an internally transluminal model of the proposed spin- $\frac{1}{2}$ photon -the transluminal energy quantum model of a spin- $\frac{1}{2}$ charged photon. Like the internally transluminal spin-1 photon model, the spin- $\frac{1}{2}$ charged photon model has an energy quantum that moves helically with a speed of $c\sqrt{2}$ c at a helical angle of 45° at all photon energies. But while the radius *R* of the helical trajectory of the spin-1 photon model is $R = \lambda / 2\pi$, the radius *R* of the spin- $\frac{1}{2}$ photon model's helical trajectory is $R = \lambda / 4\pi$. So for every one wavelength of a spin- $\frac{1}{2}$ photon model measured along its helical axis, the transluminal energy quantum makes two helical turns around this helical axis, compared to one helical turn around the helical axis per photon wavelength for the transluminal energy quantum in the spin-1 photon model.

The Equations for the Transluminal Energy Quantum Model of the Spin-1 Photon

Here are the equations from Gauthier (3) for the trajectory of the translumial energy quantum in the spin-1 photon model:

For a right-handed spin-1 photon traveling in the +z direction with energy $E = \hbar \omega$, angular frequency ω and wavelength $\lambda = 2\pi c / \omega$, the equations for the trajectory of the transluminal energy quantum (neglecting a possible phase factor) are:

$$x(t) = \frac{\lambda}{2\pi} \cos(\omega t),$$

$$y(t) = \frac{\lambda}{2\pi} \sin(\omega t),$$

$$z(t) = ct$$
(1)

for the components of the circulating transluminal quantum's position with time, and

$$p_{x}(t) = -\frac{h}{\lambda}\sin(\omega t),$$

$$p_{y}(t) = \frac{h}{\lambda}\cos(\omega t),$$

$$p_{z}(t) = \frac{h}{\lambda}$$
(2)

for the components of the circulating transluminal quantum's momentum with time.

The *z*-component of spin of the spin-1 photon above is calculated from its position and momentum component equations above as

$$Sz = (\bar{R} \times \bar{p})_{z} = x(t) \times p_{y}(t) - y(t)p_{x}(t)$$

$$= \frac{\lambda}{2\pi} \times \frac{h}{\lambda} [\cos^{2}(\omega t) + \sin^{2}(\omega t)]$$

$$= \frac{h}{2\pi} = \hbar$$
(3)

which is the spin of a spin-1 photon.

The speed v(t) of the transluminal energy quantum for the spin-1 photon model is calculated from the velocity components of the transluminal energy quantum, derived by differentiating the position components in the equations above as

$$v_{x}(t) = dx(t) / dt = -\frac{\lambda \omega}{2\pi} \sin(\omega t)$$

$$v_{y}(t) = dy(t) / dt = \frac{\lambda \omega}{2\pi} \cos(\omega t)$$

$$v_{z}(t) = dz(t) / dt = c$$
(4)

To get the transluminal energy quantum's speed v(t):

$$v(t)^{2} = v_{x}(t)^{2} + v_{y}(t)^{2} + v_{z}(t)^{2}$$

$$= \left[-\frac{\lambda\omega}{2\pi}\sin(\omega t)\right]^{2} + \left[\frac{\lambda\omega}{2\pi}\cos(\omega t)\right]^{2} + c^{2}$$

$$= c^{2}\left[\sin^{2}(\omega t) + \cos^{2}(\omega t)\right] + c^{2} \qquad (5)$$

$$= c^{2} + c^{2}$$

$$= 2c^{2}$$

So $v(t) = \sqrt{2c^2} = c\sqrt{2}$ for the speed of the transluminal energy quantum of the spin-1 photon model.

The Equations for the Transluminal Energy Quantum Model of the Spin-½ Charged Photon

For a right-handed spin- $\frac{1}{2}$ charged photon with energy $E = \hbar \omega$, angular frequency ω and wavelength $\lambda = 2\pi c / \omega$, traveling in the +z direction, the equations for the trajectory of the transluminal energy quantum (again neglecting a possible phase factor) that makes two helical turns per photon wavelength λ are:

$$x(t) = \frac{\lambda}{4\pi} \cos(2\omega t),$$

$$y(t) = \frac{\lambda}{4\pi} \sin(2\omega t),$$

$$z(t) = ct$$
(6)

for the components of the circulating transluminal energy quantum's position with time, and

$$p_{x}(t) = -\frac{h}{\lambda}\sin(2\omega t),$$

$$p_{y}(t) = \frac{h}{\lambda}\cos(2\omega t),$$

$$p_{z}(t) = \frac{h}{\lambda}$$
(7)

for the components of the circulating transluminal quantum's momentum with time.

The z-component of spin of the spin- $\frac{1}{2}$ charged photon above is calculated from its position and momentum component equations as

$$Sz = (\bar{R} \times \bar{p})_z = x(t) \times p_y(t) - y(t)p_x(t)$$
$$= \frac{\lambda}{4\pi} \times \frac{h}{\lambda} [\cos^2(2\omega t) + \sin^2(2\omega t)]$$
(8)
$$= \frac{h}{4\pi} = \hbar/2$$

which is the spin of a spin- $\frac{1}{2}$ photon.

The corresponding calculation as above for the speed of the transluminal energy quantum of the spin-¹/₂ charged photon model also gives $v(t) = c\sqrt{2}$.

Discussion

A detailed model of a spin-¹/₂ charged photon is needed to supplement the "generic" spin-¹/₂ charged photon model of a relativistic electron introduced by Gauthier (1,2). That model only contains the helical trajectory of the proposed spin-¹/₂ charged photon proposed to compose an electron. Various detailed proposals for a spin-¹/₂ charged photon could be combined with that "generic" spin-¹/₂ electron model. This article proposes an internally transluminal model of the spin ¹/₂-charged photon similar in structure to the previously proposed Gauthier (3) internally transluminal spin-1 uncharged photon model.

The present spin-½ charged-photon model could be useful for modeling the electron and similar particles like the muon and tau particles, and perhaps quarks as well, which could be composed of spin-½ charged gluons. But the spin-½ charged-photon model could also be useful for modeling the production of electron-positron pairs from a sufficiently energetic photon in proximity to an atomic nucleus, as occurs naturally and in experiments. In this process, an incoming spin-1 uncharged photon could divide into a positive spin-½ charged photon and a negative spin-½ charged photon. The positive spin-½ charged photon curls up to form a positron, while the negative spin-½ charged photon curls up to form an electron. Each of the spin-½ charged photons would carry one half of the energy of the spin-1 uncharged photon and therefore would have twice the wavelength of the spin-1 photon. But because the spin-½ charged photon model makes two helical turns per wavelength while the spin-1 uncharged photon model makes one helical turn per wavelength, the helical trajectories of the spin-1 photon and the two spin-¹/₂ photons would look the same except that the trajectories of the two spin-¹/₂ charged photons would each have half the radius of the spin-1 charged photon. The helically cycling frequencies of the spin-1 photon and the two spin-¹/₂ photons would be the same, since the spin-¹/₂ charged photon makes two helical loops for each of its longer wavelengths, compared to one helical loop per wavelength of the spin-1 photon.

The proposed spin-¹/₂ charged photon model does not explain how equal positive and negative electric charges originate from a single uncharged photon during electron-positron pair production. This electric charge of a spin-¹/₂ charged photon may be associated with the two-helical-turns-per-wavelength structure of the trajectory of the spin-¹/₂ photon model, compared to the one-helical-turn-per-wavelength structure of the uncharged spin-1 photon model.

Conclusion

The transluminal energy quantum model of a spin-1/2 charged photon introduced here could have value in more detailed modeling of a relativistic electron as a helically-circulating spin-1/2 charged photon. The model could also have value in modeling the production of electron-positron pairs from a single sufficiently-energetic photon, due to the nearly matching trajectory geometries of the spin-1 uncharged photon and the two produced spin-1/2 charged photons, which curl up to become internally double-looping positron and electron models.

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6