Entangled Double-Helix Superluminal Composite Photon Model Defined by Fine Structure Constant

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Abstract

Two spin-½ charged half-photons, each composed of one helically-circulating electrically-charged superluminal energy quantum, compose a double-helix photon model of diameter $D = \lambda / \pi$ where λ is the photon's wavelength. The electric charge Q of each energy quantum is found to be $Q = \pm e\sqrt{2/\alpha} = \pm 16.6e$ where $\alpha = 1/137.04$ is the fine structure constant of quantum electrodynamics (QED). The two charged half-photons are quantum mechanically entangled, creating the unity of the single composite photon model. The composite photon model suggests a mechanism for electron-positron pair production, while the predicted charges Q and $-Q$ provide a strong experimental test of the composite photon model.

Key words: photon, double helix, superluminal, model, entanglement, electron-positron pair production, fine structure constant, quantum

Introduction

> "All these fifty years of conscious brooding have brought me no nearer to the answer to the question, 'What are light quanta?' Nowadays every Tom, Dick and Harry thinks he knows it, but he is mistaken." (Albert Einstein, 1954)

This paper proposes a new composite model of the photon that builds on Gauthier's (1) earlier internally-superluminal models of a photon and an electron. There a spin-1 photon model is composed of a single helically circulating superluminal energy quantum. This photon model is then used to compose a stationary electron model from a double-looping charged-photon model whose two internal radii were chosen to give the resting electron model its correct spin of $\frac{1}{2}\hbar$ and a magnetic moment magnitude equal to the Dirac equation's value of one Bohr magneton.

When relativistic motion of the electron was later considered, it was realized that a circulating charged-photon model of an electron 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. Gauthier (2) then proposed a model of a relativistic electron that is composed of a helically moving spin-½ charged photon that generates the de Broglie wavelength. Details of the energy and momentum structure of the spin-½ charged photon itself were not provided there. Only the shape of the helical trajectory of the spin-½ charged photon forming a relativistic electron was given, as well as the spin-½ charged photon's associated energy and momentum relations. Then Gauthier (3) proposed a superluminal energy quantum model of a spin-½ charged photon that can be combined with the generic spin-½ charged half-photon model's trajectory in Gauthier (2) to form an electron model having spin-½ at highly relativistic velocities as well as at rest.

The author recently learned that de Broglie (4) previously hypothesized that a photon is composed of a spin-½ "half-photon". Since de Broglie is not well-known for his composite photon hypothesis, here is a two-paragraph excerpt from p. 285-286:

"From these general remarks, we concluded that in order to set up a theory of the photon it was necessary above all to use a relativistic form of wave mechanics having elements of symmetry like polarization and, secondly, to introduce *something more* in order to differentiate the photon from other corpuscles. The first part of this program is immediately realized by having recourse to Dirac's theory of the magnetic electron that we previously discussed. We know as a matter of fact that Dirac's theory is relativistic and that it has elements of symmetry which present a marked relationship with those of the polarization of light. Nevertheless it is not enough to suppose that the photon is a corpuscle of negligible mass obeying the equations of Dirac's theory, for the model of the photon thus obtained would have, as you might say, only half the symmetry of the actual photon; in addition, it would obey, it would seem, the Fermi statistics, as the electron does and would not be capable of being annihilated in the photoelectric effect. Something more is very much needed.

And this something more we have tried to introduce by supposing that the photon is made up not by one Dirac corpuscle, but by two. It can then be ascertained that these two corpuscles or demi-photons must be complementary to each other in the same sense that the positive electron is complementary to the negative electron in Dirac's theory of holes. Such a couple of complementary corpuscles can annihilate themselves on contact with matter by giving up all their energy, and this accounts completely for the characteristics of the photoelectric effect. In addition, the photon being thus made up of two corpuscles with a spin of $h/4\pi$ should obey the Bose-Einstein statistics, as the exactness of Planck's law of black body radiation demands. Finally, this model of the photon permits us to define an electromagnetic field connected with the probability of annihilation of the photon, a field which obeys the Maxwell equations and possesses all the characters of the electromagnetic light wave. Although it would still be premature to make a definitive pronouncement on the value of this attempt, it is indisputable that it leads to interesting results and that it strongly focuses attention on the symmetry properties of the complementary corpuscles whose existence, suggested by Dirac's theory, has been verified by the discovery of the positive electron."

In another book, de Broglie (5) gave a more extended discussion of his half-photon hypothesis, and the rationale behind it. He also suggested that the two half-photons might be two neutrinos.

Perkins (6) reviewed various criticisms of de Broglie's two-neutrino suggestion and found that some of these criticisms do not hold up, but that problems remain with the two-neutrino model. A recent composite model of the photon, based on de Broglie's spin-½ half-photon hypothesis, is given by Michaud (7). This model is based on a tri-space approach where a photon model moves forward through space at light speed while its electric and magnetic fields flow between two other physical spaces that are transverse to the direction of motion of the composite photon through familiar physical space.

In light of de Broglie's spin-½ half-photon hypothesis for a photon, a terminology change for the term "spin-½ charged photon" proposed by Gauthier (2) for his electron model was needed. The term "spin-½ charged photon" model of the electron has therefore been changed to the "spin-½ charged half-photon" model of the electron, to be consistent with de Broglie's composite photon hypothesis. Using this new terminology and the superluminal energy quantum model for the spin-½ half-photon model proposed in Gauthier (3), the author is now proposing a new photon model, composed of two internally superluminal spin-½ charged half-photons moving in a double-helix trajectory. Here, each half-photon is composed of an electrically charged superluminal energy quantum moving helically at $c\sqrt{2}$ with a forward helical angle of 45° and with a helical radius of $\lambda / 2\pi$, where λ is the wavelength of the composite photon, composed of the two spin-½ half-photons. The superluminal energy quantum in each spin-½ charged half-photon makes two full turns of its helical trajectory for each half-photon wavelength.

I have just discovered an article by Caroppo (8) which contains essentially the same features as the present composite model of the photon, apparently done without reference to de Broglie's hypothesis about this

The equations for one superluminal energy quantum spin-½ charged half-photon model

Here are the equations from Gauthier (3) for the trajectory of one superluminal energy quantum in the spin-½ charged half-photon model. For a right-handed spin-½ charged half-photon with energy $E = \hbar\omega = 2\pi\hbar c / \lambda$, angular frequency ω and half-photon wavelength $\lambda = 2\pi c / \omega$, traveling in the +z direction, the equations for the trajectory of the superluminal quantum (neglecting a possible phase factor) that makes two helical turns per half-photon wavelength λ are:

$$
\begin{aligned}
x(t) &= \frac{\lambda}{4\pi}\cos(2\omega t), \\
y(t) &= \frac{\lambda}{4\pi}\sin(2\omega t), \\
z(t) &= ct \qquad (1)
\end{aligned}
$$

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

$$p_x(t) = -\frac{h}{\lambda}\sin(2\omega t),$$
$$p_y(t) = \frac{h}{\lambda}\cos(2\omega t), \qquad (2)$$
$$p_z(t) = \frac{h}{\lambda}$$

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

The *z*-component of spin of the spin-½ half-photon above is calculated from the above equations as

$$\begin{aligned} Sz &= (\vec{R}\times\vec{p})_z = x(t)\times p_y(t) - y(t)p_x(t) \\ &= \frac{\lambda}{4\pi}\times\frac{h}{\lambda}[\cos^2(2\omega t)+\sin^2(2\omega t)] \qquad (1) \\ &= \frac{h}{4\pi} = \hbar/2 \end{aligned}$$

which is the spin of a spin-½ half-photon.

The speed $v(t)$ of the superluminal energy quantum for the spin-½ charged half-photon model derived by differentiating the position components for the superluminal energy quantum in the spin-½ charged half-photon equations above, giving

$$v_x(t) = dx(t)/dt = -\frac{\lambda\omega}{2\pi}\sin(2\omega t) = -c\sin(2\omega t)$$
$$v_y(t) = dy(t)/dt = \frac{\lambda\omega}{2\pi}\cos(2\omega t) = c\cos(2\omega t) \qquad (4)$$
$$v_z(t) = dz(t)/dt = c$$

So

$$\begin{aligned} v(t)^2 &= v_x(t)^2 + v_y(t)^2 + v_z(t)^2 \\ &= [-c\sin(2\omega t)]^2 + [c\cos(2\omega t)]^2 + c^2 \\ &= c^2[\sin^2(2\omega t)+\cos^2(2\omega t)] + c^2 \qquad (5) \\ &= c^2 + c^2 \\ &= 2c^2 \end{aligned}$$

Therefore $v(t) = \sqrt{2c^2} = c\sqrt{2}$ for the speed of the superluminal energy quantum in the spin-½ charged half-photon model.

The equations for both helically-moving superluminal energy quanta in the spin-½ charged half-photon model

In proposed the superluminal energy quantum model of a photon composed of two spin-½ charged half-photons, the two oppositely-charged superluminal energy quanta are across from each other and move together in a double helical trajectory. The equations for the superluminal energy quantum in the second spin-½ charged half-photon model are obtained by setting the *x* and *y* components of the second superluminal energy quantum equal to the negative values of the x and y components of the first superluminal energy quantum (Equation 1), while the z-component is the same for both superluminal energy quanta.

The coordinates for the pair of helically-moving superluminal energy quantum 1 and quantum 2 are given below. Now it will be made explicit that the wavelength of a half-photon is called λ_{half} to distinguish this wavelength from the wavelength λ of the photon model composed of the two half-photon models. The angular frequency of the half-photon will be called ω_{half} to distinguish it from the angular frequency ω of the photon model.

Helix 1

$$\begin{aligned} x_1(t) &= \frac{\lambda_{half}}{4\pi}\cos(2\omega_{half}t) \\ y_1(t) &= \frac{\lambda_{half}}{4\pi}\sin(2\omega_{half}t) \\ z_1(t) &= ct \end{aligned} \qquad (6)$$

Helix 2

$$\begin{aligned} x_2(t) &= -\frac{\lambda_{half}}{4\pi}\cos(2\omega_{half}t) \\ y_2(t) &= -\frac{\lambda_{half}}{4\pi}\sin(2\omega_{half}t) \\ z_2(t) &= ct \end{aligned} \qquad (7)$$

What is the relationship of the wavelength λ_{half} of a half-photon to the wavelength λ of the photon composed of two half-photons? A photon of energy E is composed of two half-photons each of energy E/2. The wavelength of photon is given by $E = h\nu = hc/\lambda$, or $\lambda = hc/E$ while the wavelength of each half-photon is given by $E/2 = h\nu_{half} = hc/\lambda_{half}$ or $\lambda_{half} = 2hc/E = 2\lambda$. This gives $\lambda = \lambda_{half}/2$. The wavelength of the photon composed of two half-photons is one-half of the wavelength of each half-photon. Since each wavelength of a half-photon is composed of two helical turns, then each helical turn of a half-photon is the same length $\lambda_{half}/2 = \lambda$ as the wavelength λ of the photon composed of the two half-photons. Similarly, the angular frequency ω_{half} of the half-photon model is half of the angular frequency of the photon model that is composed of the two half-photon models, or $\omega_{half} = \omega / 2$. This gives $\omega = 2\omega_{half}$. When the photon model's helically moving superluminal energy quantum's coordinates are expressed in terms of the photon model's wavelength λ and angular frequency ω rather than the half-photon's wavelength λ_{half} and angular frequency ω_{half}, we get the coordinates of the double-helix photon model as

Helix 1

$$\begin{aligned} x_1(t) &= \frac{\lambda_{half}}{4\pi}\cos(2\omega_{half}t) = \frac{2\lambda}{4\pi}\cos(\omega t) = \frac{\lambda}{2\pi}\cos(\omega t) \\ y_1(t) &= \frac{\lambda_{half}}{4\pi}\sin(2\omega_{half}t) = \frac{2\lambda}{4\pi}\sin(\omega t) = \frac{\lambda}{2\pi}\sin(\omega t) \\ z_1(t) &= ct \end{aligned} \tag{8}$$

Helix 2

$$\begin{aligned} x_1(t) &= -\frac{\lambda_{half}}{4\pi}\cos(2\omega_{half}t) = -\frac{2\lambda}{4\pi}\cos(\omega t) = -\frac{\lambda}{2\pi}\cos(\omega t) \\ y_1(t) &= -\frac{\lambda_{half}}{4\pi}\sin(2\omega_{half}t) = -\frac{2\lambda}{4\pi}\sin(\omega t) = -\frac{\lambda}{2\pi}\sin(\omega t) \\ z_1(t) &= ct \end{aligned} \tag{9}$$

where λ and ω are the wavelength and angular frequency of the photon composed of the two helically-circulating superluminal energy quanta of the two spin-½ half-photons.

From the above two sets of equations for the coordinates of the superluminal energy quanta in the two half-photons, it can be easily calculated that the distance D between the two superluminal quanta as they move helically opposite to each other, each with a helical radius $R = \lambda / 2\pi$, is the photon model's helical diameter $D = 2R = \lambda / \pi$

Calculation of the electric charge on each helically-circulating superluminal energy quantum in the composite photon model

In this composite photon model, the two helically-moving superluminal quanta carry an electric charge Q and –Q respectively, whose Coulomb attractive force keeps them moving in their double-helical trajectories. At the same time, each charge's x-y coordinates move in a circle with radius $\lambda / 2\pi$ and angular frequency ω. As seen from equation (2), the transverse component of momentum of each superluminal energy quantum of each half-photon is $p_{trans} = h / \lambda_{half} = h / 2\lambda = \frac{1}{2} h / \lambda = \frac{1}{2} p_{photon}$ where λ is the composite photon's wavelength and $\lambda_{half} = 2\lambda$ is the half-photon's wavelength.

The transverse momentum vector of each superluminal energy quantum is rotating in a circle at the composite photon's angular frequency ω. This produces a rate of change with time dp_{trans}/dt of this rotating transverse momentum vector. If a momentum vector of magnitude p_{trans} rotates in a circle with angular velocity ω, then the rate of change of vector momentum equals a centripetal force of value $F_{cent} = dp_{trans}/dt = \omega p_{trans}$. The Coulomb attractive force F_{coul} between the two opposite superluminal charges Q and –Q, separated by the distance D, produces this centripetal force F_{cent} on each charged superluminal energy quantum. We set these two forces equal in the following calculation and solve for Q. We use the relations $\omega = 2\pi\nu = 2\pi c/\lambda$ and $D = \lambda/\pi$, and also the relation $\alpha = e^2/4\pi\varepsilon_o\hbar c = 1/137.04$ in the following calculation to give

$$
\begin{aligned}
&F_{coul} = F_{cent} \\
&F_{coul} = dp_{trans}/dt = \omega p_{trans} \\
&\frac{Q^2}{4\pi\varepsilon_o D^2} = \omega p_{trans} \\
&\frac{Q^2}{4\pi\varepsilon_o(\lambda/\pi)^2} = (2\pi\frac{c}{\lambda})(\tfrac{1}{2}\frac{h}{\lambda}) \\
&\frac{Q^2\pi^2}{4\pi\varepsilon_o\lambda^2} = \frac{\pi ch}{\lambda^2} \\
&\frac{Q^2\pi}{4\pi\varepsilon_o} = ch \\
&\frac{Q^2\pi}{4\pi\varepsilon_o} = ch(\frac{2\pi}{2\pi}) = 2\pi c\hbar \\
&\frac{Q^2}{4\pi\varepsilon_o\hbar c} = 2 \\
&\frac{e^2}{4\pi\varepsilon_o\hbar c} = \frac{2e^2}{Q^2} \\
&\alpha = \frac{2e^2}{Q^2} \\
&Q^2 = \frac{2}{\alpha}e^2 \\
&Q = e\sqrt{\frac{2}{\alpha}} = e\sqrt{\frac{2}{1/137.04}} = e\sqrt{274.08} \\
&Q = 16.6e
\end{aligned}
\qquad (10)
$$

The electrical potential energy of the composite photon model

The double-helix photon model has point charges Q and –Q (where $Q = e\sqrt{2/\alpha}$ as above) separated by their double-helix diameter $D = \lambda/\pi$ as shown earlier. So the two charges will have an electrical potential energy $U = -Q^2/4\pi\varepsilon_o D$. A photon of wavelength λ also has energy $E = h\nu = hc/\lambda$. Let us now calculate the ratio U/E of these two energies in the electron model.

$$
\begin{aligned}
U/E &= \frac{-Q^2/4\pi\varepsilon_o D}{hc/\lambda} \\
&= \frac{(-2e^2/\alpha)/4\pi\varepsilon_o(\lambda/\pi)}{hc/\lambda} \\
&= (1/\alpha)(e^2/4\pi\varepsilon_o hc)(-2\pi) \\
&= (1/\alpha)(e^2/4\pi\varepsilon_o \hbar c)(-1) \\
&= (1/\alpha)(\alpha)(-1) \\
&= -1
\end{aligned} \qquad (11)
$$

This means that the electrical potential energy of the two electric charges forming the double-helix photon model is the negative of the energy of the photon being modeled. Since potential energy is a relative quantity, this calculation assumes that the potential energy of the two opposite electric charges in the model would be zero if they were infinitely far apart.

This result may be more meaningful if it is compared with the ratio of the electrical potential energy U to the total kinetic energy KE_{total} of two circling oppositely charged particles each with mass *m*, such as an electron and a positron with charge –e and +e forming an atom of positronium. The oppositely-charged particles circle around each other as a result of their mutual Coulomb force of attraction. Their U/KE_{total} is calculated below.

Each charged particle circles with a radius R and a centripetal acceleration $a_{cent} = v^2/R$ produced by the mutually-attractive Coulomb force $F_{coul} = ke^2/(D)^2 = ke^2/(2R)^2$, since $D = 2R$ is the separation of the two charged particles. The electrical constant k is the same as $1/4\pi\varepsilon_o$. Using Newton's 2nd law:

$$
\begin{aligned}
F &= ma \\
F_{coul} &= ma_{cent} \\
ke^2/(D)^2 &= mv^2/R \\
ke^2/(2R)^2 &= mv^2/R \\
ke^2/4R^2 &= mv^2/R \\
ke^2/4R &= mv^2
\end{aligned} \qquad (12)
$$

The electrical potential energy of the two circling charges is $U = -ke^2 / D = -ke^2 / 2R$. The total non-relativistic kinetic energy of the two circulating electron charges is $KE_{total} = 2 \times \frac{1}{2} mv^2 = mv^2$. The ratio of the electrical potential energy U to the total kinetic energy KE_{total} of the two circling charges is therefore

$$
\begin{aligned}
U / KE_{total} &= \frac{-ke^2 / 2R}{mv^2} \\
&= \frac{-ke^2 / 2R}{ke^2 / 4R} \qquad (13) \\
&= -2
\end{aligned}
$$

This means that the ratio of the electrical potential energy to photon energy in the composite photon model composed of two superluminal helically-moving electric charges is only half of the ratio of the electrical potential energy to total kinetic energy of the circling electron-positron pair.

In the case of the present photon model, the opposite electric charges on the two half-photons are “contained” by their mutually attractive Coulomb forces to move at superluminal speed along a double helix and form a composite photon. In the circling electron-positron example, the two particles are “contained” by the attracting Coulomb force to form an atom of positronium. In fact, a positronium atom only exists for a tiny fraction of a second before the electron and positron mutually annihilate to yield two or three photons. In the case of the present photon model, the two helically-circulating charges would remain the same distance apart until the photon interacted with a nucleus (as in electron-positron pair production), an electron (as in the photoelectric effect or the Compton effect) or with another charged particle.

The above superluminal energy quantum model of a photon composed of two spin-½ charged half-photons is consistent with de Broglie’s hypothesis for a two-particle composite photon composed of two spin-½ half-photons. De Broglie (5) proposed that the two spin-½ half-photons forming a photon might consist of two neutrinos having a zero or very small mass and zero or very small electric charge, compared with an electron. He also proposed that the two half-photons should have a correspondence and symmetry with each other, like the electron has with the positive hole in Dirac’s relativistic electron theory. If the two spin-½ half-photons in a composite photon are not oppositely charged, what force would hold them together as the composite photon moves through space?

Quantum waves generated by the composite photon model

In Gauthier’s (2) spin-½ charged photon model of the electron (which now should be called the spin-½ charged half-photon model of the electron) the charged half-photon composing an electron moves forward on its helical trajectory at light speed *c* to form the electron, which travels longtudinally at sub-light speed *v*. The quantum wave emitted by the charged half-photon was proposed to be a plane quantum wave function $\Phi(\vec{r},t) = Ae^{i(\vec{k}_{total}\cdot\vec{r}-\omega t)}$ where $\vec{k}_{total}$ is the wave vector of the circulating charged half-photon forming the electron and ω is its angular frequency. That quantum plane wave function when intersecting the helical axis of the charged spin-1/2 half-photon generates the electron's relativistic de Broglie wavelength $\lambda_{db} = h/\gamma mv$ along this axis.

For the composite photon model here the same basic quantum wave function formula for a plane quantum wave function can be used: $\Phi_{photon}(\vec{r},t) = Ae^{i(\vec{k}\cdot\vec{r}-\omega t)}$ where $\vec{k} = 2\pi/\lambda$ is the wave vector of a plane wave of electromagnetic radiation for the double-helix photon model of wavelength λ, and ω is the angular frequency of the photon model. Or each half-photon in the composite photon could emit such a wave function, producing an entangled composite quantum wave function emitted by the composite photon. This needs to be investigated further. So the photon model generates its quantum wave function as it moves forward at light speed, and this wave function predicts the probability of finding the photon in a future place and time. This wave function would be suitable for a photon in a coherent beam of electromagnetic radiation such as a laser beam, where such a plane quantum wave function is a good description of the distribution of photons in the laser beam as a whole.

The composite photon model and electron-positron pair production

An electron and a positron are produced most commonly when a photon of sufficient energy (greater than 1.022 MeV, corresponding to the combined mass of an electron and a positron) passes near an atomic nucleus. This is one example of electron-positron pair production. The present composite photon model lends itself to a relatively straightforward (if oversimplified) explanation of this process. When the composite photon is in the sufficiently strong electric field of an atomic nucleus, the electric field of the nucleus acts on the two helically-moving electric charges in the composite photon and causes the two spin-½ charged half-photons to reduce their electric charge from $\pm 16.6e$ to $\pm 1e$. The electric charges are now no longer large enough to attract each other sufficiently to maintain their double-helical trajectory. The two spin-½ charged half-photons, now with charges *e* and -*e*, separate and the two spin-½ charged half-photons curl up separately to form an electron and a positron. By curling up, the two spin-½ charged half-photons each gain the electron's mass *m* of 0.511 Mev/c^2 that they did not have when travelling together in the composite photon.

The fine structure constant $\alpha = 1/137.06$ in the composite photon model

A surprising result of the new composite superluminal double-helix photon model is that its two electric charges Q and –Q on the circulating superluminal energy quanta are related to the electron's charge *e* by the fine structure constant alpha: α = 1/137.06 from quantum electrodynamics (QED) by $Q = e\sqrt{2/\alpha} = 16.6e$. Alpha is the measure of the strength of interaction between an electron and a photon in quantum electrodynamics (QED). Whether this result can lead to a better understanding of the photon or QED or both, remains to be seen.

Is the composite photon model internally entangled?

Two particles such as two electrons or two photons are said to be quantum-mechanically entangled if they function as a single quantum object or system. The quantum wave function of an entangled pair of particles is not just the linear sum of the quantum wave functions of the two individual particles. Measurement of the quantum state of one of the two particles immediately produces a corresponding quantum state of the second particle, even if the particles are separated beyond the possibility of light-speed communication between them. The concept of quantum-mechanical entanglement was discovered by Einstein, Podolsky and Rosen (8), and given the name "entanglement" ("verschränkung") by Schrödinger (9). It was first experimentally confirmed by Aspect et al (10).

When a photon is transformed into an electron-positron pair by passing near an atomic nucleus, the produced electron-positron pair is quantum-mechanically entangled since the photon's spin-1 is conserved in the process of producing two spin-½ particles. I propose that the two spin-½ half-photons forming a composite photon, as suggested by de Broglie (4), are also quantum mechanically entangled. This means that the quantum mechanical states of the two helically circulating superluminal energy quanta composing the two spin-½ charged half-photons that compose the proposed photon model are quantum-mechanically entangled. The two circulating superluminal energy quanta function together as a single quantum object—the photon. Measurement of the quantum mechanical state of one superluminal energy quantum (or one spin-½ charged half-photon) would immediately put the other superluminal energy quantum into a corresponding quantum mechanical state consistent with the quantum mechanical state of the composite photon.

If the proposed composite photon model is internally quantum-mechanically entangled, this could make it more difficult to separately detect or measure the two superluminal energy quanta composing a photon. If the two charged superluminal energy quanta are detected separately, it may be because the detection process has triggered the transformation of the composite photon into an electron-positron pair. The composite photon model makes the strong experimental prediction that two opposite entangled charges of magnitude $Q = e\sqrt{2/\alpha} = 16.6e$ will be found on close experimental examination of the photon during the process of electron-positron pair production.

Possible criticisms of the new composite photon model

The author is aware of a number of possible criticisms of the proposed internally superluminal composite photon model.

1) It is superluminal. No particles are known to travel faster than light speed in a vacuum.
2) It is composite. There is no current experimental evidence that a photon is a composite particle.
3) A photon doesn't radiate energy. Accelerating charges in helical motion should radiate energy according to classical electromagnetic theory.
4) Photons don't produce only electron-positron pairs. Higher energy photons can produce pairs of more massive particle-antiparticle pairs also. The present composite photon model is oversimplified.
5) Light waves easily pass through each other. The circulating internal charges of different photons would interact with each other and disturb their photon trajectories, which doesn't happen.
6) What causes wave-particle duality if the photon model is only composed of two helically-circulating superluminal charged particles?
7) How does the composite photon model produce linearly and elliptically polarized light, or light with orbital angular momentum as well as spin?

The above basic criticisms and questions (there may be many others) can be briefly responded to:

1) The proposed superluminal energy quanta composing the photon model are not particles in the traditional sense but are fundamental quantum entities proposed to compose the known particles like photons and electrons and give them their quantum wave-particle nature. Particles composed of superluminal energy quanta, such as the photon and the electron, would not themselves travel faster than light, or even at light speed (in the case of an electron or other particles with mass.)
2) There are other composite particles such as protons, neutrons and mesons that are composed of quarks. But it took decades to establish this experimentally.
3) The ground state of a hydrogen atom also doesn't radiate energy although it contains an accelerating electron, which should radiate according to the classical laws of electromagnetism. So new laws about radiation may apply to superluminal energy quanta composing photons and electrons.
4) The double-helical model for the photon proposed here would be a simplified model of a future, more realistic photon model capable of producing different particle-antiparticle pairs, including neutral particles, from photons of higher energies.
5) While light waves pass easily through each other, the mutually entangled pairs of superluminal charged energy quanta may not interact with other photons due to their own quantum-mechanical self-entanglement. Or their average effect on other photons may be negligible.
6) The proposed superluminal energy quanta composing the two spin-½ charged half-photons composing a photon are proposed to generate an entangled quantum wave function that statistically predicts where the photon will be found in the future. Such quantum wave functions from superluminal energy quanta are the source of the quantum wave-particle nature of matter and energy.
7) Light comes in a variety of polarization states. But when a single photon is detected, it in only in one of two states, either spin-up or spin-down. Other

polarization states of light are quantum mechanical combinations of these two basic photon states. The composite photon modeled here could be the photon as it is detected, not the superposition of quantum-mechanical states describing a photon at other times.

There will be other criticisms of the proposed superluminal double-helix model of the photon, and the author will be pleased to hear them. Perhaps an even better model of the photon and its underlying energy structure will be the outcome.

Conclusions

A double-helical internally-superluminal quantum-mechanically self-entangled composite model of the photon is proposed. It is composed of two spin-½ charged half-photons consistent with de Broglie's hypothesis of a composite photon composed of two spin-½ half–photons. The model suggests a new approach to modeling electron-positron pair production. Due the calculated charge $Q = \pm e\sqrt{2/\alpha} = \pm 16.6e$ on the two helically-circulating superluminal charges in the composite photon model, a possible connection of the photon model to quantum electrodynamics (QED) is suggested, and a strong experimental test of the composite photon model is provided.

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Note: In 2002, while living in Europe, I published and copyrighted an article on an earlier version of the present superluminal double-helix composite photon model. The earlier version contains the main quantitative features of the present model but without reference to de Broglie’s half-photon hypothesis, which I had not heard of at that time. The article is entitled “Dumbons and Photons” and was published on the internet in English in a Dutch blog at the alternative energy site http://nulpuntenergie.net in 2005. Fortunately I kept a copy. The dumbon (looks like a dumbbell) model of the photon evolved into my single superluminal quantum model of the photon. The present article seems to be closing a circle, or hopefully a spiral.

Just before publishing the present article, I found an article on the internet by Oreste Caroppo titled “The photon double-helicoidal model”, dated March 21, 2005, at http://caroppophotonmodel.blogspot.com. The article describes a composite photon model with the same quantitative features as the present model (and my earlier model) and the same idea of half-photons (demi-photons) but without reference to de Broglie’s hypothesis. The article contains no references, but it clearly independent of my 2002 article. I recommend it to readers. There may be other superluminal double-helix models of the photon “out there” as well. Perhaps the superluminal double-helix model of a photon is an idea whose time has come.

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