Matter-light duality and speed greater than light

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Abstract

In this paper we demonstrate duality between matter and light. Through mathematical derivation we show that every fundamental matter particle with non-zero rest mass can be represented by a pair of photons. The photons in the representation are not normal photons but a special kind of continuously generating and annihilating virtual photons, whose wave functions super impose to give the wave function of the non-zero rest mass particle and the representation is in agreement with the spin of the particle. We use this duality to derive De Broglie wavelength. We show that a moving matter wave has two frequency components, one of it is with De-Broglie wavelength **h/P** and the other one is with wavelength **hc/E**. We also correct the De-Broglie wavelength for $\boldsymbol{v} = \mathbf{0}$ where we show that there is only one frequency component for $\boldsymbol{v} = \mathbf{0}$ with wavelength **hc/E**. Later in the paper we derive that every photon can be represented by a non-zero rest mass particle pair, one going below the speed of light and the other going above the speed of light.

Keywords: Matter light duality, Speed greater than light.

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I. INTRODUCTION

Matter and light have been considered as composed of two different kind of particles; while matter particles have a non-zero rest mass, the light particles have zero rest mass. They are associated with different speeds; the speed of light is always same in all frames of reference but matter particles can never be accelerated to the speed of light [1]. Though both of these statements are correct, these do not rule out the possibility of quantum jumping particles from speeds less than light to speed greater than light [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [1] [13] [14] [15].

It has been very difficult to break the speed of light barrier because the model of the fundamental particles is not complete. In this paper we propose a simpler and a more fundamental model with a few simple observations about the equations of energy and momentum. Using these observations we propose duality between matter and light and prove that this duality is consistent with the existing definition of energy and momentum.

In the section II we propose and validate the first part of the matter and light duality, which is that every non-zero rest mass particle can be represented by a photon pair. The photons in the representation are not normal photons but a special kind of continuously generating and annihilating virtual photons, whose wave functions super impose to give the wave function of the non-zero rest mass particle and the representation is in agreement with the spin of the particle. Using this result in we prove that a matter wave is composed of two frequency components, one with the wavelength equal to De-Broglie wavelength $\lambda = h / P$ [16] and the other component with the wavelength $\lambda = hc / \mathrm{E}$.

In the section III we propose and validate the second part of the duality; representation of a photon as non-zero mass particle pair with one particle with speed less than light and the other particle with speed greater than light. We further derive energy, momentum and γ for the particles with speed greater than light.

II. PARTICLE WITH NON-ZERO REST MASS REPRESENTATION AS A PHOTON PAIR

<TODO> Model of a non-zero rest mass particle as photons in Feynman Diagram

Statement 1:

Let there be a non-zero rest mass particle **P**, stationary in an inertial frame of reference **B** and moving with a non-zero velocity $\vec{V}$ w.r.t. frame of reference **A**. Then **P** can be represented by a photon pair; first photon in the $\vec{V}$ direction and the second one in the $-\vec{V}$ direction in the frame of reference **A.** In the case of $\vec{V} = \vec{0}$, direction becomes singular, which means the photon pair can be assumed to be going in any direction with the first photon in exactly opposite direction of the second photon.

Model:

Validation of statement 1 for Energy and Momentum:

Let us take a pair of photons with frequency ω in reference frame **B.** If we take $\vec{n}$ as the unit vector in the direction of $\vec{V}$ then in frame of reference **B**:

Total energy of the photon pair in B is:

$$E_b = \hbar\omega + \hbar\omega = 2\hbar\omega \qquad \ldots (1)$$

Total momentum of the photon pair in in B is:

$$\vec{P}_b = \hbar\vec{n}\omega / c - \hbar\vec{n}\omega / c = \vec{0} \quad \ldots (2)$$

Now let us consider the frame of reference **A.** In **A** the photons undergo Doppler shift as:

Energy of the away going photon in A is:

$$E_1 = \hbar\omega\sqrt{\frac{1 - v/c}{1 + v/c}}$$

Energy of the in-coming photon in A is:

$$E_2 = \hbar\omega\sqrt{\frac{1 + v/c}{1 - v/c}}$$

Where $\left\|\vec{V}\right\| = v$

Thus total energy of the photon pair in A is:

$$E_a = E_1 + E_2 = \hbar\omega\sqrt{\frac{1 + v/c}{1 - v/c}} + \hbar\omega\sqrt{\frac{1 - v/c}{1 + v/c}}$$

$$= \hbar\omega\left(\frac{1 + v/\mathrm{c} + 1 - v/\mathrm{c}}{\sqrt{1 - v^2/c^2}}\right) \quad \ldots (3)$$

$$= 2\hbar\omega\left(\frac{1}{\sqrt{1 - v^2/c^2}}\right)$$

From (2) & (3)

$$E_a = \frac{E_b}{\sqrt{1 - v^2/c^2}} = \gamma E_b \quad \ldots (4)$$

Similarly momentum in A is:

$$\vec{P}_a = \hbar\omega/c\sqrt{\frac{1 + v/c}{1 - v/c}}\vec{n} - \hbar\omega/c\sqrt{\frac{1 - v/c}{1 + v/c}}\vec{n}$$

$$= \hbar\omega/c\left(\frac{1 + v/\mathrm{c} - 1 + v/\mathrm{c}}{\sqrt{1 - v^2/c^2}}\right)\vec{n} \quad \ldots (5)$$

$$= 2\hbar\omega\left(\frac{v/c^2}{\sqrt{1 - v^2/c^2}}\right)\vec{n}$$

From (4) & (5)

$$\vec{P}_a = E_a / c^2\vec{V} = \gamma E_b / c^2\vec{V} \quad \ldots (6)$$

Equations (4) and (6) are the equations of mass and momentum transformations for non-zero mass matter particle across frame of reference.

The above proves that the representation works well with the relativistic momentum and energy transformations. From the above we can define the relation of the rest mass of the particle and the photon frequencies as:

$$E_b = \hbar\omega + \hbar\omega = 2\hbar\omega = mc^2$$

$$\Rightarrow m = 2\hbar\omega / c^2 \qquad \ldots (7)$$

A. Derivation of De-Broglie wavelength

As we have shown in the proof of the statement 1 that non-zero mass particle can be represented by 2 photons, let assume the particle **P** matter wave equation is given by the sum of 2 light waves opposite direction, which means:

$$A_P = A_+ + A_-$$

As the frequency of A_+ wave is given by $\omega\sqrt{\frac{1+v/c}{1-v/c}}$ and of A_- wave is given by $\omega\sqrt{\frac{1-v/c}{1-v/c}}$ in the frame of reference **A,** the sum of them leads to 2 frequencies:

$$\omega_1 = \omega\left(\sqrt{\frac{1+v/c}{1-v/c}} + \sqrt{\frac{1-v/c}{1+v/c}}\right) = 2\gamma\omega \qquad \ldots (8)$$

$$\omega_2 = \omega\left(\sqrt{\frac{1+v/c}{1-v/c}} - \sqrt{\frac{1-v/c}{1+v/c}}\right) = 2\gamma\omega v / c \qquad \ldots (9)$$

Substitute ω from equation (7) in equation (13)

$$\omega_2 = 2\gamma\left(\frac{c^2 m}{2\hbar}\right)v / c$$

$$\Rightarrow \omega_2 = \frac{cmv\gamma}{\hbar}$$

$$\Rightarrow \omega_2 = \frac{c\left|\vec{P}\right|}{\hbar}$$

$$\Rightarrow \lambda_2 = 2\pi c / \omega_2 = \frac{2\pi\hbar c}{\left|\vec{P}\right| c} = \frac{h}{\left|\vec{P}\right|} \qquad \ldots (10)$$

(10) is the De-Broglie wavelength.

In the above result we get another component ω_1 of the frequency as follows:

$$\omega_1 = 2\gamma\left(\frac{c^2 m}{2\hbar}\right)$$

$$\Rightarrow \omega_1 = \frac{cm\gamma}{\hbar} = \frac{E}{\hbar c}$$

$$\Rightarrow \lambda_1 = 2\pi c / \omega_1 = \frac{2\pi\hbar c}{E} = \frac{hc}{E} \qquad \text{… (11)}$$

B. Wavelength at speed 0

At speed = 0 there is a singularity in direction and there is only one component of matter wave with the wavelength $\lambda = hc / E$

<TODO> We need to look at the spin and other QM aspects.

III. PHOTON REPRESENTATION AS TWO PARTICLES WITH NON-ZERO REST MASS

<TODO> Model of photon as electron pair in Feynman Diagram

Statement 3:

Any photon can be represented as a pair of non-zero electrons, one going below the speed of light and the other going above the speed of light. If u is the speed of the non-zero mass particle below the speed of light in the opposite direction of photon, c^2 / u is the speed of the other non-zero mass particle above the speed of light in the direction of photon.

Validation:

As per [17] [18] the energy and momentum of a particle going above the speed of light is given by:

$$E_{v>c} = -mc^2 / \sqrt{v^2 / c^2 - 1}$$

$$P_{v>c} = -mv / \sqrt{v^2 / c^2 - 1}$$

If we take $v = c^2 / u$

$$E_{c^2/u} = -mc^2 / \sqrt{c^2 / u^2 - 1} = -mcu / \sqrt{1 - u^2 / c^2} \qquad \text{… (12)}$$

$$P_{c^2/u} = -(mc^2 / u) / \sqrt{c^2 / u^2 - 1} = -mc / \sqrt{1 - u^2 / c^2} \qquad \text{… (13)}$$

Also

$$E_u = mc^2 / \sqrt{1 - u^2 / c^2} \qquad \text{… (14)}$$

$$P_u = mu / \sqrt{1 - u^2 / c^2} \qquad \text{… (15)}$$

Adding (12) & (14)

$$E_p = mc^2 / \sqrt{1 - u^2 / c^2} - mcu / \sqrt{1 - u^2 / c^2}$$

$$\Rightarrow E_p = mc^2 \left(\frac{1 - u/c}{\sqrt{1 - u^2/c^2}} \right)$$

$$\Rightarrow E_p = mc^2 \left(\sqrt{\frac{1 - u/c}{1 + u/c}} \right) \qquad \ldots (16)$$

Adding (13) & (15)

$$P_p = mu/\sqrt{1 - u^2/c^2} - mc^2/\sqrt{1 - u^2/c^2}$$

$$\Rightarrow P_p = -mc^2 \left(\frac{1 - u/c}{\sqrt{1 - u^2/c^2}} \right)$$

$$\Rightarrow P_p = -mc^2 \left(\sqrt{\frac{1 - u/c}{1 + u/c}} \right) \qquad \ldots (17)$$

From (16) & (17)

$$E_p / P_p = -c$$

The above ratio of energy and momentum means that the combine energy and momentum of the pair of electrons one going below the speed of light and one going above the speed of light has the same momentum and energy of a photon. **<TODO>** We will look at the spin and other QM aspects.

References

[1] N. D. Mermin, "It's About Time: Understanding Einstein's Relativity. Princeton University Press," Princeton University Press, 2005.

[2] I. Newton, "Axioms or Laws of Motion," *The Mathematical Principles of Natural Philosophy,* vol. 1, p. 19, 1729.

[3] I. Newton, "Section 1," *The Mathematical Principles of Natural Philosophy,* vol. 1, p. 41, 1729.

[4] J. v. Mayer, "Remarks on the forces of inorganic nature," *Annalen der Chemie und Pharmacie,* vol. 43, p. 233, 1842.

[5] W. R. Grove, The Correlation of Physical Forces, London: Green Longmans, 1874.

[6] A. Einstein, "Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig?," *Annalen der Physik,* vol. 323, pp. 639-641, 1905.

[7] A. Einstein, " Zur Elektrodynamik bewegter Körper," *Annalen der Physik,* vol. 322, no. 10, pp. 891-921, 1905.

[8] A. Einstein, "Über das Relativitätsprinzip und die aus demselben gezogenen Folgerungen," *Jahrbuch der Radioaktivität und Elektronik,* vol. 4, pp. 411-462, 1908.

[9] H. Poincaré, "Sur la dynamique de l'électron (On the Dynamics of the Electron)," *Comptes Rendus,* vol. 140, pp. 1504 - 1508, 1905.

[10] R. W. Hadden, On the shoulders of merchants: exchange and the mathematical conception of nature in early modern Europe, SUNY Press p 13, 1994.

[11] A. Einstein, Relativity: The special and general theory, by Albert Einstein. Translated by Robert W. Lawson., New York: Henry Holt and Company, 1920.

[12] A. Einstein, "E = mc2: the most urgent problem of our time," *Science illustrated,* vol. 1, no. 1, pp. 16-17, 1946.

[13] M. Planck, "On the Dynamics of Moving Systems," in *Sitzungsberichte der Königlich-Preussischen Akademie der Wissenschafte,* Berlin, Erster Halbband, 1907, pp. 542-570.

[14] D. Topper, "Einstein's 1934 two-blackboard derivation of energy-mass equivalence," 2007. [Online]. Available: http://www.relativitycalculator.com/pdfs/einstein_1934_two-blackboard_derivation_of_energy-mass_equivalence.pdf.

[15] I. Newton, "Definitions," *The Mathematical Principles of Natural Philosophy,* vol. 1, p. 1, 1729.

[16] L. d. Broglie, "Recherches sur la théorie des quanta (Researches on the quantum theory)," *Ann. Phys. (Paris),* pp. 3, 22, 1924.

[17] R. P. Feynman, "The Theory of Positrons," *Physical Review*, vol. 76, no. 6, pp. 749-759, 1949.

[18] R. Feynman and . A. Hibbs, Quantum Mechanics and Path Integrals, New York: McGraw-Hil, 1965.

[19] V. P. S. P. Shalender Singh, "Extended principle of relativity beyond speed of light and a method to push particles beyond the speed of light," *Research Gate*, 2014.

[20] J. M. H. a. B. J. Cox, "Einstein's special relativity beyond the speed of light," *Proceedings of the Royal Society 'A'*, vol. 468, no. 2148, pp. 4174-4192, 2012.