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Superluminal Electron-Positron Pair

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Abstract

It is deduced that when an electron and a positron form a stable structure, the dimensionless speed of either of them, $\alpha = v/C$, where C is speed of light, satisfies the so-called basic equation of $\alpha^2 - b\alpha + 1 = 0$, where b is the reciprocal of a , the fine structure constant of a hydrogen atom. One of solutions to the basic equation, the superluminal speed, $\tilde{\alpha}_1 = b = 137.036$, represents a superluminal pair of electron and positron, in which there is the Lorentz force only while neglecting the Coulomb force between the two particles at an ultrahigh speed. Another solution stands for a positronium with a short-lived life time. The superluminal pair of electron and positron or superluminal electron-positron pair consists of an electron and a positron moving at a superluminal speed of $\tilde{v}_1 = bC$ and has a stable quantized energy system with quantized energy of $\tilde{E}_n = 2m_{0e}\tilde{v}_n^2 = n\hbar\tilde{\mathcal{V}}_n$ where $\tilde{v}_n = nbC$ with n being an integer, and is able to radiate and absorb rays of electrons and positrons with ultrahigh energy. The superluminal electron-positron pair may possibly be a particle of dark matter. A divided superluminal electron-positron pair on an energy level n can release electrons and positrons, moving at a superluminal speed of $\tilde{v}_n = nbC$, which may possibly be particles of dark energy as well. Therefore, we are led to conclude that there might exist quantized superluminal motions of electrons and positrons in the universe.

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1. Introduction

Einstein believed that speed of light is the upper limit of speed of any particle of matter. This is determined by his theory of relativity. However, the ratio of visible matter to the total matter in the universe is less than 5 % while invisible matter takes more than 95 % of the total [1-11]. As shown in this article, it is reasonably anticipated that there might be superluminal electrons in the invisible matter -dark matter.

Starting from the stable structure of an electron and a positron led to by the deduced basic equation which both the electron and positron obey. The superluminal solution to the basic equation represents a superluminal electron-positron pair (SEPP) that consists of an electron and a positron moving at a superluminal speed. The SEPP may possibly be a particle of dark matter, whereas energy of the SEPP in a free state may be a particle of dark energy. It is correspondingly concluded that there possibly exist superluminal motions of electrons and positrons in the universe.

Historically, the substance composed of an electron and a positron under the action of the Coulomb interaction is termed a positronium that is a hydrogen-like atom with a life time of nanoseconds [12-16]. Positronium is an old topic investigated and discussed by many theoretical and experimental authors for several tens years since positron was predicted by P. Dirac from relativistic theory of electrons in 1928 and experimentally discovered by C. D. Anderson in 1932 [17]. However, there was no exception that the hydrogen-like substance is unstable and both of particles are undoubtedly moving at a subluminal speed. It is shown below that a stable structure of substance composed of an electron and a positron is able to be formed, when they approach to each other under a certain condition exerted by the Lorentz force only in comparison with the negligible Coulomb force, and is by no means the positronium. In this substance two particles are whirling at a superluminal speed around a momentary center of mass relative to each other. The substance might be a particle of dark matter.

2. Basic Equation

Based on the fact that a charged particle in motion undergoes the Coulomb and Lorentz forces produced by another moving particle with charge, as shown in Fig. 1, when an electron and a positron move towards but apart from each other *by* R at the same speed v in opposite direction, it is possible for the two particles to form a stable structure of matter due to interaction under the certain condition. This is because either of the particles may be treated as the center of a momentary circular motion of the other one as shown in Fig. 2. The necessary and sufficient condition leading to this possibility is the force acted on between two particles is the Lorentz force only, which is true when the speed v is as high as superluminal.

In general, the momentary circular motion of the electron in Fig. 1 is simultaneously exerted by the Coulomb and Lorentz forces, obeying the equation of motion of

$$m_e v^2 / R = e^2 / 4\pi\epsilon_0 R^2 + \mu_0 e^2 v^2 / 4\pi R^2. \quad (1)$$

According to the Bohr's quantum assumption of angular momentum,

$$m_e R v = \hbar, \quad (2)$$

where $\hbar = 2\pi\hbar$ is the Plank constant; ϵ_0 and μ_0 are the dielectric constant and magnetic permulbility, respectively. If R is reduced from both sides in Eq. (1), the rest is the equation of energy relation.

Introducing the dimensionless speed of electron.

$$\alpha = v/C, \quad (3)$$

where C is the speed of light in vacuum. On account of $\mu_0\epsilon_0 c^2 = 1$. Based on Eqs. (1)-(3), we are led to an important relation that may be called the basic equation.

$$\alpha^2 - b\alpha + 1 = 0 \quad (4)$$

This equation describes the law which the dimensionless speed follows. In Eq. (4) b is just the reciprocal of the fine structure constant a of a hydrogen atom ($ab = 1$) which is given by

$$b = 2\hbar\epsilon_0 C / e^2 = 137.0360 \quad (5)$$

There are two solutions to the basic equation, α_1 and α_2 , which are found to be reciprocal to each other, i. e. they satisfy that

Fig.1 Electron & positron moving towards but apart from each other by R at the sane speed v in opposite direction

Fig. 2 Momentary circular motion of electron

$$\alpha_1 \alpha_2 = 1 \quad (6)$$

$$v_1 v_2 = C^2 \quad (7)$$

Each of the solutions can be expanded to a power law series as shown below

$$\alpha_1 = b[1 - b^{-2} - b^{-4} - o(b^{-6})] > 1 \quad (8)$$

$$\alpha_2 = a[1 + a^2 + 2a^4 + o(a^6)] < 1 \quad (9)$$

Eqs. (8) & (9) correspond to the two solutions of the electron-positron pair, in which both particles are making a circular motion at either superluminal or subluminal speed. Their relevant approximate solutions are given by

$$\tilde{\alpha}_1 = b = \tilde{v}_1/C = 137.036 \quad (10)$$

$$\tilde{\alpha}_2 = a = \tilde{v}_2/C = 7.29735 \times 10^{-3} \quad (11)$$

Obviously, the two approximate solutions meet the relations

$$\tilde{\alpha}_1 \tilde{\alpha}_2 = 1 \quad (12)$$

$$\tilde{v}_1 \tilde{v}_2 = c^2, \quad (13)$$

where the subscript 1 represents a superluminal and 2 stands for a subluminal motion, respectively (the same below except that explained otherwise). The approximate subluminal solution $\tilde{\alpha}_2$ is for a hydrogen-like atom, the so-called positronium under the action of the Coulomb force only and its fine structure constant is the dimensionless speed of electron, i.e., $\tilde{\alpha}_2 = a = 7.29735 \times 10^{-3}$ and its speed is equal to $\tilde{v}_2 = aC$ that is clearly subluminal and much less than the speed of light, which has been investigated for many years [12-16] and we do not intend to discuss it in this article. In contrast, the superluminal approximate solution of $\tilde{\alpha}_1$ stands for a pair of electron and a positron moving at a superluminal speed. They are associated with each other by the strong Lorentz force and thus called the superluminal electron-positron pair (SEPP).

3. Solution of a Superluminal Electron-Positron Pair

3.1 Parameters of Electron in a Superluminal Motion

When only the Lorentz force is exerted on an electron-positron pair while the Coulomb force is negligible, which is true at as high as a superluminal speed from Eq. (1), the dimensionless speed of two particles in motion described by Eq. (4) is simplified to $\alpha^2 - b\alpha = 0$, and hereby, the approximate solution is so simple that $\tilde{\alpha}_1 = \alpha = b$, According to Eq. (10), the speed $\tilde{v}_1 = bC =$ constant. It means that the electron and positron have been coupled to be one entity due to the

Lorentz force, making a circular motion at the superluminal speed of $\tilde{v}_1 = bC$ around the momentary center of mass of the other particle, resulting in a SEPP. Based on the reciprocal relation, Eq. (6), between subluminal and superluminal speeds and the fact that the speed of light C is a singularity of mass for a subluminal motion from Einstein's relativity, it is reasonably believed that for a superluminal motion the speed of light C is also the singularity of mass, i.e., the mass approaches to infinity when speed tends to the speed of light C and the superluminal mass-speed relation can thus be written as

$$m_e = m_{0e} / \sqrt{1 - 1/\alpha^2} \quad (14)$$

where $\alpha > 1$. Eq. (14) is applicable to all the superluminal solutions, including those on energy levels, which are reciprocal to the subluminal solutions, and also indicates that when a particle is in a superluminal motion of α , its mass is equal to the one in the subluminal motion of $1/\alpha$. Substantially, Eq. (14) is one more expression of the subluminal mass-speed relation under special circumstances of two dimensionless speeds reciprocal to each other. When $\alpha \rightarrow 1$, $m_e \rightarrow \infty$, whereas for $\alpha \gg 1$, $m_e \rightarrow m_{0e}$. The superluminal curve is hence approximately symmetrical about the speed of light ($\alpha = 1$) on the dimensionless mass-speed plane (Fig. 3), resulting in a conclusion that the mass of electron in a superluminal motion remains almost the same as the rest mass m_{0e} and other parameters are given by the following. When $\alpha = \tilde{\alpha}_1 = b$, the mass of electron $m_e = m_{0e}$, and all the parameters of electron are given by

Fig. 3 Dimensionless mass-speed relation

$$m_e = m_{0e} \quad (15-1)$$

$$\tilde{v}_1 = \tilde{\alpha}_1 C = bC = 4.10824 \times 10^{10} \text{ m/s} \quad (15-2)$$

$$\tilde{R}_1 = \hbar / 2\pi m_{0e} \tilde{v}_1 = 2.81794 \times 10^{-15} \text{ m} \quad (15-3)$$

$$\tilde{E}_{1,e} = -m_{0e} \tilde{v}_1^2 = -9.59592 \text{ GeV}, \quad (15-4)$$

where Eq. (15-3) is obtained from Bohr's quantization of angular momentum of the electron or

positron in its momentary circular motion, but it is also easy to get from Eq. (1) in which drop off the the last term - the contribution of the Lorentz force on the right side hand of the equation. If so, it is verified that the Bohr quantization condition of angular momentum remains valid for a superluminal motion; $\tilde{E}_{1,e}$ is the sum of kinetic and potential energies of electron. The absolute value of potential energy equals double kinetic energy and $\tilde{E}_{1,e}$ is therefore negative, implying that the potential is prevailing. The double absolute value of $\tilde{E}_{1,e}$ is the binding energy of electron and positron, which is greater than the binding energy of atomic nuclei by four orders of magnitude. Moreover, according to Eq. (8), all the perturbative terms expressed in terms of b show that the existence of the Coulomb force is to vary parameters of electron slightly. Therefore, in analogy to the fine structure constant a of a hydrogen atom, its reciprocal $b = 1/a$ can be viewed as the fine structure constant of the SEPP as well as the dimensionless speed of electron in motion ($\tilde{\alpha}_1 = b$).

3.2 Structure Picture of a Superluminal Electron-Positron Pair

Assuming that the charge of an electron is uniformly and symmetrically distributed over a sphere, the mass energy of the electron itself, $m_{0e}C^2 = e^2/8\pi\epsilon_0 R_e = W_e$, where W_e is the energy of the electrostatic field of the electron with a radius of $R_e = 1.408971 \times 10^{-15} m$, which is calculated from the above relation. Noting that in the superluminal approximate solution the radii of R_e and $\tilde{R}_e$ are identical, compared with Eq.(15-3), it is obtained that

$$\tilde{R}_1 = 2\tilde{R}_e \quad (16)$$

Fig. 4 Sketch of a SEPP Structure

The radius of electron $\tilde{R}_e$ is also an approximation and variable slightly. This equation means that the distance between the electron & positron in the superluminal approximate solution is equal to the sum of the spin radii of electron and positron. The zero Coulomb force between the electron and positron is just the necessary and sufficient condition for the superluminal approximate solution, indicating that the distance between the electron and positron reaches its extreme value under the action of the strong Lorentz force. As shown in Fig. 4, the electron and positron are

located on the two ends of the connecting line $\tilde{R}_1$ and make a momentary circular motion with a radius of the connecting line $\tilde{R}_1$ around the center of mass of the other . This is a circular motion of two point masses connected to be like a dumbbell due to the Lorentz force.

3.3 Stability of a Superluminal Electron-Positron Pair

The electron and positron in a SEPP is apart from each other by $\tilde{R}_1$. We are now discussing the stability of the solution near $\tilde{R}_1$. At an arbitrary place R near $\tilde{R}_1$, both the electron and positron have kinetic and potential energies. Nevertheless, the potential energy has two parts: the Coulomb potential and the equivalent one from the Lorentz force, as can be seen below. Neglecting the slight change of speed $\tilde{v}_1 = bC$ and noting that $\mu_0 \epsilon_0 c^2 = 1$, either of the electron and positron is exerted by the Lorentz force $\mu_0 e^2 \tilde{v}_1^2 / 4\pi R^2 = b^2 e^2 / 4\pi \epsilon_0 R^2$ that is equal to a force produced by the equivalent electrostatic potential energy $-b^2 e^2 / 4\pi \epsilon_0 R$; Thus, the total energy of two particles in the SEPP is given by $\tilde{E}_{1,e}(R) = E_{k1} + E_{p1} = \hbar^2 / (4\pi^2 m_{0e} R^2) - 2b^2 e^2 / 4\pi \epsilon_0 R$. Making a derivative with respect to R and letting it be zero, the location at which energy reaches its extreme value is given by

$$R_{01} = \hbar^2 \epsilon_0 / \pi m_{0e} e^2 b^2 = 2.81794 \times 10^{-15} \text{ m} = \tilde{R}_1 \quad (17)$$

Since the second-order derivative of $E_{1,e}(R)$ at $\tilde{R}_1$ is greater than 0, the potential energy reaches its minimum of $\tilde{E}_{1,e}(\tilde{R}_1) = -b^2 W e = -m_{0e} \tilde{v}_1^2$, i. e., the potential energy of the electron and positron possess the minimum value when they are apart from each other by $\tilde{R}_1$ and thus the SEPP is stable.

What is the effect of the Coulomb force neglected? According to Eq. (9), neglecting all the terms of orders higher than a^4 (inclusive of), the increase of speed is $\Delta \tilde{v}_2 = a^3 C$. It means that the role of the Lorentz force is to expedite particles in the subluminal approximate solution. In contrast, in the superluminal approximate solution the existence of the Coulomb force arouses a change of speed, but it is a decrease. Because two approximate solutions satisfy $\tilde{v}_1 \tilde{v}_2 = C^2$, i. e., $\tilde{v}_1 \Delta \tilde{v}_2 + \tilde{v}_2 \Delta \tilde{v}_1 = 0$. On account of $\Delta \tilde{v}_2 > 0$, in the superluminal approximate solution $\Delta \tilde{v}_1 = -(\tilde{v}_1 / \tilde{v}_2) \Delta \tilde{v}_2 = -aC < 0$. The same result can also be directly obtained only if ignoring all the terms of order higher than b^{-4} (inclusive of) in Eq. (8). This shows that the existence of the Coulomb force in the superluminal approximate solution does not increase, instead, decrease the speed of both of electron and positron. This results in a conclusion that the Coulomb force between the electron and positron is outward the momentary center of mass and hence repulsive! As can be seen here, It is completely beyond the ordinary expectation that the Coulomb law behaves reversely when the two particles with opposite charges are in a superluminal motion.

Also, the above result can be otherwise derived. If we use the subscript c to denote the effect

of the Coulomb force on parameters of either of the paired particles, its speed and position are represented by $\tilde{v}_{1,C}$ and $\tilde{R}_{1,C}$, respectively, and satisfy the equation below.

$$m_{0e}\tilde{v}_{1,C}^2/\tilde{R}_{1,C} = f_{1,L} + f_{1,C} \quad (18-1)$$

$$m_{0e}\tilde{R}_{1,C}\tilde{v}_{1,C} = \hbar, \quad (18-2)$$

where the Lorentz force is approximately expressed by $f_{1,L} = \mu_0 e^2 \tilde{v}_{1,C}^2 / 4\pi \tilde{R}_{1,C}^2 = b^2 e^2 / 4\pi \varepsilon_0 \tilde{R}_{1,C}^2$ when it is in motion at the speed of $\tilde{v}_1$, and the Coulomb force is given by $f_{1,C} = -e^2 / 4\pi \varepsilon_0 \tilde{R}_{1,C}^2$ with the negative sign representing that Coulomb force is outwards, according to the definition of the force sign in this case. Based on Eqs. (18-1) and (18-2), there is $\hbar \tilde{v}_{1,C} / \tilde{R}_{1,C}^2 = b^2 e^2 / 4\pi \varepsilon_0 \tilde{R}_{1,C}^2 - e^2 / 4\pi \varepsilon_0 \tilde{R}_{1,C}^2$, the solution of $\tilde{v}_{1,C}$ can be obtained and the solution of $\tilde{R}_{1,C}$ is deduced from Eq. (18-2). Therefore, one has the following.

$$\tilde{v}_{1,C} = \tilde{v}_1 + \Delta\tilde{v}_1 \quad (19-1)$$

$$\Delta\tilde{v}_1 = -aC \quad (= -a^2 \tilde{v}_1) \quad (19-2)$$

$$\tilde{R}_{1,C} = \tilde{R}_1 + \Delta\tilde{R}_1 \quad \text{or} \quad \tilde{R}_{e,C} = \tilde{R}_e + \Delta\tilde{R}_e \quad (19-3)$$

$$\Delta\tilde{R}_1 = a^2 \tilde{R}_1 \quad \Delta\tilde{R}_e = a^2 \tilde{R}_e \quad (19-4)$$

Therefore, we are led to conclude that under the influence of the Coulomb force in the superluminal approximate solution the speed of either electron or positron in the SEPP is lightly slowed down, getting the distance between them a little bit larger. This implies that the minimum of speed is $\tilde{v}_{1,min} = (1-a^2) \tilde{v}_1$ and the maximum of distance is $\tilde{v}_1 \tilde{R}_{1,max} = (1+a^2) \tilde{R}_1$, which is equivalent to the spin radius of either of the electron and positron being $\tilde{R}_{e,max} = (1+a^2) \tilde{R}_e$. Obviously, the existence of the Coulomb force in a SEPP not only does not squeeze the electron and positron, arousing their annihilation, but favors the stability of the solution only if the Coulomb force does not exceed a certain value.

4. General Solutions of a Superluminal Electron-Positron Pair

4.1 Equations and Solutions

In general, Eqs. (1) & (2) have the formations below for each of the energy levels ($n = 1, 2, 3, \dots$)

$$m_{n,e}v_n^2/R_n = e^2/4\pi\epsilon_0 R_n^2 + \mu_0 e^2 v_n^2/4\pi R_n^2 \quad (20-1)$$

$$m_{n,e}R_nv_n = n\hbar \quad (20-2)$$

Making the speed v_n of a particle in Eq. (1) dimensionless, i. e., $\alpha_n = v_n/C$, one has the dimensionless basic equation as below.

$$\alpha_n^2 - nb\alpha_n + 1 = 0 \quad (21)$$

The equation above has a superluminal and a subluminal general solution, α_{n1} and α_{n2} , respectively. We do not discuss the subluminal solution in this article. The superluminal solution can thus be simply denoted as α_n .

$$\alpha_n = nb[1 - n^{-2}b^{-2} - n^{-4}b^{-4} - o(n^{-6}b^{-6})] > 1 \quad (22-1)$$

$$\alpha_{n2} = (a/n)[1 + n^{-2}a^2 + 2n^{-4}a^4 + o(n^{-6}a^6)] < 1 \quad (22-2)$$

and the approximate solutions of the general solutions are $\tilde{\alpha}_n = nb$ and $\tilde{\alpha}_{n2} = a/n$, which satisfy

$$\tilde{\alpha}_n \tilde{\alpha}_{n2} = 1.$$

4.2 Superluminal Approximate Solutions and Discussion on Energy Levels

When there is the Lorentz force only, the basic equation (21) is simplified as $\alpha_n^2 - nb\alpha_n = 0$, the superluminal approximate solution of Eq. (22-1) on the n -th level of energy is given by $\tilde{\alpha}_n = nb$. According to Eq. (14), regardless of the energy level, because of $\tilde{\alpha}_n \tilde{\alpha}_{n2} = 1$ the mass of electron or positron remains m_{0e} , the other parameters on the n -th level are given by

$$m_{n,e} = m_{0e} \quad (23\blacktriangleup 1)$$

$$\tilde{v}_n = \tilde{\alpha}_n C = nbC = n\tilde{v}_1 \quad (23\blacktriangleup 2)$$

$$\tilde{R}_n = \tilde{R}_1 = 2\tilde{R}_e \quad (23\blacktriangleup 3)$$

$$\tilde{E}_{n,e} = -m_{0e}\tilde{v}_n^2 = n^2\tilde{E}_{1,e} = -n\hbar\tilde{\mathcal{V}}_{n,e} \quad (23\blacktriangleup 4)$$

$$\tilde{\mathcal{V}}_{n,e} = \tilde{v}_n/2\pi\tilde{R}_1 \quad (23-5)$$

where Eq. (23-3) is obtained from Eq. (20-2) and Eq.(23-2), $\tilde{E}_{n,e}$ is the sum of kinetic and potential energies and negative, implying that the potential energy prevails, while $\tilde{\nu}_{n,e}$ is the energy frequency of the particle. The results above indicate that the parameters of the general approximate solution of a SEPP are quantized. Namely, the electron and positron in a SEPP have a quantized superluminal speed, quantized energy and only the distance between them remains constant. A SEPP is a superluminal quantum pair with opposite charges. Obviously, the ground state of $n=1$ is the superluminal approximate solution discussed above. Moreover, analyses have shown that

(1) Stable Energy Levels

Eq. (23-3) indicates that $\tilde{R}_n = \tilde{R}_1$, i. e., the energy level is independent of orbits and stays on the ground state $\tilde{R}_1$. Based on the method of Section 3.3, the electron's energy $\tilde{E}_{n,e}$ on the n -th level is the minimum of the potential energy on the level and its stable position is $\tilde{R}_1$. Now that charged quanta are quantized superluminal waves of matter, in light of the fact that $\tilde{R}_n = \tilde{R}_1$ and $\tilde{\nu}_n = n\tilde{\nu}_1$, we have $2\pi\tilde{R}_1 = n\tilde{\lambda}_1$, indicating that the quantized superluminal waves of matter are standing waves. In a word, the energy levels are stable, regardless of how high the level and how large the Lorentz force is. The distance between the electron and positron remains within the vicinity of $\tilde{R}_1 = 2\tilde{R}_e$ because the energy of the charged quanta at this position takes the minimum of the potential energy. The effect of the Coulomb force is shown in Eq. (22-1). Its existence is to slightly decrease the speed $\tilde{\nu}_n$ and energy $\tilde{E}_{n,e}$, but slightly increase $\tilde{R}_1$. All the changes in magnitude are in accordance with the results in Sec. 3.3. i.e., the fact that the existence of the Coulomb force decreases other than increases the speed implies that the Coulomb force between two oppositely charged superluminal quanta is repulsive and energy levels are stable only if the Coulomb force does not go beyond a range of magnitude;

(2) Stable System of Quantized Energy of a Superluminal Quantum Pair with Opposite Charges

There is a pair of positive and negative quanta on the energy level n of a superluminal quantum pair with opposite charges (SQPOC). Based on Eq.(23-4), the energy of each of the charged quanta is a system of the quantized potential energy, $\tilde{E}_{n,e} = -n\hbar\tilde{\nu}_{n,e}$, where $n = 1, 2, 3 \dots$. Two constituent systems of such a kind construct the system of quantized energy of a SQPOC. Taking the absolute value of Eq. (23-4),

$$\tilde{E}_n = n\hbar\tilde{\nu}_n \quad (= -2\tilde{E}_{n,e}) \quad (24\blacktriangleup 1)$$

$$\tilde{\nu}_n = 2\tilde{\nu}_{n,e} \quad (24\blacktriangleup 2)$$

where $n = 1, 2, 3 \dots$. According (23-4), $\tilde{E}_n = n^2 \tilde{E}_1$, i.e. the energy on the n -th level is n^2 times the energy of the ground state: the higher the level, the larger the energy. Because two constituent systems of potential energy are stable, the system of quantized energy of the charged quantum pair is stable as well. The energy on an energy level may also be written as $\tilde{E}_n = M_{ee,n} C^2$, where $M_{ee,n} = n^2 b^2 2m_{0e}$ is the equivalent energy mass of the quantum pair on the n -th level;

(3) Absorption or Emission of Invisible Ultrahigh Energy Particles or Rays of Ultrahigh Energy Electron-Positron Pairs

When the energy system of a superluminal charged quantum pair exchanges its energy with the outside, there are transfers of charged quanta between energy levels. The energy system of a quantum pair is composed of two constituent systems of potential energy, it is possible to absorb or emit one portion of ultrahigh energy particles or two portions of rays with equal energies of electrons and positrons, respectively, when the quanta with opposite charges transfer from the level k to the level l . The frequency of the absorbed or emitted particles or rays is given by

$$\nu_p = (k^2 - \ell^2) \tilde{\nu}_1 \quad (k > 1, \ell \geq 1) \quad (25-1)$$

$$\nu_e = (k^2 - \ell^2) \tilde{\nu}_{1,e} \quad (25-2)$$

where a negative value represents absorption and positive stands for emission and, moreover, ν_p is the frequency of emitted or absorbed ultrahigh energy particles; whereas, ν_e is the frequency of rays of emitted or absorbed electrons and positrons with $\tilde{\nu}_{1,e} = \tilde{\nu}_1 / 2\pi \tilde{R}_1 = 2.32030 \text{ Hz}$, $\tilde{\nu}_1 = 2\tilde{\nu}_{1,e}$. Because ν_p and ν_e are not frequencies of photons with the speed of light, the particles which oppositely charged superluminal quantum pairs absorb or emit are not photons with the speed of light, instead, are ultrahigh energy particles or rays of electrons and positrons with ultrahigh energy. For example, for $k = 2$ and $l = 1$, if the radiation is a ray of electrons or positrons, the frequency of $\nu_e = 3\tilde{\nu}_1 = 3.480446 \times 10^{24} \text{ Hz}$, reaching 10^{24} Hz of the order of magnitude, which is minimum of the emitted energy.

5. Possibility of Existence of Quantized Superluminal Motion of Electrons or Positrons

Why is it possible for an electron or a positron to make a superluminal motion at a speed of $\tilde{v}_n = nbC$? There are three major reasons besides ultrahigh binding energy.

(1) The superluminal and subluminal solutions are reciprocal to each other. According to Eq.(14),

the mass of electron or positron in a superluminal motion is equal to that in the corresponding subluminal one. Moreover, a superluminal electron or positron has mass of a determined finite value equal to the rest mass, and carries a charge acted by the Lorentz force that makes it possible to move at a superluminal speed. The fact that superluminal and subluminal solutions are reciprocal to each other is applicable to any of the energy levels. Hence, the electron-positron pairs are able to make a quantized superluminal motion at a speed of $\tilde{v}_n = nbC$, $n = 1, 2, 3, \dots$, the minimum of which is 137 times the speed of light.

(2) the binding force of an electron-positron pair is the electrostatic attractive force of $b^2 e^2 / 4\pi\epsilon_0 R^2$, which is unable to make the electron or positron to move at a superluminal speed. Because the electrostatic attractive force appears to be the Lorentz force of $b^2 e^2 / 4\pi\epsilon_0 R^2 = \mu_0 e^2 \tilde{v}_1^2 / 4\pi R^2$ (due to $\epsilon_0 = 1/\mu_0 C^2$) that acts on the electron and positron, leading them to move at a superluminal speed of $\tilde{v}_1 = bC$. Although the defined speed of light plays an important role, yet it affects rather bC than arbitrary superluminal speed.

(3) **Why must the superluminal speed of an electron or a positron be bC or nbC , instead of an arbitrary value?**

As the charge of an electron or a positron could be assumed to be uniformly and symmetrically distributed over a sphere, the electrostatic energy of the electron or positron would be $e^2 / 8\pi\epsilon_0 R_e = m_{0e} C^2$. Based on Eqs. (15-3) & (16), it can be shown that the spin speed of the electron or positron satisfies $m_{0e} \tilde{R}_e \tilde{v}_{es} = \hbar/2$ and is given by $\tilde{v}_{es} = \hbar/2 m_{0e} R_e = 2\hbar\epsilon_0 C / e^2 = bC$, out of which the constant $b = 2\hbar\epsilon_0 C / e^2 = 137.036 \tilde{R}_e$. This indicates that the spin speed of the electron or positron is also superluminal and possesses the certain value of bC . If the angular momentum of the spin of electron is quantized, the quantized superluminal spin speed can also be shown to be $\tilde{v}_{n,es} = nbC$, thus, the electron can make a quantized superluminal motion at a speed of $\tilde{v}_n = nbC$. Among a variety of particles there is only electrons that possess a superluminal spin speed. Therefore, if there exist superluminal particles, the most likely particles are electrons and positrons.

An electron or a positron has a superluminal speed of spin, but it does not mean that there are

particles that move at a superluminal speed inside the electron or positron. As a fundamental particle, an electron or positron does not have any interior moving particles. Nevertheless, a SEPP consisting of an electron and a positron are afferent. They are real particles moving at a superluminal speed. If there exists a structure of matter of SEPP, it implies that there must be superluminal electrons.

6. Summary

The basic equation has a superluminal solution that corresponds to a SEPP with a binding energy of $2m_{0e}\tilde{v}_1^2 = M_{ee}c^2$, equal to the mass energy of the SEPP itself and larger than that of deuterium nucleus by four times order of magnitude, but the mass of moving particles is smaller than that of neutron or positron by four orders of magnitude. Therefore, the electron and positron make superluminal motions. A SEPP possesses the rest mass, quantized energy levels, and radiates neutral ultrahigh energy rays of electrons and positrons like nuclear radiations, but the radiated energy level is higher than that of the nuclear radiation by several orders of magnitude. Hereby, the SEPP is by no means a nucleus. In this sense, if there could really be SEPPs, they would be particles of dark matter. A particle of dark matter with the Lorentz force being the binding force and the rest mass being $M_{ee} = 2b^2m_{0e} = 3.42128 \times 10^{-26} \text{ kg}$ is an invisible article of dark matter with the size given by the radius of electron $\tilde{R}_e = 1.40897 \times 10^{-15} \text{ m}$. A quantized energy level of a SEPP has superluminal electrons in the bound state. If those superluminal electrons in the bound state are divided into free superluminal electrons, the superluminal electrons in the free state may be the particles of dark energy. It is seen that there might be quantized superluminal motions of electrons and positrons in the invisible matter. Therefore, the conclusion that speed of light is the upper limit of speed might apply to the visible world only.

7. Reference

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Figures

Figure 1

Electron & positron moving towards but apart from each other by R at the same speed v in opposite direction

Figure 2

Momentary circular motion of electron

Figure 3

Dimensionless mass-speed relation

Figure 4

Sketch of a SEPP Structure