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The Principal Role of Antimatter

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Abstract

In a previous paper, we proposed that $ud\tilde{d}\tilde{u}$ exotic mesons, comprised of even number of quarks and antiquarks, form a QCD gas that fills space and further proposed a method to determine the QCD gas effective mass based on a pseudo-first order β decay reaction kinetics. In a second paper, we proposed a method to determine if the QCD gas density on black hole ergospheres grows in time and hence their ergoregions act as matter reactors that break matter and antimatter symmetry by trapping antimatter particles. In this paper, we suggest that quark and antiquark pair exchange reactions between particles and the QCD gas may accelerate or decelerate particles and that the quarks and antiquarks numbers are strictly conserved in these pair exchange reactions. We further suggest that antimatter plays a principal role in the universe and is inseparable from both matter, via Dirac' spinors, and space, via the quarks and antiquarks pair exchange reactions with the QCD gas; however with a singular exception, black hole ergospheres separate and black hole ergoregions trap antimatter particles.

Keywords

General Relativity (GR), Dirac Equation, QED, Gravitational Ether, Antimatter, QCD Gas, Exotic Mesons, Pseudo-First Order β Decay, Black Hole (BH), Ergoregions, Ergospheres

1. Electron Dynamics and the Gravitational Ether

Albert Einstein said in his lecture "Ether and the Theory of Relativity [1]" on May 5, 1920, at the University of Leiden, 5 years after he published the GR theory [2] and six years before Schrödinger [3], and a year later Heinsberg [4] and Dirac [5] published their quantum mechanics theories, that GR disposed the view that space is physically empty and that space without gravitational ether is unthinkable. Einstein thought that space and matter are causally connected: "*Since according to our present conceptions the elementary particles of matter* *are also, in their essence, nothing else than condensations of the electromagnetic field, our present view of the universe presents two realities which are completely separated from each other conceptually,* ***although connected causally****, namely, gravitational ether and electromagnetic field, or as they might also be called space and matter* [1]".

In 1928, Dirac discovered the antimatter [6]. Dirac proposed that the vacuum includes a sea of infinite number of invisible negative energy electrons that prevents the positive energy electrons to radiate and decay to the occupied negative energy levels. Dirac thought that quantum electrodynamics (QED) should not assume a bare electron that moves in empty space since the electron is always surrounded by virtual electron-positron pairs.

Brito *et al.* [7] described the Klein paradox [8] related to the solution of Dirac equation in the presence of a step potential. In 1929, Klein showed that an electron beam propagating in a region with a large enough potential barrier can emerge without the exponential damping expected from nonrelativistic quantum tunneling processes. Further studies by Hund [9] in 1941 showed that the step potential could give rise to the production of pairs of charged particles when the potential is sufficiently strong which was the resolution of the Klein paradox, the creation of particle-antiparticle pairs at the barrier explained the undamped transmitted part. Brito writes that this result can be seen as a precursor of the modern quantum field theory results of Schwinger [10] and Hawking [11] who showed that spontaneous pair production is possible in the presence of strong EM and gravitational fields.

However, Feynman described a non-local electron exchange reaction with a virtual electron-positron pair created by a vacuum fluctuation with no external field or step potential [12]:

$$e^- + \left[e^+ - e^-\right]_{\text{virtual pair}} \xrightarrow{\text{electron exchange}} \left[e^- - e^+\right]_{\text{virtual pair}} + e^- \tag{1}$$

The virtual electron-positron pair is spontaneously created by the vacuum in a spacetime point (x_c, t_c) where the positron moves backward in time to spacetime position (x_a, t_a) as shown above. It seems that the electron jumps in space from x_1, t_1 to x_2, t_2 positions; however, it is not the first electron that appears at x_2. According to the diagram, it is another electron released from its virtual pair positron. Thus, electrons do not move continuously along classical paths, and they are annihilated in a first position and created by a vacuum fluctuation in another position in empty space also in cases where a step potential does not exist as proposed by Klein in 1929.

In a previous paper, we proposed that $u\tilde{d}d\tilde{u}$ exotic mesons, comprised of even number of quarks and antiquarks, form a QCD gas that fills space and further proposed a method to determine the QCD gas effective mass based on a pseudo-first order β decay reaction kinetics [13]. In a second paper, we proposed a method to determine if the QCD gas density on black hole ergospheres grows in time and hence their ergoregions act as matter reactors that break matter and antimatter symmetry by trapping antimatter particles [14]. Here, we propose that the electron-positron pairs, described above as virtual vacuum fluctuations, may be less virtual and part of the QCD gas dynamics. Taking a hint from the pseudo-first order β decay reaction kinetics in the presence of the QCD gas $u\tilde{d}d\tilde{u}$ exotic mesons described in the previous paper [13]

$$udd(n) + u\tilde{d}d\tilde{u}(\text{exotic meson}) \to udu(p^{+}) + d\tilde{u}d\tilde{d}(\pi^{-*}) \quad (2a)$$

$$d\tilde{u}d\tilde{d}(\pi^{-*}) \to e^{-} + \tilde{\nu}_{e} \quad (2b)$$

We re-write here the electron exchange reaction of Equation (1) above in terms of the $u\tilde{d}d\tilde{u}$ exotic meson and the excited exotic charged pion $d\tilde{u}d\tilde{d}(\pi^{-*})$

$$d\tilde{u}d\tilde{d}(\pi^{-*}) + u\tilde{d}d\tilde{u}(\text{exotic meson}) \to u\tilde{d}d\tilde{u}(\text{exotic meson}*) + d\tilde{u}d\tilde{d}(\pi^{-*}) \quad (3)$$

The $u\tilde{d}d\tilde{u}$ exotic meson reacts with the exotic charge pion tetraquark, and a quarks and antiquarks pair exchange reaction occurs. The $d\tilde{u}$ meson of the charged pion replaces the $d\tilde{u}$ of the QCD gas exotic meson and transfers some of its momentum to the QCD gas. The quarks and antiquarks numbers in Equation (3) is strictly conserved from the right-hand-side to the left-hand-side of the exchange reaction equation, quarks and antiquarks are not annihilated nor created from the empty vacuum in Equation (3).

Assuming that the QCD gas density is extremely high, on the order of the nucleus density, the quark and antiquark pair exchange reactions may be non-local chain reactions where the QCD gas gravitational ether acts as a medium that replaces the illustrated "jump" of a particle from one position, where it was "annihilated" to another position where it was "re-created" in Figure 1 below. Hence, we suggest that the QCD gas acts like a medium that transfers momentum over distance. It should be also noted that the excited charged pion that decays

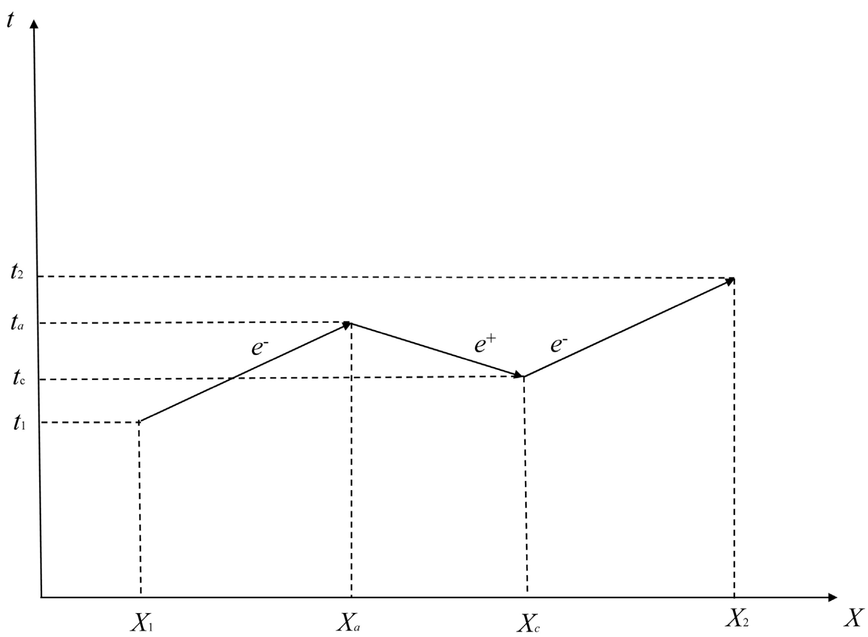

Figure 1. A non-local electron exchange reaction with a virtual electron-positron pair created by a vacuum fluctuation [10].

into the electron, $d\tilde{u}d\tilde{d}\left(\pi^{-*}\right)$ (Equation (2b)), hints that the electron may not be an elementary particle [15].

It should be noted that the proposed QCD gas is not comprised of regular matter, it is comprised of an even number of matter and antimatter quarks, the exotic mesons $u\tilde{d}d\tilde{u}$, which are invisible and are observed only indirectly by the pseudo-first order β decay rates variability [16] [17]. The QCD gas density may vary in space due to mass, charge or external fields and thus it may be inhomogeneous and anisotropic as Einstein expected the gravitational ether would be. The outcome of the electron exchange reactions with the QCD gas (Equation (3)) will depend on both the initial electron momentum and the QCD gas state. Charged pions/electrons can be accelerated or decelerated by their interaction with the QCD gas gravitational ether via the quark and antiquark pair exchange reactions.

2. Quark Confinement and the Gravitational Ether

The strong force quark confinement is explained by the Yukawa potential [18]. A quark confinement mechanism is proposed here based on the quarks and antiquarks pair exchange reactions with the QCD gas. We assume that the QCD gas density is extremely high such that whenever a small gap between quarks in a proton is created, for example by an accelerated electron that hits one of the proton quarks, a $u\tilde{d}d\tilde{u}$ exotic meson enters the created gap performs a quark and antiquark pair exchange reaction with the excited proton quark and carries away part of the proton's quark momentum and energy and hence decreases the distance between the quarks. The quark and antiquark pair exchange reaction confines the excited proton's quarks, cools down the proton and heats up the QCD gas as illustrated below in **Figure 2**.

$$\begin{aligned} &uu^{*}d\left(\text{proton}*\right)+u\tilde{d}d\tilde{u}\left(\text{exotic meson}\right) \\ &\rightarrow uud\left(\text{proton}\right)+u^{*}\tilde{d}d\tilde{u}\left(\text{exotic meson}*\right) \end{aligned} \tag{4}$$

The quark and antiquark pair exchange reactions may repeat with additional $u\tilde{d}d\tilde{u}$ exotic mesons until the gap is closed. The quarks and antiquarks pair

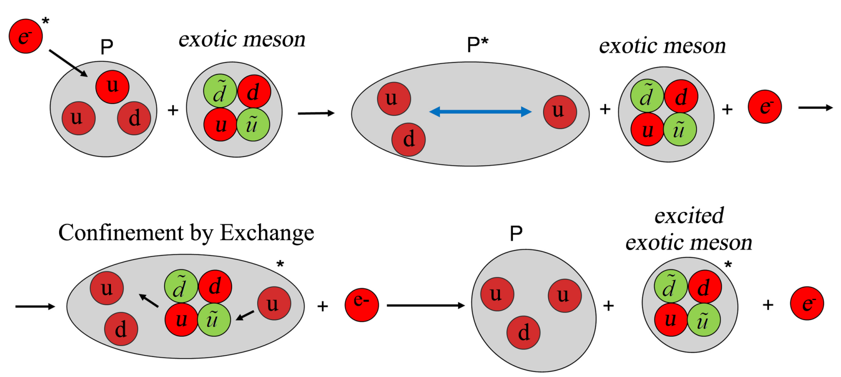

Figure 2. The quark and antiquark pair exchange reaction that confines the proton quarks.

exchange reactions with the QCD gas can accelerate or decelerate matter particles (Equation (4)). The quarks and antiquarks pair exchange reactions maintain a strict quark and antiquark balance, e.g., the number of quarks and antiquarks on the left-hand-side and right-hand-side of the reactions are conserved as shown in the reaction Equations (2a), (3) and (4). Quarks are not annihilated nor created by the quark and antiquark pair exchanges. The strict quark conservation rule may be a fundamental quantum dynamics rule.

3. Summary

We suggest that quark and antiquark pair exchange reactions between matter particles and the QCD gas accelerate or decelerate the particles and that the quarks and antiquarks numbers are strictly conserved in these pair exchange reactions. The quarks and antiquarks are not annihilated nor created, which may be a fundamental rule of quantum dynamics.

Einstein thought that space and matter are causally connected, and that the gravitational ether must exist [1]. We suggest here that the gravitational ether, comprised of even number of matter and antimatter particles, the $u\tilde{d}d\tilde{u}$ exotic mesons, exchanges quarks and antiquarks pairs with the matter particles. Space and matter are inseparable on the quantum scale like the inseparable matter and antimatter spinor components of Dirac's equation [5]. Antimatter plays a principal role in the universe and is inseparable from both matter (via Dirac' spinor) and space (via the quarks and antiquarks pair exchange reactions with the QCD gas); however with a singular exception, black hole ergospheres separate and black hole ergoregions trap antimatter particles.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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