

# An Approach to an Element of Order Number Zero in the Periodic System

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Received September 26, 2020; Revised October 28, 2020; Accepted November 05, 2020

**Abstract** The question for anti-particles is one of the most outstandingly difficult problems in physics. There were many successful attempts from researchers including models to find a suitable explanation for anti-matter appearing in atom and matter theory. Some examples show really to demonstrate anti-matter character as it reveals the Dirac's quantum mechanical formalism. Indeed, a series of those atoms are found by experiment. In addition some exotic sounding ones are theoretically predicted and proven by experiment as it is the Positronium. This atom is formed by an electron and a positron and seems really to be represented particle and co-particle in one so that it can be considered its own anti-particle itself. Obviously, this construct besides other ideas can meet the requirement of negative states predicted by Dirac as it finally led to the discovery of the positron as well many decades ago. The consideration of negative states in atom physics and the aspect to involve that phenomena into the description of particles could also lead to an extension in the chemical periodic system similarly to arrive at bordering edges those could limit the chemical elements at one side by the Feynmanium and on the other a Positronium. In addition, this research is one of the main goals in elementary physics as it opens a way for interpretation of the Dirac's equation allowing or even demanding for negative states. Although, particles negative in electric charge or atoms reversed in the charges of nucleus and the surrounding electric clouds, respectively, still demonstrate positive in mass. As a consequence it stands the question whether and how this requirement can be overcome to entirely obey the demands for negative states, because the mass in all those investigations remains positive and every atom found consists of real and positive matter. However, those suggestions are missing. The aim of the present study is to propose a model that becomes suitable to consider those facts, especially not to ignore a mass negative. In this investigation a theory is tried in a simple model that considers both states of matter together to arrive at an atomic system consisting of an electromagnetic wave. Since electromagnetic waves are that way a true phenomena as they do not appear in a rest-mass differing from zero and there are also no electric or magnetic interaction either, the simplest form of an atom is proposed in the result of a pure electromagnetic wave alone.

**Keywords:** classical electrodynamics, classical mechanics, special relativity, general relativity

**Cite This Article:** T. G.M. Gerlitz, and W. Walden, "An Approach to an Element of Order Number Zero in the Periodic System." *International Journal of Physics*, vol. 8, no. 4 (2020): 134-146. doi: 10.12691/ijp-8-4-4.

## 1. Introduction

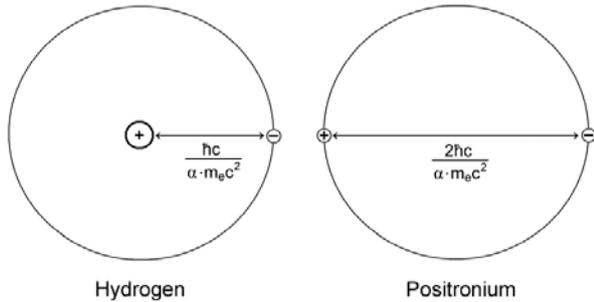
In the search for outstanding or sometimes exotic sounding proposals for new elements in the periodic system of chemical elements many attempts were demonstrated, but a model for an atom numbered before hydrogen is missing. The aim of the current work is to find a real atom with order number zero and located between both the atomic matter and the atomic anti-matter, and should be expected in the midst between the two periodic tables. In a similar request several models have been suggested.

Since the demand for a chemical element with atomic number zero is not new, there are indeed a series of research articles dealing with this thematic. A first proposal is a substance coined Neutronium [1], and later discussion during the following decades led to extremely

dense substances resembling the neutron-degenerate matter being theorized to exist in the cores of neutron stars. It is seen a conjectured form of matter made up of neutrons with no protons or electrons either and subsequently placed into the periodic table [2].

A further interesting proposal consists of an electron and its suggested co-particle, a positron, bound together into an atom (Figure 1). This theoretically predicted system [3,4,5] was experimentally proven, named Positronium, Ps [6], and extensively investigated [4,7,8,9,10]. It is unstable, because the two particles annihilate each other to predominantly produce gamma-rays [11]. In this exotic atom orbit and energy levels of entailed by the two real particles are similar to that found on hydrogen [12]. Due to its reduced mass the frequencies in the spectral lines are less than half of the corresponding hydrogen lines [13]. The Positronium was described as its anti-particle itself. This statement, however, leads to a misinterpretation with regard to a proper definition in the difference between a

particle consisting of real matter and an associated anti-particle consisting of the demanded anti-matter. A positron is an electron of positive electric charge, and its name is gained from the nomenclature by simply combining the two words posi-tive and elec-tron into posi-tron with regard to its opposite electric charge, but not due to their opposite mass characters, *i. e.*,  $m_+$  opposite to an  $m_-$ .



**Figure 1.** A hypothetical atom consisting of an electron and a positron forming the Positronium

Everything with regard to atomic physics, however, is held due to a description of electromagnetic waves, *i. e.*, the wave mechanics, and is based on the discussion of their effects. Involved in the above discussion appears the question for the nature of light as an electromagnetic wave, and is subject of research for many descades as well. A description of the properties of light by the Maxwell’s equations [14] from classical electromagnetism leads to quantum and relativistic aspects. However, the set of those equations certainly is a consequence of special theory of relativity, but not reverse.

The existence of the photons had already been accepted by Newton [15], but appeared after the discovery of interference and diffraction phenomena of light not to confirm. Another proposal followed the vision “Every point on a wave-front may be considered a source of secondary spherical wavelets which spread out in the forward direction at the speed of light. The new wave-front is the tangential surface to all of these secondary wavelets” [16]. In this *Huygens’ Principle* the sum of these secondary waves determines the form of the wave at any subsequent time Here, the secondary waves propagate only in the forward direction.

After formation, the quantum hypothesis by Planck [17,18] led Einstein [19,20,21] to explain the external photoelectric effect again, and convincing experimental proof of existence was made by Compton [22], later attempts by Ioffe and Dobronravov regarding dualism of wave and particle [23,24], which had been formulated by de Broglie [25,26,27,28]

$$p = \frac{h}{\lambda} \tag{1}$$

This expression is a generalization as it incorporates the Einstein’s energy quanta [19,20,21,29]

$$E = h\nu \tag{2}$$

and with the mass-energy equivalent

$$E = mc^2 \tag{3}$$

It incorporates the proportionality

$$\nu \sim \frac{1}{\lambda}$$

between frequency and wave those couple by a proportionality constant  $c$  to the identity

$$\nu = c \cdot \frac{1}{\lambda}, c = \lambda \cdot \nu \tag{4}$$

The constant  $c$  denotes the respective propagation speed of a wave and depends on the medium, *e. g.*, gas, fluids, solids, the vacuum influenced by external conditions, and the free and empty vacuum being uninfluenced by external conditions, where the latter medium then allows a free electromagnetic wave to propagate exactly at the vacuum light-speed  $c = 299792458$  m/s. The expressions eq. (1) and (4) are generally valid for any being, moving or at rest, electrically charged or uncharged, of rest mass or not, consisting of everything or nothing, but never restricted explicitly to an electromagnetic wave as it is light. It appears as coupling between solid matter and an oscilating wave, and the latter can be used for the statistical description with later statement and evaluation of espatial distribution and local behaviour. As a consequence, this dualism entails the idea of a photon as a particle that stands out from all others. There is no anti-particle, and a photon in the universe is not an anti-photon in an anti-universe. In addition, the Heisenberg’s uncertainty [30]

$$\Delta p_i \cdot \Delta r_i \geq \hbar / 2 \tag{5}$$

should complete the basics for modern atom physics and follows from the non-vanishing commutator between both of the related quantum mechanical operators, *e. g.*, momentum and space.

The crux in photon theory is the postulate that massless messenger particles from the emission point to the absorption point is not within the four-dimensional space-time continuum; special theory of relativity collapses at the speed of light, because the space-time is shortened to zero to a point so that photon effects can not be described by this special theory of relativity.

An important question appears in the suggestion of an anti-particle. The consequence of the Dirac’s formalism [31,32] is a theoretical prediction of negative energy states and particles of negative mass. This is remarkable in the view that, *e. g.*, the anti-particle of an electron definitively must be an anti-electron, but never a positron. Though, the latter is experimentally proven [33] as positively charged and extensively discussed [34], it is the same mass the electron. Here, both masses are the same manner, namely positive in sign, but the mass of the positron is not negative that would the requirement for a real anti-particle. In other words: a positron can only be treated an electrically positiv charged electron, but is never completely an “anti-electron” in the sense of “anti”-particle. It only differs in sign of charge, but the mass of a positron is positive as well, but not negative. In addition, actual proposals for anti-matter are dstricted in the view to an “anti-atom” that is built by a negatively charged “anti-proton” in its center surrounded by a positively charged “anti-electron” or positron, but nothing else. In

analogy the simplest anti-atom is then the anti-hydrogen, which is observed in the laboratory [35,36], and the process to achieve the stable confinement of antihydrogen within the trap is in progress to test the standard model [37,38]. In the same kind other anti-atoms should have the same properties when compared to their counterparts. Then, the “normal” atom and its mass will be exactly the same and, of course, remain positive and will never become or turn into negative. It is therefore clearly to emphasise there is no anti-matter found yet in that way up to now.

The above discussion is grounded in the Dirac’s theory [31,32] based on the general form of the wave equation

$$\square\Psi_{(r,j)} = 0. \quad (6)$$

It underlies the condition of the d’Alembertian,  $\square$ , certainly with an extension to the mechanical momentum of light by the relativistic four-momentum, which yields to the homogen twin pair of first-order differential equations

$$(E - c\boldsymbol{\alpha} \cdot \mathbf{p} - \beta m_0 c^2)\Psi_{(r,i)} = 0 \quad (7)$$

$$(E + c\boldsymbol{\alpha} \cdot \mathbf{p} + \beta m_0 c^2)\Psi_{(r,i)} = 0 \quad (8)$$

for a free particle concerning positive and negative states in the electromagnetic wave. In the view of the above statements the result from annihilation of a matter particle with its anti-particle consisting of anti-matter is easily demonstrated when these twins of equations are added together like

$$\begin{aligned} E &= + (c\boldsymbol{\alpha} \cdot \mathbf{p} + \beta m_0 c^2)\Psi_{(r,i)} \\ + E &= - (c\boldsymbol{\alpha} \cdot \mathbf{p} + \beta m_0 c^2)\Psi_{(r,i)} \\ \hline 2E & \quad \quad \quad 0 \quad \quad \quad \Psi_{(r,i)} \end{aligned} \quad (9)$$

and shows both disappear instead transformation of their masses into another kind of energy to say radiation.

The expressions eqs. (7) and (8) lead in turn to the, now however, heterogeneous twins of Hamiltonians

$$H^+_{DIR} = + \{ (c\boldsymbol{\alpha} \cdot \mathbf{p}) + \beta m_0 c^2 \} + V^+(\mathbf{r}) \quad (10)$$

$$H^-_{DIR} = - \{ (c\boldsymbol{\alpha} \cdot \mathbf{p}) + \beta m_0 c^2 \} + V^-(\mathbf{r}) \quad (11)$$

When applied to the  $\Psi$ -function the respective first expression still describes a particle of positive mass, while the other points to a negative mass  $m$ , and this is remarkable to note. In this case, change in sign for the mass as turned from positive into negative takes place in the presence of interactions [39,40]. The pair eqs. (7) and (8) for a free particle can be symmetrically transformed in each another with respect to their sign, whereas the potential  $V$  appearing in the expressions (10) and (11) strictly emphasises their different behaviour that demands to carefully distinguish these facts when the signs of the mass or the electric charge are simply tried to interchange.

The result of the Dirac equation for the lowest energy state of an H-like atom is given by [41]

$$E^+_{DIR} = -(m_0 c^2) \sqrt{1 - (Z\alpha)^2} \quad (12)$$

and the same for an anti-hydrogen, certainly with the same sign due to the also positive mass  $m_0$  involved.

While in the equations of Schroedinger [42] with Hamiltonian

$$H_{SCH} = + \{ -\hbar^2 / 2m_0 \cdot \Delta \} + V(r) \quad (13)$$

as well as in the twins of Dirac’s eqs. (10) and (11) the sign of the mass entails energie eigen-values denoted by the same sign - *i. e.*, both either positive or respective negative - this is not true for the Klein-Gordon-Fock (KGF) equation [43-53]. The KGF with energy operator

$$H_{KGF} = \pm \sqrt{-\hbar^2 c^2 \cdot \Delta + (m_0 c^2)^2} + V(r) \quad (14)$$

is quadratic in all summands and so are energy and mass terms, therefore allowing positive and negative states. This eigenvalue problem can be solved analytically in an exact way [54]. It gives the subsequent binding energy for a H-like atom in the ground state

$$E_{KGF} = (m_0 c^2) \cdot \frac{1 - 2(Z\alpha)^2 + [1 - 4(Z\alpha)^2]^{1/2}}{1 + [1 - 4(Z\alpha)^2]^{1/2}} \quad (15)$$

In contrast to the Dirac’s formalism the KGF considers particles moving forward and backwards equally.

In the non-relativistic limit and if the rest-energy exceeds all other energy terms the equation can be reduced to the Pauli’s and to the Schroedinger’s equation [55,56]. The negative expression eq. (11) can be treated the same as the positive Hamiltonian eq. (10), which leads to eigen-values corresponding to those of an electron [32,33,57], again concerning a positive mass denoting real matter.

From the Schroedinger’s equation eq. (13) the lowest energy state of an H-like atom is

$$E_{SCH} = -(m_0 c^2) \frac{(Z\alpha)^2}{2} \quad (16)$$

It is obvious in the above mentioned differential equations a rest-mass  $m_0$  is explicitly taken into account as well as in the earlier models, *e. g.*, Bohr [58,59] and Sommerfeld [60]; it predominates the description of the respective model. However, the search for a rest-mass  $m_0$  of the photon particle that would be necessary to meet the requirements remains a difficult challenge. This search either leads to a zero or to a negligibly small value, *e.g.*,  $m_{0(L)} < 1.07 \cdot 10^{-27} \text{ eV}/c^2$  [61],  $< 3 \cdot 10^{-27} \text{ eV}/c^2$  [62], or in a test of Coulomb’s law by the Higgs mechanism  $\leq 10^{-14} \text{ eV}/c^2$  [63]. However, an apparent weight of photons has experimentally proven first in 1960 already [64].

In addition, theoretical attempts derive a photon’s imaginary mass [65]. As a consequence, it would be natural to look for a mass that could serve the description of the cumbersome properties of light from a classical point of view. However, if mass is involved in the discussion gravitational interaction comes to the forth [66,67,68] as gravitation alters the trajectory of light [69,70] that is also true in case of light-light interaction as light produces a gravitational field [71,72,73]. The essential idea led Schwarzschild formulate the

Schwarzschild’s metric [74,75], which is originated principally from the question: If curvature of space is true as are the equations of motion for objects in spacetime and consequently mass affects light to leave its trail propagating straight ahead for the favour of curvature, what mass will determine light to follow a circle around that object?

Although, theory of gravitation as embedded in general relativity is understood regarding space-time curvature the discussion reads back to the foundations entailed from the Newtonian mechanics [15]. The law

$$E_{G(d)} = G \cdot \frac{m_a \cdot m_b}{d} \tag{17}$$

considers the energy  $E_{G(d)}$  between two masses  $m_a$  and  $m_b$  interacting in a distance  $d$  via the gravitation constant  $G$ . The sign of the gravitation energy follows from the product of the two masses and is negative in case of opposite signs. Hence, matter attracts matter as well as anti-matter attracts anti-matter, whereas matter and anti-matter devolve. In case of gravity the wave is prevented from propagation as a progressive wave. It is therefore no longer free and uninfluenced by external conditions, and the behavior of the wave no longer corresponds to that of a free progressive wave travelling in a straight path. Instead, this light takes geodesic paths around these gravitational fields, and the speed of light is not a simple scalar in a gravitational field, but rather a tensor [68,74].

In the view of the possibility of an atom concerning negative and positive energy states together towards relativistic quantum mechanics, the present work is presented on a hypothetical particle consisting of light.

## 2. Theory

The underlying condition is the d’Alembertian with an extension to the mechanical momentum of light. There is neither a resulting electric nor magnetic field, but only electromagnetic and gravitational interactions. It sets to reason the factors underlying the basis that for a particle with the elementary charge  $e$  there are two speeds limiting the speed of light [76]. The maximum speed for a bradyon and the minimal for a tachyon is close to  $c$ , and these “limit speeds” are the constants

$$v_B = (1 - \alpha^2)^{1/2} \cdot c \tag{18}$$

and

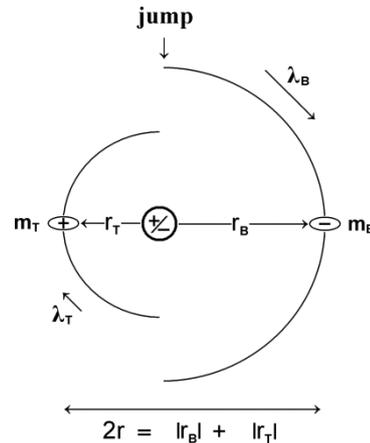
$$v_T = [2 - (1 - \alpha^2)^{1/2}] \cdot c \tag{19}$$

[76,77] with the abbreviation

$$\alpha = \frac{e^2}{2h\epsilon_0 c} \tag{20}$$

for the fine-structure constant [60]. This definition is valid in the view towards pure and free electrostatic interactions in the vacuum. In the current study the considered particle can cross the light barrier by a “jump” (Figure 2) to converse from subluminal character of a bradyon  $B$  into that of a superluminal tachyon  $T$  and reverse in alternating

their properties. A particle carrying the above elementary charge  $e$ , either positive or chosen negative as well, can never reach the speed of light as to the conditions eqs. (18), (19); these conditions are independent on any mass and even valid for a mass zero [76]. The transition entails symmetry reflection, that means mirroring in the signs of, e.g., mass, time interval, and space; the electrical charge can be treated to change in sign as a consequence of the Coulomb’s law due to the change in sign of the electrical field,  $+\mathbf{E}_B \leftrightarrow \mathbf{E}_T$ .



**Figure 2.** The electromagnetic wave splitted into their components subluminal bradyon  $B$  and superluminal tachyon  $T$ . In accordance to the suggested atom consisting of both states at the same time the picture shows their differences with regard to the two the respective distinguished radii together with the notation for the related wave-length  $\lambda_B$  and  $\lambda_T$ . It emphasizes the “jump” between the two speeds those together result in the speed of light in the vacuum

The theory is based on the postulate that a photon is represented by means of permanent interchanging sub- and superluminal state by light-barrier crossing. This leads to a pair consisting of a bradyon particle and its tachyon co- or anti-particle. Thus, it demands for the use of the twin pair of Dirac’s equations (10), (11) to describe the character of the entire system in accordance to eq. (6). Since always related to the propagation of light given by the constant  $c$  this phenomena requires for the entire system explicitly a permanent consisting  $B$  particle and its  $T$  co-particle altogether; they behave correlated and the one cannot exist without the other. This statement is the basis for the current study as it completely obeys the requirement for incorporation of both properties, i. e., matter and anti-matter, at the same time and to strongly satisfy the demands by the above Dirac’s equations eqs. (10) and (11) together to describe the model entirely.

In the view as the model developed is proposed an atom it is drawn right now in accordance to the final goal, although the anticipated conditions for it have not been worked out already as well as the solution to resolve the entire task is not found yet. Therefore, the figures are given as if the result already exists to accompany the way in the following calculation and to emphasise the conditions to build it.

In a first attempt an artificial photon rest-mass will be estimated equating the electrostatic attraction energy between the charge centers of the subluminal particle and its superluminal co-particle considered their elementary charges as  $+e$  and  $-e$  separated classically by  $2r_0$  and

relativistically considered  $2r$  (Figure 2) as considered elsewhere [76], respectively. It is then

$$E_e = \frac{e^2}{2r_o \cdot 4\pi\epsilon_o} \equiv \frac{\alpha\hbar c}{2r_o} \equiv \frac{\alpha\hbar c}{2\alpha r_o} \equiv \frac{\hbar c}{2r}. \quad (21)$$

Due to the relativistic mass-energy relation eq. (3) at one of the both limit-speeds [76]

$$E_m = mc^2 \equiv m_o c^2 / \alpha \quad (22)$$

the consequence is an expression, *e. g.*, either for the *B* or the *T* part of the photon rest-mass as function of the distance  $2r$  between *B* and *T*. Due to the intention to reduce the system to a one-particle problem the sign for the mass of these particles comes into the view. In the search for a suitable description of a stable atom a behaviour with regard to the positive Dirac's equation eqs. (10) and (12) is decided. This way requires a positive rest-mass together with a compared larger nuclear-charge number to favour one particle character. These conditions are satisfied by the faster *T* co-particle in the system, which is chosen positive in mass. Although, the electric charge does not require a sign to be favoured it is also chosen positive with the aim to ease a full understanding in the following investigation. As a consequence, the *T* particle is based on

$$m_{o(T,r)} = +\frac{\alpha\hbar}{2rc} \quad (23)$$

and the *B* with  $m_- = -m_+$  analogously

$$m_{o(B,r)} = -\frac{\alpha\hbar}{2rc} \quad (24)$$

It is true, under these conditions positive and negative rest-mass would properly cancel each other out,  $m_{o(B)} + m_{o(T)} = 0$ , and they can never be simply averaged this way, because their masses do oscillate and that is, of course, the nature of light.

The formulae eqs. (23) and (24) show an artificial rest-mass of the *B* and *T* parts of an eventual light-particle that touches the light-barrier at exactly the associated limit speeds eqs. (18) and (19), and is identified at the location where B-T transition takes place, in no time. The result could be defined as (artificial) representative for a photon rest-mass  $m_o$ . It must be emphasized that a mass discussed here is always related to the atomic diameter  $2r$  or respective radius  $r$  since this alone is its definition.

Despite all these considerations, however, it is fact light can certainly never be divided into two halves, but there are always particle and its co-particle involved, which travel together; there is no slow down of the light and therefore also properly no real rest-mass except on the calculation presented in the current study. The objective consequence actually is light in one unit alone not to associate a rest-mass different from zero. That is the same reason one Dirac's equation of the twins eqs. (10), (11) alone is not sufficient for an entire discussion in the description of a complete result. In that case, one twin can not be treated separately and without taking the other twin into account either, although and rigorously the expressions eqs. (7), (8) are of course valid alone to state

the conditions for one free particle, *e. g.*, the spin for a respective particle under consideration.

The different speeds of the current twin-particles must entail the two different momentae (Figure 2)

$$\begin{aligned} \mathbf{p}_{kin(T)} &= +m_{(T)} \cdot v_{(T)} \\ &\equiv +(m_{o(T)} / \alpha) \cdot [2 - (1 - \alpha^2)^{1/2}] \cdot c \\ \rightarrow \mathbf{p}_{kin(T)} &= +(m_{o(T)} / \alpha) \cdot [2 - (1 - \alpha^2)^{1/2}] \cdot c \end{aligned} \quad (25)$$

and

$$\begin{aligned} \mathbf{p}_{kin(B)} &= +m_{(B)} \cdot v_{(B)} \\ &\equiv +(m_{o(B)} / \alpha) \cdot (1 - \alpha^2)^{1/2} \cdot c \\ \rightarrow \mathbf{p}_{kin(B)} &= -(m_{o(T)} / \alpha) \cdot (1 - \alpha^2)^{1/2} \cdot c \end{aligned} \quad (26)$$

Note that in these expressions (25) and (26) both the *T* rest-mass  $m_{o(T)}$  appears, and they differ only in their opposite signs.

As a consequence there must be two different Coulomb potentials each explicitly acting on the *T* and on the *B* particle those can be related to their total and always positive electrostatic interaction  $V \rightarrow E_e$  in eq. (21) between them (Figure 3) as

$$V_{T(r)} = +\frac{\hbar c}{2r_T} \equiv Z_T \cdot \frac{\alpha\hbar c}{r} \quad (27)$$

$$V_{B(r)} = +\frac{\hbar c}{2r_B} \equiv Z_B \cdot \frac{\alpha\hbar c}{r} \quad (28)$$

with their specific virtual-nuclear-charge numbers  $Z$  be determined. In these expressions the conventional notation for the nuclear-charge number is used to ease later treatment of the problem in comparison to H-like atoms. It opens to face this investigation in the view of the positronium atom. The different  $Z$  entail the two different potentials denoted  $V_{(r)}^+$  and  $V_{(r)}^-$  in the above pair of the Dirac's equations (10) and (11). It is obvious the mass is ideally mirrored at the limit speeds, *i. e.*,  $m_{(T)} = -m_{(B)}$ , but the kinetic momenta are not, because the particle and its co-particle differ in their limit speeds eqs. (18) and (19). It is true, each "distance" from the respective speed limit to the light barrier at  $c$  is obviously the same,

$$\begin{aligned} \Delta v_{(c,B)} &= c - v_{(B)} \equiv c - (1 - \alpha^2)^{1/2} \cdot c \\ &\equiv \{1 - (1 - \alpha^2)^{1/2}\} \cdot c \\ \Delta v_{(T,c)} &= v_{(T)} - c \equiv [2 - (1 - \alpha^2)^{1/2}] \cdot c - c \\ &\equiv \{1 - (1 - \alpha^2)^{1/2}\} \cdot c \end{aligned}$$

and shows the speed "gap" between sub- and superluminality as the "light-barrier thickness" (Figure 2, Figure 4) be

$$\begin{aligned} \Delta v_{(B,T)} &= \Delta v_{(c,B)} + \Delta v_{(c,T)} \equiv 2\{1 - (1 - \alpha^2)^{1/2}\} \cdot c \\ &\approx 53.252063474 \cdot 10^{-6} \cdot c \end{aligned} \quad (29)$$

The average of the particles' speeds is always  $c$  leading to an identical artificial rest-mass eqs. (23), (24) of the same absolute magnitude in both cases, *T* and *B*. It can be calculated by the wave-length or respective momentum

of the entire system as always entailed by the average speed  $c$ .

According to the Heisenberg's uncertainty in eq. (5) it is generalized

$$\hbar / 2 \leq p_i \cdot 2r_i \tag{30}$$

The addition of the total values of the respective distances from the center of the system to the particular  $T$  and  $B$  particles,  $r_T$  and  $r_B$ , results in twice the average distance to this center, *i. e.*, twice the average radius  $r$  of the system (Figure 2 - Figure 4), and the same is true for the associated momentae

$$2r = |r_T| + |r_B|, |2p| = |p_T| + |p_B| \tag{31}$$

Obviously is

$$\frac{r_B}{r_T} = \frac{p_T}{p_B} \equiv \frac{\alpha \cdot [2 - (1 - \alpha^2)^{1/2}]}{\alpha \cdot (1 - \alpha^2)^{1/2}}. \tag{32}$$

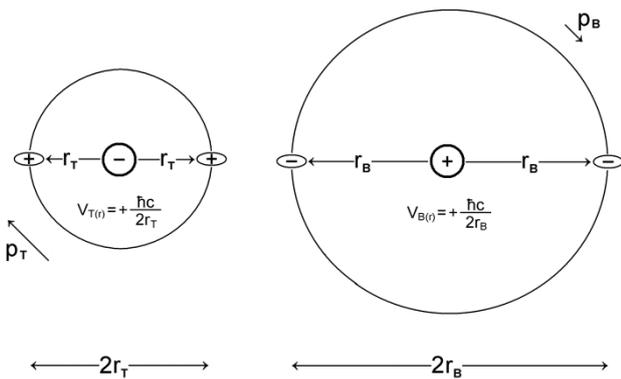
This leads the system fall apart into its respective expressions for the  $T$  and  $B$  components (Figure 3)

$$\mathbf{r}_T = +r \cdot (1 - \alpha^2)^{1/2}, \mathbf{r}_B = -r \cdot [2 - (1 - \alpha^2)^{1/2}] \tag{33}$$

and with respect to eqs. (27) and (28) reveals the virtual-nuclear-charge numbers

$$Z_T = +\frac{1}{2\alpha \cdot (1 - \alpha^2)^{1/2}}, Z_B = +\frac{1}{2\alpha \cdot [2 - (1 - \alpha^2)^{1/2}]} \tag{34}$$

associated with the respective potentials acting each explicitly on the two different states of the particle under investigation (Figure 3, Figure 4). The negative sign in the radius for the  $T$  is considered and therefore compensated by its negative mass in eq. (24), which justifies the always positive sign in both of the above virtual-charge numbers.



**Figure 3.** A picture to envision the behaviour of the electromagnetic wave splitted into its two different speeds limiting the light-speed barrier where transition from subluminal bradyon into superluminal tachyon occurs. It shows the two particles of "artificial masses" designed  $m_B$  and  $m_T$  moving at their momentae  $p_B$ ,  $p_T$  on two orbits around the atomic center those belong to the two corresponding wave-lengths (see text). The centers are marked to denote the locations of the prospective electric charges as to distinguish the differences in the electrostatic forces acting respectively to particle and co-particle

For clarity, the subindices 0 (zero) for the respective particle at rest, kin designing the momenta as kinetic, and  $r$  for radius dependency are avoided in the following description. In accordance to the nuclear-charge numbers  $Z$  the specific potentials  $V$  are also subindexed  $T$  and  $B$ ,

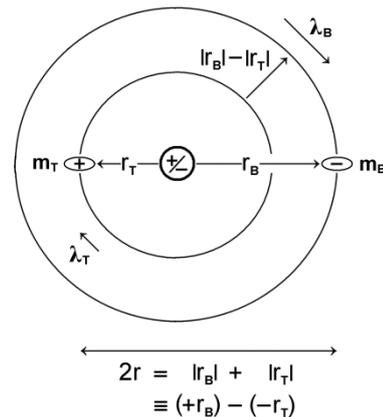
respectively. As a conclusion, it is drawn abbreviated instead

$$\begin{aligned} m_T &= +\frac{\alpha\hbar}{2rc}, m_B = -\frac{\alpha\hbar}{2rc} \\ \mathbf{p}_T &= +(m_T / \alpha) \cdot [2 - (1 - \alpha^2)^{1/2}] \cdot c \\ \mathbf{p}_B &= -(m_T / \alpha) \cdot (1 - \alpha^2)^{1/2} \cdot c \\ V_T &= +\frac{1}{2\alpha \cdot (1 - \alpha^2)^{1/2}} \cdot \frac{\alpha\hbar c}{r} \\ V_B &= +\frac{1}{2\alpha \cdot [2 - (1 - \alpha^2)^{1/2}]} \cdot \frac{\alpha\hbar c}{r} \end{aligned} \tag{35}$$

In a view similar to the Bohr's atom model the particle and its co-particle surrounding a nucleus  $n$  would occupy two orbits (Figure 4). The nucleus in the present model does not really exist. It is drawn to facilitate an easy comparison between the two systems, though their difference with respect to the electrostatics is emphazisingly tiny.

The task is now to develop the entire model incorporating the above data from the set eqs. (35) with regard to the properties of the  $B$  and the  $T$  particle twin related to the two different pseudo-charges of a suggested nucleus located at the same center (Figure 5) in the use of a mean value  $Z$  alone to completely represent the atom model (Figure 4). A way straight forward is then the search for an average nuclear-charge number

$$\begin{aligned} \rightarrow Z &= \frac{(Z_T + Z_B)}{2} \\ \rightarrow Z &= \frac{1}{2\alpha[2 - (1 - \alpha^2)^{1/2}] \cdot (1 - \alpha^2)^{1/2}} \\ \rightarrow Z &= \frac{1.00000000071}{2\alpha} \approx 1/2 \cdot \alpha^{-1} \end{aligned} \tag{36}$$



**Figure 4.** The bradyon  $B$  and tachyon  $T$  together to occupy two orbits in circumference of a central point representing the location of a real nucleus in a real existing atom in nature. In addition to the respective radii  $r_B$  and  $r_T$  the "gap"  $|r_B| - |r_T|$  is drawn between the both states belonging to their speeds. The mass positive  $m_T$  and mass negative  $m_B$  are travelling at their speeds super- and subluminal, respectively

A further calculation should properly involve also the two distinguished momentae,  $p_B$  and  $p_T$ , which properly then would require exact treatment of the problem by the two associated and different differential operators, *i. e.*,  $p_B = -i\hbar_B$  and  $p_T = -i\hbar_T$ . These obstacles can be

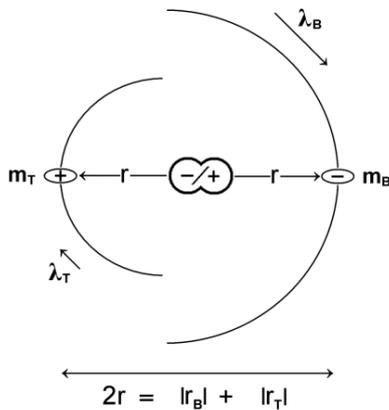
overcome introducing one effective mass alone as follows. The related distances  $\mathbf{r}_T$  and  $\mathbf{r}_B$  to the system's center (Figure 4, Figure 5) modify eqs. (23) and (24) into

$$m_T = + \frac{\alpha \hbar}{2rc} \equiv - \frac{(1-\alpha^2)^{1/2}}{r_T} \cdot \frac{\alpha \hbar}{2c} \quad (37)$$

$$m_B = \frac{\alpha \hbar}{2rc} \equiv + \frac{2-(1-\alpha^2)^{1/2}}{r_B} \cdot \frac{\alpha \hbar}{2c} \quad (38)$$

With the aim to discuss the model on the basis of only one particle occupying one atom orbital (Figure 5) instead of two (Figure 3) a weighting to the center of gravity can balance the two masses relative to their respective speeds according to their momenta in eqs. (25), (26). It is consequently

$$\begin{aligned} \frac{1}{m^*} &= + \frac{1}{m_T (1-\alpha^2)^{1/2}} + \frac{1}{m_B [2-(1-\alpha^2)^{1/2}]} \\ \rightarrow \frac{1}{m^*} &= + \frac{2-(1-\alpha^2)^{1/2}}{m_T \cdot [2-(1-\alpha^2)^{1/2}](1-\alpha^2)^{1/2}} \\ &+ \frac{(1-\alpha^2)^{1/2}}{m_B \cdot [2-(1-\alpha^2)^{1/2}](1-\alpha^2)^{1/2}} \quad (39) \\ \rightarrow \frac{1}{m^*} &= + \frac{2-(1-\alpha^2)^{1/2}}{m_T \cdot [2-(1-\alpha^2)^{1/2}](1-\alpha^2)^{1/2}} \\ &+ \frac{(1-\alpha^2)^{1/2}}{m_T \cdot [2-(1-\alpha^2)^{1/2}](1-\alpha^2)^{1/2}} \end{aligned}$$



**Figure 5.** The local arrangement to unite the centers to one bearing mass and electric charge for facilitation to the treatment regarding one reduced mass and one nuclear charge both located at the same center

In the last line the mass symbol of the  $B$  particle designed  $m_B$  is replaced by the symbol  $m_T$  belonging to the  $T$  co-particle, but negative in sign. After rearranging

$$\frac{1}{m^*} = + \frac{2[1-(1-\alpha^2)^{1/2}]}{m_T \cdot [2-(1-\alpha^2)^{1/2}](1-\alpha^2)^{1/2}}$$

and inserting  $m_T$  from eq. (23) finally gets

$$m^* = + \frac{\alpha \hbar \cdot [2-(1-\alpha^2)^{1/2}](1-\alpha^2)^{1/2}}{4rc \cdot [1-(1-\alpha^2)^{1/2}]} \quad (40)$$

The last expression shows a reduced and positive artificial photon rest-mass depending on a distance  $\mathbf{r}$  from

a suggested center of the atom model (Figure 4, Figure 5). If in the last equation the absolute value  $r = |\mathbf{r}|$  can replace its vector, the current problem will be spherical symmetric as in an H-like atom.

It is seen the value found for this truly “artificial” reduced rest mass  $m^*$  is large. A representation by  $mc^2 = E_{(m)}$ ,

$$\begin{aligned} E_{(m)} &\equiv \frac{\alpha \cdot [2-(1-\alpha^2)^{1/2}](1-\alpha^2)^{1/2}}{4 \cdot [1-(1-\alpha^2)^{1/2}]} \cdot \frac{\hbar c}{r} \\ &\approx 68.5171 \cdot \frac{\hbar c}{r} \end{aligned} \quad (41)$$

allows comparison to the average potential energy

$$\begin{aligned} V &\equiv \frac{1}{\alpha \cdot [2-(1-\alpha^2)^{1/2}](1-\alpha^2)^{1/2}} \cdot \frac{\hbar c}{r} \\ &\approx 68.5190 \cdot \frac{\hbar c}{r} \end{aligned} \quad (42)$$

and shows almost exact agreement as expected.

At this stage the problem is still due to a continually moving electromagnetic wave as described by the KGF-equation eq. (14). However, both characters of a particle are involved to obey the Dirac's formalism pointing to both a positive and a negative states together and at the same time. Though, the problem is reduced to the view of only one particle, both twins in eqs. (7), (8) are coupled by a potential involved in the expressions (10), (11), and the treatment is not due to a free particle any more. As a consequence of the given potential in eq. (21) entailing the eqs. (27), (28) the spins vanish as in an undisturbed free but electromagnetic wave, and any spin character is hidden [78]. The now even positive rest-mass  $m^*$  allows further treatment on the basis of the positive Dirac's twin eq. (10) alone for a spinless particle, zero spin. It is in some kind reduced and simplified to almost a Schrodinger's model [42,57], eq. (13). However, everything demands for relativistic consideration and clearly prohibits any classical treatment especially in the view of the mass.

This is still not yet the entire model completed, since the particles still exchange their places as they constantly do in a moving electromagnetic wave. There is no reason up to now why they should really leave their way moving on continually to describe a path straight forward, but to form an atom by the circumference of a circular orbit, classically spoken, surrounding its center instead (Figure 4). This is the essential key in this atom model.

Now, since the particle is appointed a mass gravitational influence must be taken into account. In this case the related frame discussed in special relativity will no longer remain an inertial system, but leaves in the favour for general relativity [79], and the idea of the event horizon [69,70,80] comes to the forth. The point is to consider the problem on the basis of the escape velocity that is required to even escape gravitation described by the energy in Newton's law eq. (17) and found by equating with the relativistic kinetic energy eq. (3) of the particle considered. The idea is now to try the gravitational influence to force the respective moving particle into an orbit-like behaviour by the demand to follow a trail rectangular to the center of the atom, *i. e.*, to keep an angle

of  $\vartheta = \pi/2$  between its orbital movement and the distance  $r$  pointing to this center. In a more substantiated formulation the task is to cram the continuously propagating wave into an electromagnetic mode at equilibrium, *i. e.*, a standing wave as to a suitable wave function to exhibit the atom particle-like characteristics. The concern is due to the search for a model having the typical properties of an atom in nature that properly consists of electronic clouds around a centered proton.

Although, the angle due to the interaction of a light-beam with matter can be calculated [73,81]

$$g = \frac{4G \cdot m}{rc^2} \quad (43)$$

to allow the condition

$$\frac{\pi}{2} = \frac{4G \cdot m}{rc^2} \quad (44)$$

a more rigorous way is decided here by considering the pure escape velocity. This concept is justified with respect to the fact that in the current theory interaction between particles of matter is resourced the way to form an atom in contrast to a properly and truly existing electromagnetic wave propagating continuously straight forward instead. Hence, equating the energies in eqs. (3) and (17) for two identical masses provides the condition

$$m \cdot c^2 = G \frac{m \cdot m}{r} \quad (45)$$

$$\rightarrow r = \frac{m \cdot G}{c^2}$$

Here, the variable  $d$  for the distance of attraction is replaced by the radius  $r$  to adapt to the formalism developed above, where it denotes the atomic radius pointing to its center. This means a positive mass  $m_+$  neither to leave gravitational force generated from a central positive mass  $m_+$  involved to it nor to get pulled into the center. It is true, both masses could still be chosen negative as well, but both masses are identical in magnitude and sign as considered already before.

The consequence from combining the last expression with eq. (40) into

$$m_{(e,G)} = \pm \frac{1}{2} \cdot \sqrt{\frac{\alpha \hbar c \cdot [2 - (1 - \alpha^2)^{1/2}] - (1 - \alpha^1)^{1/2}}{G \cdot [1 - (1 - \alpha^2)^{1/2}]}} \quad (46)$$

shows the exclusive and unique condition for the magnitude of a rest-mass required as the basis for a description of the hypothetical atom model. It is obvious the factor  $\alpha$  considers the relativistic discrepancy in the relation radius-to-circumference. If the light velocity in a vacuum without external disturbances was taken

$$c = 299792458 \text{ m/s}$$

and the gravitation constant assumed the classical value

$$G = 66,7384 \cdot 10^{-12} \frac{\text{m}^3}{\text{kg} \cdot \text{s}^2} \quad (47)$$

then the demanded rest-mass for the particle in the atom orbital of the lowest and unique energetic state, as well would appointed the absolute value

$$|m| = 0.179921 \cdot 10^{-6} \text{ kg} \equiv 1.12298 \cdot 10^{+12} \text{ eV} / c^2 \quad (48)$$

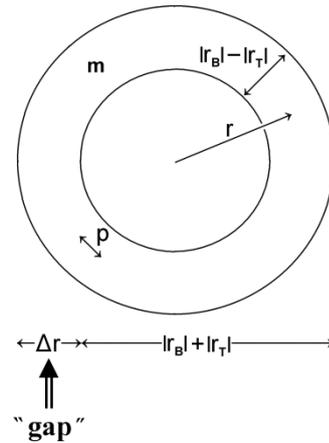
As entailed from real light this result is due to a positive energy process to produce light, then this particle under investigation must consequently decided appear positive in mass according to the above calculation performed on the reduced mass. It is the only one allowed in this hypothetical atom, which obviously then and alone in this exclusive case can only consist of real and (positive) matter - not (negative) anti-matter.

As noted above the variable  $r$  can replace the vector  $\mathbf{r}$  in its character as representative to describe the atomic constitution spherical symmetric, which justifies the positive sign in eq. (46) and consequently its numerical value positive eq. (48) as well.

The radius  $r$  in the current model follows from eqs. (40) with (45)

$$r = \frac{1}{2c} \cdot \sqrt{\frac{\alpha \hbar G \cdot [2 - (1 - \alpha^2)^{1/2}] \cdot (1 - \alpha^2)^{1/2}}{c \cdot [1 - (1 - \alpha^2)^{1/2}]}} \quad (49)$$

and shows the final result of this theory (Figure 6).



**Figure 6.** Final result of the atom formed by an electromagnetic wave. The details contain a visible "gap" constituted by the two limiting light-speeds and a single radius pointing into the unique orbital. In this picture the band between the two rings is located within the light-speed barrier appearing between the limit speeds. It is drawn representative and to compare this theoretical system with a real atom consisting of a nucleus in its center surrounded by an electronic cloud

The main average value from relativistic theory for the radius of a H-like atom is [54]

$$\rho = \frac{1}{2} \frac{\hbar}{mc \cdot (Z\alpha)} \quad (50)$$

However, the relativistic influence considered by the factor  $\alpha$  to explicitly appear in this formula is taken into account in eq. (21) already from the beginning of the calculation and entirely throughout the current theory. When the above statements eqs. (36) and (46) are inserted this main average radius for the current atom models should exactly agree with the atomic radius  $r$  in eq. (49) found before. The main average radius reads

$$\rho = \frac{1}{2c} \cdot \frac{\hbar}{\frac{1}{2} \sqrt{\frac{\alpha \hbar c \cdot [2 - (1 - \alpha^2)^{1/2}] \cdot (1 - \alpha^2)^{1/2}}{G \cdot [1 - (1 - \alpha^2)^{1/2}]} \cdot c \frac{1 - (1 - \alpha^2)^{1/2}}{2\alpha [2 - (1 - \alpha^2)^{1/2}] \cdot (1 - \alpha^2)^{1/2}}} \quad (51)$$

$$\rightarrow \rho = \frac{1}{2c} \cdot \sqrt{\frac{\alpha \hbar G \cdot [2 - (1 - \alpha^2)^{1/2}] \cdot (1 - \alpha^2)^{1/2}}{G \cdot [1 - (1 - \alpha^2)^{1/2}]}}$$

*Quod erat demonstrandum.*

### 3. Results

The general result of this study is an atom formed alone by an electromagnetic wave. It is a consequence of a coupling of the two differential equations in the Dirac's relativistic wave theory by an appropriate choice for an interaction potential between the positive and negative states, which consecutively interchange within the character of this wave. It is true the speed of light and the gravitation constant are treated as those with care, but not at all valued in any property to give absolute or truthworthy numerical results considered to allow a solid statement with regard to final consequences. The theory is seen, instead, as a proposal for a more relative answer with the attempt for a hypothetical atom to justify the existence of a being to behave positive in mass, in the universe and an anti-universe as well.

In this proposal a theory is developed to describe an atom consisting of an electromagnetic wave alone, which draws a picture kind like a tiny glass globe formed by an extremely thin and slight layer of an almost diminishing skin thickness. If the constants  $c$  and  $G$  for demonstration served by their numerical values

$$c = 29.9792458 \cdot 10^{+9} \text{ m/s}$$

$$\text{and } G = 66,7384 \cdot 10^{-12} \frac{\text{m}^3}{\text{kg} \cdot \text{s}^2}$$

the data would be appointed the following absolute values:

Particle mass in the spherical atomic orbit

$$|m| = 0.179921 \cdot 10^{-6} \text{ kg} \equiv 1.12298 \cdot 10^{+12} \text{ eV/c}$$

Main average radius

$$r = 13.3603 - 10^{-33} \text{ m} \equiv 0.133603 - 10^{-21} \text{ \AA}$$

Diameter (thickness)  $2[1 - (1 - \alpha^2)^{1/2}]$  of a the center surrounding envelope (Figure 6) representing the unique orbital

$$r_{\text{gap}} = 0.711465 - 10^{-36} \text{ m} \equiv 7.11465 - 10^{-27} \text{ \AA}$$

The atom claims the most effective nuclear-charge number compared to any other atom that is not of ionic character but consists of a nucleus surrounded by an electronic cloud. In the present model it is

$$Z_{\text{eff}} \approx \frac{1}{2} \cdot \alpha^{-1}$$

In the case of a free particle no character of the mass in their property being positive or negative is favoured, whereas and in contrast in an electromagnetic wave as light the positive dominates and serves the driving force.

The properties of the suggested atom are light-like. It behaves like a noble gas atom with a nucleus of positive mass, but due to electric charge can be both either positive or negative as well. With regard to the above assumption it demonstrates an estimated density or respective specific weight

$$m_{\text{spec}} = 18 \cdot 10^{+84} \text{ g/cm}^3$$

Further, it has no resulting spin, and as it is embodied perfectly isotropic and spherical there is no angular momentum either. In addition the atom behaves electric and magnetic neutral. An electromagnetic interaction is certainly not excluded, and it presents gravitational interaction due to its rest-mass. Due to the origin of the model it can be certainly presented as built of matter and anti-matter together those can and will never annihilate in their one-particle system.

As a conclusion, the model (Figure 6) presents an atom of a single particle "surrounding" a center of nothing, there is no nucleus like a proton and consists of nothing else than an electromagnetic wave alone. The proposed atom looks like a totally empty globe. It is of positive matter in the universe as well as in an anti-universe and can be coined *Luxonium* with chemical symbol  ${}^0\text{Lm}$ .

### 4. Discussion

On a first view, it seems ridiculous to suggest an atom consisting of nothing else than an electromagnetic wave instead of a body of a solid nucleus in its center surrounded by a cloud of electrons. Generally, at least two separate and real particles are incorporated into a calculation. It stands the reason, why two hypothetical photon-particles together may not form this also hypothetical atom as well as they maintain the enormous constancy of  $c$  in vacuum. Moreover, atom theories and quantum mechanics are even based on the properties of waves as they are always discussed due to their properties for true statistical interpretation.

Photons and other messenger particles with zero mass exist from the point of emission to the point of interaction (absorption). There is also the argument that two particles like an electron and a positron annihilate to result in electromagnetic radiation, whose nature is precisely the question, at issue here. In contrast to the Positronium [3,4,6,7,8,9,13,33,34,73] the two particles in the current study - those are a positive bradyon  $B$  and its negative co-particle tachyon  $T$  forming an atom - can never annihilate since they are really only one particle that appears interchanging in both characters.

This point even is the advantage in the view there are no two separate particles those could annihilate and cancel each other out, which would be the case if there were really two different particles complementary to each

another. The latter is even a condition for a resulting mass of light that must be zero at rest. Further, the difference of the suggested atom to light is emphasized as the angular momentum is zero in contrast to propagating light having an angular momentum of 1 [82]. The model is distinguished from all other natural atoms as a nuclear-charge number  $\approx \frac{1}{2} 137$  appears outstanding especially with regard to the other extrema that is suggested the Feynmanium of order number 137. In the case of the latter it has to be taken into account that a demand for this atom at the end of the periodic table is reasoned by the Dirac's theory, which does not allow a nuclear charge of larger than 137. It has to be mentioned, however, that question can satisfyingly only be answered for such an atom having only one electron and is then 136 fold ionized so that there is no shielding by any other electrons in the system and an effective  $Z = 1/\alpha$  can be expected.

If light consists of a  $B$  and its  $T$  co-particle, then only one particle will be required to consider as discussed recently [76]. On the other side, fraction experiments on a slit can verify the Heisenberg's uncertainty [30] even on a single photon, which reveals evidence of the existence of the particle / co-particle pair demonstrating the mysterious character found on the nature of electromagnetic waves, *e. g.*, light. The current study deals with this feature, which obviously can be valued as a hint to the Heisenberg's uncertainty as a relativistic effect.

With regard to the proposal presented here and based on the above particle pair their properties together also meet the requirements by the Pauli's principle [83-90]. The approach is tried this direction since theory opens this way [34,91-96]. Further, the Dirac's formalism [31,32] predicts negative energy states and a positive electron [93,94,97], where the latter has been proven by experiment [33]. Thus, it is worth the decision to involve the summand containing the rest-mass in the calculation. In spite of the idea for a particle demonstrating character complementary to the electron with the aim to obey the demands from both twins of the Dirac's equations this search must follow a strict way. That is not to discard or even deny the complete and true statement of the sometimes so-called "negative" Dirac equation. The key in those first-order differential equations is their origin from a second-order wave equation consisting of quadratic terms. As the latter in their character is formulated the Klein-Gordon-Fock (KGF) equation [43-53] it includes the fundamental characteristics of electromagnetic waves, though a spin for the free particle is hidden [78]. It is certain that formalism allows positive and negative states as well, a condition as required by an electromagnetic propagation of waves and used in the present theory in that way concerning a B-T pair in their complete complementary characteristics.

As to the discussion about negative energy states and anti-particles it comes to the forth that an anti-particle generally is suggested complementary to the related particle in its electric charge, but not carefully taking into account their mass to entirely and really obey that important requirement by the above cited "negative" Dirac's equation. There are several publications dealing with anti-matter those are for example found on anti-hydrogen [35,36,37,38]. Further, the influence of gravity to anti-matter is studied [37]. In the present theory

that is an important factor, too, and emphasized to consider with regard to the attempt to formulate an idea for an atom of true order-number zero. Although, a great discovery, well studied and experimentally proven the Positronium is, of course, not consisting of a particle and its anti-particle bound together so that it would become really its anti-particle itself. Never, because of the same reason the mass of a positron is positive as well as that of the electron, it is not anti-matter and does not obey the respective Dirac's equation.

At this point properly starts another search for such an atomic system as it presents a special and also unusual case investigated in the current paper. It is in some kind difficult with regard to find a suitable rest-mass gained from an electromagnetic wave to act instead of the real particles as a proton and electron found as consisting of real matter in a real matter atom. Those cumbersome obstacles can be tried to overcome by the proposal of one particle that steadily and continuously interchanges its character between bradyon and tachyon together with its properties with respect to change mass and electrical charge in sign. Further, the spin it must be taken into account.

The central and most important task, however, appears in the fact to make an electromagnetic wave change its direction the way to force it into an orbit to dress the atom model an orbital character. As electromagnetic waves in accordance to general relativity [79] interact with matter [67-73] also gravitation matter waves are extensively discussed [39] as well as anti-matter gravity [37]. Those investigations led to the idea to involve gravitational mechanism to argue the wave can be driven that way. This is the only possibility to succeed in this goal.

It is true, gravitational interaction of light beams [81] on the one side and spinning [98] on the other are important facts appearing in discussions towards gravity. The effect of spinning is proven on spin-torsion interaction between spinning protons [99].

Since it has been already pointed out two anti-parallel electromagnetic waves can indeed demonstrate gravitational interaction, the contrasting phenomena revealed by those in parallel orientation is shown as well. As a consequence, the current theory can solidly be based on the first as the counterparts as particle and its co-particle move anti-parallel as well as in the case of their corresponding waves. The investigation demonstrates in addition treatment of a properly single-particle model and therefore how to justify a spin-less system to overcome involvement of the latter strictly pointing to the Kerr's metrics [98]. Due to the special character of photons as properly massless at rest and therefore not consisting of real matter like the elements in an existing atom, the current project is delicate and the way fragile. It opens the central question for an appropriate gravitation constant like  $G$  in the Newton's classical model [15] to quantitatively determine how matter affects light but more specifically how light can alter light [81]. The latter citation reveals very distinguished differences in the orientation of two light beams facing each another. In the view of sub-atomic and nuclear forces large differences in about  $10^{-39}$  between gravitation and strong interaction comes to the forth.

In the studies on gravitational interactions in atomic and sub-atomic investigations the results differ quite distinctly.

There are several ways to assess the magnitude in gravitational force as it depends on the type of objects. In a first study of electron versus gravity very large values appeared as entailed from gravitational effects [100]. As an example a  $G = 2.06 \cdot 10^{26} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$  was determined from the interaction of two deuterium nuclei [101]. Another study was based on the analogy between hadrons and Kerr-Newman black holes [102,103,104] to accept the value  $G = 6.7 \cdot 10^{27} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$ . The sub-atomic values to consider strong gravitation differ between the properties of gravitations and those of matter at different levels [105] leading to Hierarchical Nesting of Matter, i. e., the Le Sage's theory of gravitation [106,107]. Any discussion the way points to the nature of elementary particles being much more fundamental than the character of black holes [108]. Then a large arbitrary number for the gravitational constant has to be considered [109,110]. As a consequence a strong atomic gravitational constant can be assumed. Since nuclear size can be fitted with a nuclear Schwarzschild radius this can be considered "strong nuclear black hole" [111]. Following that approach it stands the reason whether to justify a single constant physically significant, however, just leading to the grand unification program and dark matter projects.

The current study does not ignore those facts, but it rather argues the figure presented here points to an "artificial" mass of light and reasons due to the obviously existing electromagnetic wave instead. Though, the theory certainly can be considered a rough estimation it must be understood as treatment to explain the basic condition with respect to an interaction of these waves. The mass involved is originated from the demand for a rest mass as to consider the model for purposes to justify properly an existence of an atom founded from the requirement to involve both characters, i. e., positive and negative. It is due to entirely obey the demands presented by the KGF and Dirac's formalisms together with the demand for the proposal to consider positive and negative states together and at the same time. The latter is the essential point in this description, and it purely omits to ignore the negative state as to favour solely the positive. This argument even holds in this model as both states are involved, although, it emphasizes the calculation is reduced to only one single and positive state and developed to restrict the problem on the positive state, though, at the same time the negative states are not ignored. Since the existence of gravitational interaction between electromagnetic waves is obvious as well as the electromagnetic the proposal in this work shows a qualitative result to explain the possibility of an atom consisting of particle and its anti-particle as it is its anti-particle itself and consequently deserves to claim the order-number zero in the periodic system.

## 5. Resume

The general result of this study is an atom formed by an electromagnetic wave. It is a consequence of a coupling of the two differential equations in the Dirac's relativistic wave theory by an appropriate choice for an interaction potential between the positive and negative states, which consecutively interchange in the character of this wave. The description of the model is successfully achieved by

reducing the problem on the treatment of one single and positive particle alone as a key to overcome the obstacles with negative energy states. Since the bradyon  $B$  as the matter part in the model is favoured over the tachyon  $T$  representing the anti-matter part consecutively a real atom with positive mass can be postulated.

On the basis of the speed-limit of a particle touching the light-barrier the related value for a reduced mass in the model is found as a representative for a bradyon particle and its tachyon anti-particle both together those interchange mirroring their characters in the electromagnetic wave.

In addition to pure electrostatic interaction the gravitational attraction is involved allowing the particle to keep an orbital trail as to occupy an atomic orbital around a defined center. This calculation is based on the conventional gravitation constant that is justified by the small reduced mass of the particle in comparison to the electrostatic interaction energy before gravitation takes place. Due to this argument, the possibility to arrive at a suitable rest-mass for an entire and complete description of the model is successfully achieved. The study can claim to manifest a true probability of spatial density represented by a photon particle in form of an electromagnetic wave at the same time.

On the basis of the speed-limit of a particle touching the light-barrier the related value for a reduced mass in the model is found as a representative for a bradyon particle and its tachyon anti-particle those interchange characters their character in the electromagnetic wave.

In addition to pure electrostatic interaction gravitational attraction is involved allowing the particle to keep an orbital trail as to occupy an atomic orbital around a defined center. This calculation is based on the conventional gravitation constant that is justified by the small reduced mass of the particle in comparison to the electrostatic interaction energy before gravitation takes place. Due to this argument the possibility to arrive at a suitable rest-mass for an entire and complete description of the model.

It can be manifested in the case of a free particle no character of the mass in their property be positive or negative is favored, whereas in light the positive is preferred. Although the theory grounds on being originated by matter and anti-matter those components do not annihilate, since they are identified couple-like in one single particle but interchanging both of those characters; they strictly never interfere. An emphasizing consequence is therefore light could never exist otherwise.

A further treatment dealing with this mass as a particle is the possibility the Dirac's equation can be interpreted for positive states so that the calculation leads to the ground state energy of an atom model demonstrating real and always positive in matter.

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