Superluminal Wavelike Interaction, or the Same, De Broglie Relationship, as Imposed by the Law of Energy Conservation, in All Kinds of Interaction, Making a Whole New Unification

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Previously, based on the law of energy conservation, we figured out that, the steady state elliptic motion of an electron around a given nucleus depicts a rest mass variation throughout. We happened to develop our theory, originally *vis-à-vis* gravitational bodies in motion with regards to each other, providing us with all known end results of the General Theory of Relativity. Hence, it is comforting to have both the atomic scale and the celestial scale, described, on just the same conceptual basis. One way to conceive the phenomenon we disclosed, is to consider a "jet effect". Accordingly, a particle on a given orbit through its journey, can be conceived to eject a net mass from its back to accelerate, or must pile up a net mass from its front to decelerate, while its overall relativistic energy, in a closed system, stays constant throughout. The speed U of the jet, strikingly, points to the de Broglie wavelength λ_B, thus coupled with the period of time T_0, inverse of the frequency ν_0, delineated by the electromagnetic energy content $h\nu_0$ of the object of concern; $h\nu_0$ is originally set by de Broglie equal to the total rest mass m_0 of the object (were the speed of light taken to be unity). This makes that, on the whole, the "jet speed" becomes a superluminal speed $U = \lambda_B \big/ T_0 = c_0^2 \sqrt{1 - v_0^2/c_0^2} \big/ v_0$, *a fortiori* excluding any transport of energy. We call it wavelike speed. This result, in any case, seems to be important in many ways. Amongst other things, it may mean that, either gravitationally interacting macroscopic bodies, or electrically interacting microscopic objects, sense each other, with a speed greater than that of light, and this, in exactly the same manner, in both worlds. Note that what we do, well stays within the frame of Quantum Mechanics, since in fact, we ultimately land at the de Broglie relationship. Note also that, we well stay within the frame of the Special Theory of Relativity (STR). Our disclosure seems to be capable to explain the spooky experimental results recently reported, though without having to give away neither the STR, nor Quantum Mechanics, one for the other.

1. The de Broglie Relationship [1] [1-3]

Consider an object of mass m_0 at rest. In his doctorial thesis [4], de Broglie anticipated that there should be a periodic phenomenon inside m_0, depicting a frequency ν_0, such that

$$h\nu_0 = m_0 c_0^2 \ . \tag{1}$$

where h is the Planck Constant, and c_0 the speed of light in "empty space". It is remarkable that he considered Eq. (1), at a time even when, the "annihilation process" of an electron with a positron remained far away to be discovered. Anyway Eq. (1) constitutes the energy content equality of the object in hand. Thus, let λ_0 be the wavelength, and T_0 the period of time, to be associated with the electromagnetic wave coming into play. By definition of the speed of light, we have

$$c_0 = \frac{\lambda_0}{T_0} = \lambda_0 \nu_0 \ . \tag{2}$$

Eqs. (1) and (2) thus, as usual, lead to

$$\lambda_0 = \frac{h}{m_0 c_0}, \tag{3}$$

the wavelength of the electromagnetic radiation associated with mass m_0, as originally assigned by de Broglie, to describe the periodic phenomenon inside the object at hand.

The frequency ν_0 and the mass m_0, are transformed differently, were the object brought to a uniform translational motion [5]. Indeed, as well-known, according to the Special Theory of

[1] This article is made of the text of the presentation the author has the privilege of having made to the PIRT (Physical Interpretation of the Relativity Theory) that was held between July 2 – 5, 2007, in Moscow, and to the distinguished audience of Lebedev Physics Institute (Moscow), in July 6, 2007. It constitutes the summary of the detailed articles (Part I / Electrically Bound Particles, and Part II / Gravitationally Bound Particles) by the author, recently published in the International Journal of Physical Sciences (see the list of references at the end of this summary).

Relativity (STR), the frequency decreases while the mass increases. This observation (as he mentions it, himself) intrigued de Broglie for a long time [1]. He ended up with the introduction of a new wavelength λ_B describing the manifestation of the wave-like character of the object. Thus supposing that the object is moving with the velocity v_0; de Broglie framed λ_B, similar to the RHS of Eq.(3), as

$$\lambda_B = \frac{h}{mv_0} \ , \tag{4}$$

the de Broglie relationship written for the object in hand, brought to a translational motion, where m is the relativistic mass of the moving object, i.e.,

$$m = \frac{m_0}{\sqrt{1-\frac{v_0^2}{c_0^2}}} \ . \tag{5}$$

Via Eqs. (3), (4) and (5), one can write, in a straightforward, though unusual, way the relationship

$$\lambda_B = \lambda_0 \frac{c_0}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}}; \quad v_0 \neq 0 \ , \tag{6}$$

the de Broglie wavelength written along with Eq.(1), in terms of λ_0, the wavelength of the periodic phenomenon displayed by the object, at rest, between the two wavelengths λ_B and λ_0, in question [*cf.* Eqs. (3) and (4)].

Here, we have taken the precaution to write the de Broglie wavelength for a non-zero velocity, since ordinarily one would think that de Broglie relationship could only be defined, along with a motion. But as will be elaborated later, it seems that, it can be defined for a zero velocity, as well. (And there is no reason, why it should not be!) In this latter case, de Broglie's wavelength becomes infinitely long. As we will soon detail, it appears then to constitute, without however involving, any mass or energy exchange, the basis of an immediate action at a distance. Whether immediate or not, the speed of such an action, as we will see, right below, is always higher than the speed of light. We would like to call it, wave-like interaction.

Thus, the de Broglie wavelength, happens to be the wavelength to be associated with an "information" of frequency ν_0, but free of energy whatsoever, propagating with the velocity: $\left(c_0^2/v_0\right)\sqrt{1-v_0^2/c_0^2}$, so that

$$\frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} = \lambda_B \nu_0 \ . \tag{7}$$

Let us now divide the two sides of Eq. (6) by T_0:

$$\frac{\lambda_B}{T_0} = \frac{\lambda_0}{T_0}\frac{c_0}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} = \frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \ . \tag{8}$$

We pose the definition

$$U_B = \frac{\lambda_B}{T_0} \ , \tag{9}$$

and write instead of Eq. (8)

$$U_B = \frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \ , \tag{10}$$

the velocity defined based on de Broglie relationship and the period of the periodic phenomenon of the object at rest, as defined by Eqs. (1) and (2).

Below, we are going to show that, we can obtain this relationship, just based on the relativistic law of energy conservation, broadened to embody the mass & energy equivalence of the STR, for both electric and gravitational interactions, in fact for any kind of interactional motion, which further delineates interesting conclusions.

2. Previous Work: A Novel Approach to the Equation of Electric Motion

In order to proceed, we state the following postulate, which is nothing else, but the relativistic law of energy conservation [6].

Postulate: The rest mass of an object bound either gravitationally or electrically, or else, amounts to less than its rest mass measured in empty space, the difference being, as much as the mass, equivalent to the static binding energy *vis-à-vis* the field of concern.

Thus, consider a pair of static electric charges, for instance an electron and a proton — which can be assumed for simplicity, without any loss of generality, to be practically infinitely heavy as compared to the proton — bound to each other at a distance r_0 from the proton. In order to bring the electron from this location, to infinity, one has to furnish to it, an amount of energy equal to its static binding energy, *i.e.* Ze^2/r_0 at r_0. Because the proton can be, just for convenience, assumed to be infinitely heavy as compared to the electron, it will not be disturbed throughout the process, in question. In other terms, the electron will receive the energy Ze^2/r_0, all by itself, when it is carried to infinity.

Conversely, when the electron, brought quasistatically from infinity, is bound at r_0, to the nucleus; the binding energy coming into play, owing to the relativistic law of energy conservation, ought to be discharged from the original electron's rest total energy, alone. (One can well assume that the proton, which is not infinitely more massive than the electron, will also get altered, through the process in question, though just a little, in which case the essence of our derivation still holds, except that the presentation of our basic idea would become more complicated.) The rest mass (or better, the rest relativistic energy content) of the bound electron, accordingly becomes

$$m(r_0)c_0^2 = m_0c_0^2 - \frac{Ze^2}{r_0} = \kappa(r_0)m_0c_0^2 \ , \tag{11}$$

along with the definition

$$\kappa(r_0) = 1 - \frac{Ze^2}{r_0 m_0 c_0^2} \tag{12}$$

Thence, the rest mass (or, again, the rest relativistic energy content) of the bound electron, comes to be decreased as much as the static binding energy coming into play. Note that the rest mass decrease, as we will elaborate on, a little, below, alters the metric. Fortunately this may not have to be detailed for the derivation we will now, offer. Nevertheless it should be remembered that, in order to successfully cope with the experimental results, we should first consider to work in the proper frame of reference of the electron (and then make the necessary transformations to place ourselves in the position of a laboratory oberver). Thus below, we work in the proper system of the electron.

Now, suppose that the electron is engaged in a given motion around the nucleus. Recalling that the total energy does not depend on the path the system is composed throughout, the motion in question can be conceived as made of the two following steps:

1. Bring the electron quasistatically, from infinity to the given location r_0, on its orbit, but keep it still at rest.
2. Next, deliver to the electron at this location, its motion on the given orbit. On a stationary orbit, the overall relativistic energy $m_\gamma(r_0)c_0^2$, must be constant (Const).

Thus:

$$m_\gamma(r_0)c_0^2 = m(r_0)c_0^2\frac{1}{\sqrt{1-\frac{v_0^2}{c_0^2}}} = m_0c_0^2\frac{1-\frac{Ze^2}{r_0m_0c_0^2}}{\sqrt{1-\frac{v_0^2}{c_0^2}}} = \text{Const} \tag{13}$$

is overall relativistic energy of the electron in orbit. Note that one classically used to write, instead, the following equation:

$$m_\gamma(r_0)c_0^2 = \frac{m_0c_0^2}{\sqrt{1-\frac{v_0^2}{c_0^2}}} - \frac{Ze^2}{r_0} = \text{Const}\,. \qquad \text{Wrong!} \tag{14}$$

This latter equation, according to the present approach, is regrettably incorrect, given that it does not take into account the rest mass decrease of the statically bound electron, thus constituting a clear violation of the relativistic law of energy conservation. (Note anyway that, as mentioned, when precaution to work first, in the proper frame of reference of the electron, is taken, and then the former equation is written in the frame of the laboratory system, the latter two equations, lead to results, which overlap with the experimental results, to a very high degree of precision.)

Next, the differentiation of Eq. (13) leads to

$$-\frac{Ze^2}{m_0r_0^2}\frac{1-\frac{v_0^2}{c_0^2}}{1-\frac{Ze^2}{r_0m_0c_0^2}} = v_0\frac{dv_0}{dr_0}\ , \tag{15}$$

a differential form of Eq. (14), equivalent to the equation of motion. One can transform Eq. (15), into a vector equation; the RHS, is accordingly transformed into the acceleration (in vector form) of the electron on the orbit. Thus, recalling that the LHS of Eq. (13), *i.e.* $m_\gamma(r_0)c_0^2$, is constant, one can write

$$-\frac{Ze^2}{r_0^2}\sqrt{1-\frac{v_0^2}{c_0^2}}\frac{\mathbf{r}_0}{r_0} = m_\gamma(r_0)\frac{d\mathbf{v}_0(t_0)}{dt_0}\ , \tag{16}$$

a vectorial equation written based on Eq.(15), or the same equation of motion written by the author, via the energy conservation law, extended to cover the relativistic, mass & energy equivalence. Here, $\mathbf{r}_0$ is the "radial vector" of magnitude r_0, directed outward, and $\mathbf{v}_0$ is the "velocity vector" of the electron, at time t_0; note that $d\mathbf{v}_0$ and $\mathbf{r}_0$ lie in opposite directions.

Chiefly at this stage, with regards to the electrically bound particles, for a complete presentation, it would have been useful to add to our dissertation [2] a discussion about how one should view the connection between classically considered electric charges and the bound charges. The motion equation of bound electron within the framework of the present approach, indeed, diverges no matter very little, but, conceptually speaking, still seriously, from the standard motion equation, classically coined for a bound electron. In any case, one will raise the question that the approach we will present herein somewhat negates the Maxwell equations. Then of course, one should be expected to write explicitly new field equations, which are compatible with the postulate we have formulated above — in fact nothing else, but the relativistic law of energy conservation, though embodying the mass and energy equivalence of the STR. Or, even more fundamentally, one would have been expected to write a new expression for the Lagrangian density of the electromagnetic field coming into play, and charged particles, and using the variation principle to find new field equations and a new force law, etc. This may even have been the topic of a separate article.

However, throughout the time that elapsed since 2006, when the material we will present below was essentially all ready, this problem was fortunately handled by Kholmetskii, et al [7], who framed the pure bound field theory and named it, in short, PBFT. They thus came out with new field equations and a new Lorentz force law, though in a totally different mean than that is presented herein; nevertheless their results back certainly up those we present herein, allowing us, now, in the first place, not to have to reundertake the problems just mentioned.

It is important to emphasize that the PBFT is not a controversial approach at all. In fact it consists in the implementation of the law of momentum conservation for bound, thus non-radiating charges, on the basis of quantum mechanics. The PBFT, briefly, stays within the framework of the standard approach, but gears it:

1. with respect to a full consistency, *vis-à-vis* the law of momentum conservation, and
2. for quantum mechanically bound, non-radiating electric charges.

PBFT's range of applicabilitity, though, as mentioned, is quantum mechanically "bound particles". PBFT, nevertheless, wipes out the long lasting quest of how to bridge the classical Maxwell equations and quantum mechanics, and formulate accordingly a useful framework, essentially for non-radiating bound particles, thus filling the gap between the classical electrodynamics and the standard quantum mechanical approach.

In any case, our stand point is that any interaction depicts a rest mass change. Say in a free fall in a gravitational medium, the object at hand accelerates due to the transformation of a minimal part of its rest mass into kinetic energy. Such an understanding brings up the question of how this can take place. The coupling of acceleration and rest mass change induces the thought that, in the example at hand, rest mass is ejected from the back of the object, to match the extra kinetic energy acquired by the object, in fact just like in a rocket. This picture, finally, as we will see, thus based on just the relativistic energy conservation, together with the law of momentum conservation, leads to the de Broglie relationship, providing us with an invaluable bridge and symbiosis between the STR and quantum mechanics.

3. Mass "Sublimes" into Kinetic Energy, and Kinetic Energy "Condenses" into Mass, Throughout the Motion: a Jet Model

For a closed system, according to our approach, the total relativistic energy $c_0^2 m_{0\gamma}(r_0)$ of the electron ought to remain constant all along the electron's journey around the proton. On an elliptic orbit, for instance, this implies an alternating decrease and increase of the static binding energy of the electron in exchange with a corresponding variation of its kinetic energy. The kinetic energy decreases as the static binding energy increases, and vice versa. But, as stated above, the change in the static binding energy implies a change of the electron's rest mass (or, the same, rest relativistic energy). Thus on the elliptic orbit, as the kinetic energy of the electron increases, its rest mass decreases, and vice versa. Thereby, as the electron speeds up nearby the proton, an infinitesimal part of its rest mass somehow sublimes into extra kinetic energy (the electron acquires kinetic energy as it accelerates). In other words, the extra kinetic energy in question is fueled by the decomposition of an equivalent rest mass. Conversely, as the electron slows down away from the proton, through its orbital motion, the corresponding portion of its kinetic energy somehow condenses, into rest mass. The rest mass change occurs throughout the orbit as a requirement imposed by the law of energy conservation, which is broadened to embody the mass and energy equivalence of the STR.

One way to account for the process of concern is to consider a jet model. Thus, a minimal amount of net rest mass should be thrown from the back of the electron through the acceleration process (which would mean the same as the sublimation of a corresponding part of the rest mass, into kinetic energy), along the tangential direction to the orbit, or absorbed from the front, through a deceleration process (which would mean the same as the condensation of a corresponding part of the kinetic energy, into rest mass), still along the tangential direction to the orbit. Below, we will write the law of momentum conservation, with regards to the system made of the accelerating electron and its jet, alone (since the proton is assumed to be at rest, throughout). Thus, the magnitude of the linear momentum $P(t_0)$ of the electron, moving with a given velocity v_0, at time t_0, at the given location r_0, is

$$P(t_0) = m_\gamma(r_0) v_0 , \tag{17}$$

the magnitude of the linear momentum of the electron, at the given location and at the given time. The momentum becomes $P(t_0 + dt_0)$, following the dumping of the rest mass $|dm(r_0)|$, via the jet effect, of speed U:

$$P(t_0 + dt_0) = dm(r_0)U + m_\gamma(v_0 + dv_0) , \tag{18}$$

the equation of conservation of momentum with regards to the electron, assuming that the proton is at rest, all the way through. This yields†

$$m_\gamma dv_0 = -dm(r_0)U , \tag{19}$$

the kick received by the electron due to the jet effect, on the orbit.

Let us emphasize that $dm(r_0)$ here is a rest mass variation. (It is negative when it is question of an acceleration.) It is obvious that, when thought to be thrown out, $|dm(r_0)|$ has a relativistic mass equivalent. Thus, to avoid misinterpretations, the "jet momentum" $U|dm(r_0)|$ should better be written as

$$|dm(r_0)|U = \frac{|dm(r_0)|}{\sqrt{1-\frac{V^2}{c_0^2}}} V = \gamma_V |dm(r_0)| V , \tag{20}$$

the momentum of the jet expressed in relativistic terms, where γ_V is

$$\gamma_V = \frac{1}{\sqrt{1-\frac{V^2}{c_0^2}}} , \tag{21}$$

and V is the jet speed of the "relativistic mass" $\gamma_V |dm(r_0)|$, so that

$$\gamma_V V = U . \tag{22}$$

The RHS of Eq. (20), *i.e.* $\gamma_V |dm(r_0)| V$, can visibly be read either as $(\gamma_V |dm(r_0)|)V$, or as $(\gamma_V V)|dm(r_0)|$. The writing $(\gamma_V |dm(r_0)|)V$ is the customary one, given that it embodies the relativistic mass $(\gamma_V |dm(r_0)|)$ multiplying as usual the speed V, to yield the relativistic momentum of the jet in consideration.

The second writing, *i.e.* $(\gamma_V V)|dm(r_0)|$ (in which the Lorentz dilation factor and the related mass are decoupled from each other) is obviously unusual, but becomes very interesting for cases where $|dm(r_0)|$ is zero, pointing to an interaction with no net mass variation at all, such as the case of a motion through a circular motion. Thence, the product $\gamma_V V = U$ [Eq.(22)] can well be considered *en bloc*. Anyhow, the product $\gamma_V V$ comes into play as a whole, since it turns out that we will end up with U as just one single quantity, and not disjointedly with γ_V and V.

Thus, Eq. (20) is remarkable because as simple as it may look, here may be a clue for the wave-particle duality. In other terms, the relativistic momentum $(\gamma_V |dm(r_0)|)V$, evidently points to the particle character of the electron, whereas $\gamma_V V = U$ as a whole, taking place in the product $|dm(r_0)|(\gamma_V V)$ (as we will soon discover), seems to operate as the heart of the wave-like character of the electron. As mentioned, this becomes particularly evident when $|dm(r_0)|$ vanishes. From here on we will call U the wave-like jet speed or just wave-like speed. It is, as we will elaborate on, to

† Note that, $dm(r_0) = m(r_0 + dr_0) - m(r_0) < 0$, when the electron accelerates via dumping out rest mass.

convey given information, though without energy transfer. We will call this wave-like information. Such information may make a given interaction in fact, such as electric or gravitational interaction, which we will thereby call wave-like interaction.

4. Derivation of the de Broglie Relationship

Let us now multiply Eq.(19) by c_0^2:

$$c_0^2 m_\gamma(r_0)dv_0 = -c_0^2 U dm(r_0) \tag{23}$$

The relativistic law of energy conservation requires that, the quantity $-c_0^2 dm(r_0)$, appearing at the RHS of this equation, must be equal to the change in the corresponding electrostatic binding energy [*cf.* Eq. (11)]. Thus

$$c_0^2 dm(r_0) = \frac{Ze^2}{r_0^2} dr_0 \ , \tag{24}$$

is the variation of the rest mass in terms of the static electrostatic binding energy, written in CGS unit system. Let us plug this result into the RHS of Eq.(23):

$$c_0^2 m_\gamma dv_0 = -U \frac{Ze^2}{r_0^2} dr_0 \ . \tag{25}$$

We can further replace dv_0, by its homologous furnished by Eq.(15). Thence, the wave-like jet speed U, as assessed by the distant observer, turns out to be

$$U = \frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \ , \tag{26}$$

the wave-like jet speed as referred to the outside fixed observer. This is the same expression that we derived based on de Broglie relationship [*cf.* Eqs.(6) and (10)]; but note that we arrived at it through just the relativistic law of energy conservation.

Multiplying both sides of this equation by T_0 of Eq.(2), and defining

$$\lambda_B = UT_0 \ , \tag{27}$$

one arrives at

$$\lambda_B = \lambda_0 \frac{c_0}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \ , \tag{28}$$

the de Broglie relationship written for the electron in orbit.

We can further use the "energy content equality" delineated by Eq.(1), and get the conventional de Broglie equation:

$$\lambda_B = \frac{h}{m_0 v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \ , \tag{29}$$

written for the electron in orbit, and here derived based on the jet speed. One can show that V and γ_V of Eq.(21), respectively, become

$$V = c_0\sqrt{1-v_0^2/c_0^2} \ , \tag{30}$$

and

$$\gamma_V = \frac{c_0}{v_0} \ . \tag{31}$$

5. Generalization to all Kinds of Interaction

Let us recall that the overall relativistic energy m_γ [*cf.* Eq.(19)] of the object remains constant throughout. In effect, in order to speed up along the direction of motion as much as dv, the object has thrown from its back the rest mass $-dm(r)$ at the location r. Of course we do not know whether or not this is so. Yet the rest mass variation we have introduced to fulfill the relativistic law of energy conservation induced the jet model we presented. The tangential velocity U becomes even independent of the mass variation $-dm(r)$. So in the worse case Eq. (19) becomes an artifact framing the rest mass decrease in the field the object is bound to, along with the law of conservation of momentum. Let us emphasize that the rest mass decrease is a must imposed by the relativistic law of energy conservation.

One can easily show that the foregoing derivation holds generally (including the particular case of a circular motion), no matter what the type of interaction is considered.

Rigorously speaking, Eq. (19) should be written in vector form as

$$m_\gamma d\mathbf{v}_0 = dm(r_0)\mathbf{U}_R \ , \tag{32}$$

the general jet equation in vector form. We will call $\mathbf{U}_R$ the wave-like jet velocity. It always lies in the same direction as $d\mathbf{v}_0$. Thus $\mathbf{U}_R$ lies in the radial direction in the case, say, of elliptic motion. The U that we tackled with so far becomes the tangential component of $\mathbf{U}_R$.

One has to be careful, with regards to a stationary circular motion, since, through such motion, both (the scalar) dv and dm are null. Thus $\mathbf{U}_R$ must become infinite to secure a finite LHS in the above equation, and we have here, perhaps an expression of the Mach Principle [8-9]. More specifically, the tangential component of $\mathbf{U}_R$ is $U = |\cos\theta \mathbf{U}_R|$, θ being the angle $\mathbf{U}_R$ makes with the tangent, *i.e.* $\pi/2$. Accordingly, $\cos\theta$ is null. The magnitude of $\mathbf{U}_R$, as stated, is infinity. This, as we disclose below, makes $U = |\cos\theta \mathbf{U}_R| = \infty \times 0$, a finite quantity, thus matching Eq.(19) well. Thence, in any case U, is finite.

One can easily achieve the foregoing derivation, for a gravitational field, in fact, any field. The latter can even be a straight a non-inertial centrifugal field. Indeed, it is important to note that, above, de Broglie relationship is obtained as a result of our equation of motion in its general form, written for any field

$$m_\gamma(r_0)c_0^2 = m(r_0)c_0^2 \frac{1}{\sqrt{1-\frac{v_0^2}{c_0^2}}} = m_0 c_0^2 \frac{1-\frac{B(r_0)}{m_0 c_0^2}}{\sqrt{1-\frac{v_0^2}{c_0^2}}} = \text{Const} \ , \tag{33}$$

where now, we have written $B(r_0)$ as the static binding energy of the pair of particles in hand, as a generalization — still assuming that the binding source element is infinitely more massive than the bound object of concern.

Eq. (33), again, is nothing else, but the application of the law of energy conservation, in the broader sense of the concept of energy, embodying the mass and energy equivalence of the Special Theory of Relativity. The differentiation of Eq. (33) leads to

$$dB(r_0)\sqrt{1-\frac{v_0^2}{c_0^2}} = m_\gamma v_0 dv_0 \qquad (34)$$

the differential form of the general equation of motion. Let us go back to the momentum conservation kick equation, due to the jet effect:

$$m_\gamma dv_0 = -dm(r_0)U \ . \qquad (35)$$

Recall that the jet mass is introduced to adjust the variation in the static binding energy:

$$-c_0^2 dm = dB(r_0) \ , \qquad (36)$$

the energy conservation equation for the dumped rest mass. Let us use Eqs. (34) and (36), in Eq. (35):

$$\frac{m_\gamma}{m_\gamma v_0} dB(r_0)\sqrt{1-\frac{v_0^2}{c_0^2}} = \frac{dB(r_0)}{c_0^2}U \ , \qquad (37)$$

which again yields the de Broglie relationship, as an expression of the wave-like jet speed:

$$U = \frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \ , \qquad (38)$$

referred to the outside fixed observer, obtained for any force field. Note that, although we have started in the proper frame of the bound object; in our approach, the lengths and periods of time are altered in the field, by the same amount, which makes that all speeds, thus including the speed of light are left untouched.

Whereas the jet speed scheme we have conceived in order to account for the rest mass loss or rest mass gain is quite compatible with the law of energy conservation; it was still necessary to conceive it (to account for the mechanism related to the rest mass change) which led us, in return, to the de Broglie relationship. Thus, we can state the following. The "jet mass assumption", comes to be well equivalent to the "de Broglie relationship assumption".

Note that the last part of Eq. (32) is valid for gravitation, as well [10-11], i.e.

$$m_0 c_0^2 \frac{1-\dfrac{B(r_0)}{m_0 c_0^2}}{\sqrt{1-\dfrac{v_0^2}{c_0^2}}} = m_0 c_0^2 \frac{e^{-\alpha}}{\sqrt{1-\dfrac{v_0^2}{c_0^2}}} = \text{Const} \ , \qquad (39)$$

$$B(r_0) = m_0 c_0^2 (1-e^{-\alpha}) \ , \qquad (40)$$

and

$$\alpha = \frac{GM}{Rc_0^2} \ , \qquad (41)$$

for a relatively massive celestial body of mass M and radius R, and a small object of mass m_0 bound to it; G is the gravitational constant.

6. Conclusion

Herein, based on just energy conservation, we figured out that any interactional motion, in general, depicts a rest mass change throughout. One way to conceive this phenomenon is to consider a jet effect. Accordingly, an object on a given orbit through its journey must eject mass to accelerate, or must pile up mass to decelerate. The velocity U (tangent to the motion) of the jet (as referred, not to the object, but to the fixed outside observer), strikingly delineates the de Broglie wavelength when coupled with the period of time T_0, displayed by the corresponding electromagnetic energy content of the object [as required by Eq.(1)]. There appears reason to believe that even when the jet mass is null, which is the case for an object at rest, whatever is the information (free of energy), we would expect to be carried by the wave-like jet speed, this information is transferred instantaneously. A similar phenomenon occurs in a circular rotation around an attraction center, in which case too there is no rest mass change throughout. But there surely exists interactional information between the interacting bodies. The wave-like jet speed $U = (c_0^2/v_0)\sqrt{1-v_0^2/c_0^2}$ in this case is still a superluminal speed, though finite. We call it the wave-like interaction speed. The greater v_0, the smaller is U, but always exceeding the speed of light. U, of course, does not carry any energy, yet still delineates the propagation of a given information which we call the wave-like information. In other words, it appears that the information in question can be transferred along with no mass exchange in between interacting bodies whatsoever. The interaction in question is a wave-like interaction.

Note that in the case of a circular motion, the wave-like velocity $\mathbf{U}_R$, displayed by Eq.(32), becomes infinite, evoking a concrete expression of the Mach Principle; the tangential component U of $\mathbf{U}_R$, still being a finite quantity.

One can accordingly conjecture that information can be transferred with no need of energy at all. Such a transfer always occurs at speeds greater than the speed of light and can occasionally become infinite. Thus, an immediate action at a distance seems well to be possible, which is in effect the case for bodies at rest.

In any case, an action at a distance with superluminal speeds, thus always greater than the speed of light, comes into play. And this appears to be connected to the wave property of the object in hand. A superluminal interaction is thus generally evoked. Note that recent measurements seem to back up our arresting deduction [12-14]. Thus, our approach also comes out to bring an answer to the quest of "gravitational interaction achieved with a speed much faster than the speed of light", disclosed more than two centuries ago, by the French scientist Laplace [15]. Our approach can be equally applied to a macro system or a micro system, and for all kinds of interactions.

Since we came to obtain de Broglie's relationship, quantization follows immediately for all fields. In any event, our approach induces the fact that, the rest mass of any bound particle (contrary to the general wisdom) must decrease; thus, the mass of the gravitationally bound celestial object too, must decrease. But then, the metric must change not only nearby a celestial body, but also nearby a nucleus. Such an occurrence can be experimentally checked, if say a muon is considered to be bound to a nucleus instead of the electron; the decay rate of the bound muon is indeed retarded as compared to the decay rate of a free muon [16-23]. Our prediction about this remains better than any other available predictions. Thence, either gravitationally interacting macroscopic bodies or electrically interacting microscopic objects interact in essentially the same way. Moreover, due to the wave-like character of all interactions, practically everything in the universe must affect each other from very far distances and this at speeds much greater than the speed of light. Note that our conjecture is in full compatibility with the established theory of Quantum Mechanics and the Special Theory Relativity. Thence (on the contrary to what may ever be the worries brought up by [14]), we do not really have to give away either of these fundamental theories to adopt the other. In effect, de Broglie relationship, thence Quantum Mechanics, as we have shown throughout, is driven by the relativistic law of energy conservation.

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