SUPERLUMINAL WAVE-LIKE 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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ABSTRACT

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* $U = \lambda_B / T_0 = c_0^2 \sqrt{1 - v_0^2 / c_0^2} \big/ v_0$, *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.

DE BROGLIE RELATIONSHIP[*,1,2,3]

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

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

Here 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

[*] 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, that is just published (Part I) and is about to be published (Part II), in the International Journal of Physical Sciences *(see the list of references at the end of this summary);* the continuation

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

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

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

(wavelength of the electromagnetic radiation associated with the mass m_0*, as originally assigned by de Broglie, to describe the periodic phenomenon inside the object in hand)*

The frequency ν_0 and the mass m_0, are transformed *differently,* were the object brought to a uniform translational motion;[5] as well-known, according to the *Special Theory of 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 suppose that the object is moving with the velocity v_0; thus de Broglie framed λ_B, similarly to the RHS of Eq.(3), as

$$\lambda_B = \frac{h}{m v_0} \ ; \tag{4}$$

(de Broglie relationship written for the object in hand, brought to a translational motion)

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 way, though *unusual,* the relationship

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

[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 $c_0^2 / v_0 \sqrt{1 - v_0^2 / c_0^2}$:

$$\frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} = \lambda_B \nu_0 \ . \tag{6-b}$$

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

$$\frac{\lambda_B}{T_0} = \frac{\lambda_0}{T_0}\frac{c_0}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} = \frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \quad . \tag{7-a}$$

We pose the definition

$$U_B = \frac{\lambda_B}{T_0} \quad , \tag{7-b}$$

(definition)

And write, instead of Eq.(7-a):

$$U_B = \frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \quad . \tag{7-c}$$

[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.

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 though 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. *(Not assuming the proton infinitely more massive than the electron will not change anything, except that the presentation would become more complicated.)* . The rest mass *(or better, the rest relativistic energy content)* of the bound electron, accordingly becomes

$$m(r_0)c_0^2 = m_0 c_0^2 - \frac{Ze^2}{r_0} = \kappa(r_0) m_0 c_0^2 \quad , \tag{8}$$

(rest mass, or better, the rest relativistic energy content of the bound electron)

along with

$$\kappa(r_0) = 1 - \frac{Ze^2}{r_0\, m_0 c_0^2} \quad . \tag{9}$$

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 consider to work in the proper frame of reference of the electron.

Now, suppose that the electron is engaged in a given motion around the nucleus; the motion in question can be conceived as made of the two following steps:

i) Bring the electron quasistatically, from infinity to the given location r_0, on its orbit, but keep it still at rest.
ii) 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. Thus:

$$m_\gamma(r_0)c_0^2 = m(r_0)c_0^2 \frac{1}{\sqrt{1-\frac{v_0^2}{c_0^2}}} = m_0 c_0^2 \frac{1-\frac{Ze^2}{r_0 m_0 c_0^2}}{\sqrt{1-\frac{v_0^2}{c_0^2}}} = \mathit{Constant} \quad . \tag{10}$$

(overall relativistic energy of the electron in orbit)

Note that, one classically is used to write, instead the following equation,

$$m_\gamma(r_0)c_0^2 = \frac{m_0 c_0^2}{\sqrt{1-\frac{v_0^2}{c_0^2}}} - \frac{Ze^2}{r_0} = \mathit{Constant}\text{: Wrong !} \tag{11}$$

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 in the proper frame of reference of the electron, is taken, 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.(10) leads to

$$-\frac{Ze^2}{m_0 r_0^2}\frac{1-\frac{v_0^2}{c_0^2}}{1-\frac{Ze^2}{r_0 m_0 c_0^2}}=v_0\frac{dv_0}{dr_0} \tag{12-a}$$

[differential form of Eq.(11-a), equivalent to the equation of motion]

One can transform Eq.(12-a), 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.(10), i.e. $m_\gamma(r_0)c_0^2$, is constant, one can write

$$-\frac{Ze^2}{r_0^2}\sqrt{1-\frac{v_0^2}{c_0^2}}\frac{\underline{r}_0}{r_0}=m_\gamma(r_0)\frac{d\underline{v}_0(t_0)}{dt_0}; \tag{12-b}$$

[vectorial equation written based on Eq.(12-a), or the same, equation of motion written by the author, via the energy conservation law, extended to cover the relativistic, mass & energy equivalence]

here, $\underline{r}_0$ is the *"radial vector"* of magnitude r_0, directed outward, and $\underline{v}_0$ is the *"velocity vector"* of the electron, at time t_0; note that $d\underline{v}_0$ and $\underline{r}_0$ 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 *(cf. Reference 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.

How ever, 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 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, i) with respect to a full consistency, vis-a-vis the the *law of momentum conservation,* and this ii) 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.

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 proton speeds up nearby the proton, it is that, an *infinitesimal part* of its rest mass somehow *sublimes* into extra kinetic energy *(the electron acquires, 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, it is that, the corresponding portion of its kinetic energy somehow condenses, into rest mass, on the orbit. The *rest mass change* occurring throughout, anyway, as shown, is a requirement imposed by the *law of energy conservation, broadened to embody the mass & 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

$$P(t_0) = m_\gamma(r_0) v_0 \ . \tag{13}$$

(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:

$$P(t_0 + dt_0) = dm(r_0)U + m_\gamma(v_0 + dv_0)\ . \tag{14}$$

(magnitude of the momentum of the electron, an infinitely small period of time, after the given time)

Because of the law of conservation of momentum *(for the closed system made of the electron and the jet in question, simulating the electric interaction in question),* we must have:

$$P(t_0) = m_\gamma v_0 = P(t_0 + dt_0) = dm(r_0)U + m_\gamma(v_0 + dv_0)\ , \tag{15}$$

(equation of conservation of momentum with regards to the electron, assuming that the proton is at rest, all the way through)

which yields†

$$m_\gamma dv_0 = -dm(r_0)U\ . \tag{16}$$

(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, not to yield misinterpretations, the *"jet momentum"* $U|dm(r_0)|$, should better be written, as

$$|dm(r_0)|U = \frac{|dm(r_0)|}{\sqrt{1-\frac{V^2}{c_0^2}}}V = \gamma_V|dm(r_0)|V\ , \tag{17-a}$$

(momentum of the jet expressed in relativistic terms)

where γ_V is

$$\gamma_V = \frac{1}{\sqrt{1-\frac{V^2}{c_0^2}}}\ , \tag{17-b}$$

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

$$\gamma_V V = U\ . \tag{17-c}$$

The RHS of Eq.(17-a), 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.

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

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.(17-c)], 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.(17-a) is remarkable, because, as simple as it may look, here may be a clue for the *wave-particle duality.* In other terms, he 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 convey a *given information,* though without energy transfer. We will call this, a *wave-like information.* Such an information, may make a given interaction, in fact such as electric or gravitational interaction, which we will thereby call *wave-like interaction.*

DERIVATION OF THE DE BROGLIE RELATIONSHIP

Let us now multiply Eq.(16) by c_0^2:

$$c_0^2 m_\gamma(r_0) dv_0 = -c_0^2\, U\, dm(r_0)\,, \tag{18}$$

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.(8)]. Thus

$$c_0^2 dm(r_0) = \frac{Ze^2}{r_0^2} dr_0 \quad , \tag{19}$$

(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.(18):

$$c_0^2 m_\gamma dv_0 = -U \frac{Ze^2}{r_0^2} dr_0 \quad . \tag{20}$$

We can further replace dv_0, by its homologous furnished by Eq.(12-a). Thence, the *wave-like jet speed* U, as assessed by the distant observer, turns out to be

$$U = \frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \quad , \tag{21}$$

(the wave-like jet speed as referred to the outside fixed observer)

which is the same expression, as that we derived based on de Broglie relationship [cf. Eqs. (6-a) and (7-c)]; but note that we landed at it, through just the relativistic law of energy conservation.

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

$$\lambda_B = UT_0 \quad , \tag{22}$$

(definition)

one arrives at

$$\lambda_B = \lambda_0 \frac{c_0}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \quad . \tag{6-a}$$

(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:

$$\lambda_B = \frac{h}{m_0 v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \quad . \tag{4}$$

(de Broglie relationship written for the electron in orbit, here derived based on the jet speed)

One can show that V and γ_V of Eq.(17-b), respectively, become

$$V = c_0\sqrt{1 - v_0^2 / c_0^2} \ , \tag{23}$$

$$\gamma_V = \frac{c_0}{v_0} \quad . \tag{24}$$

GENERALIZATION TO ALL KINDS OF INTERACTION

Let us recall that the *overall relativistic energy* m_γ [cf. Eq.(16)] 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.(16) 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.(16) should be written in *vector form* as

$$m_\gamma d\underline{v}_0 = dm(r_0)\underline{U}_R \ . \tag{25}$$

(the general jet equation in vector form)

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

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 $\underline{U}_R$ 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 $\underline{U}_R$ is $U = |\cos\theta \underline{U}_R|$, θ being the angle $\underline{U}_R$ makes with the tangent, i.e. $\pi/2$. Accordingly, $\cos\theta$ is null. The magnitude of $\underline{U}_R$, as stated, is *infinity.* This, as we will disclose right below, indeed makes that, $U = |\cos\theta \underline{U}_R| = \infty \text{ x } 0$, a *finite quantity,* thus well matching Eq.(16). 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

$$m_\gamma(r_0)c_0^2 = m(r_0)c_0^2 \frac{1}{\sqrt{1-\frac{v_0^2}{c_0^2}}} = m_0 c_0^2 \frac{1-\frac{B(r_0)}{m_0 c_0^2}}{\sqrt{1-\frac{v_0^2}{c_0^2}}} = \mathit{Constant} \quad , \tag{26}$$

(Our Equation of Motion in its General Form, Written for Any Field)

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.(26), 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 & energy equivalence* of the Special Theory of Relativity. The differentiation of Eq.(26) leads to

$$dB(r_0)\sqrt{1-\frac{v_0^2}{c_0^2}} = m_\gamma v_0 dv_0 \ . \tag{27}$$

(Differential Form of the General Equation of Motion)

Let us go back to the *momentum conservation kick equation, due to the jet effect:*

$$m_\gamma dv_0 = -dm(r_0)U \ . \tag{16}$$

(kick due to the jet effect)

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

$$-c_0^2 dm = dB(r_0) \ . \tag{28}$$

(energy conservation equation regarding the dumped rest mass)

Let us use Eqs. (27) and (28), in Eq.(16):

$$\frac{m_\gamma}{m_\gamma v_0} dB(r_0)\sqrt{1-\frac{v_0^2}{c_0^2}} = \frac{dB(r_0)}{c_0^2} U \quad , \tag{29}$$

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

$$U = \frac{c_0^2}{v_0}\sqrt{1-\frac{v_0^2}{c_0^2}} \quad . \tag{30}$$

(wave-like jet speed as referred to the outside fixed observer, obtained for any force field)

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.(25) is valid for gravitation, as well,[10,11] i.e.

$$m_0 c_0^2 \frac{1-\dfrac{B(r_0)}{m_0 c_0^2}}{\sqrt{1-\dfrac{v_0^2}{c_0^2}}} = m_0 c_0^2 \frac{e^{-\alpha}}{\sqrt{1-\dfrac{v_0^2}{c_0^2}}} = \mathit{Constant} \quad ; \tag{31}$$

$$B(r_0) = m_0 c_0^2 (1 - e^{-\alpha}) \quad , \tag{32}$$

$$\alpha = \frac{G\mathcal{M}}{Rc_0^2} \quad , \tag{33}$$

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

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 an 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 $\underline{U}_R$ displayed by Eq.(25), becomes, infinite, evoking a concrete expression of the Mach Principle, the tangential component U of $\underline{U}_R$, 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.[12,13,14] 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;[16,17,18,19,20,21,22,23] 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 the Reference 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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