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Revealing the Mystery of the Galilean Principle of Relativity. Part I: Basic Assertions

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Abstract As Galileo has formulated, one cannot detect, once embarked in a *uniform translational motion*, and not receiving any information from the outside, *how fast* he is moving. Why? No one that we recall of, has worked out the answer of this question, although the *Galilean Principle of Relativity* (*GPR*), constituted a major ingredient of the Special Theory of Relativity (STR). Thus, consider a quantum mechanical object of "*clock mass*" M_0 (*which is just a mass*), doing a "*clock motion*", such as *rotation, vibration*, etc., with a *total energy* E_0, in a *space of size* $\mathcal{R}_0$. Previously we have established that, if the mass M_0 is multiplied by an *arbitrary number* γ, then through the *relativistic* or *non-relativistic* quantum mechanical description of the object (*which ever is appropriate to describe the case in hand*), the *size* $\mathcal{R}_0$ of it, shrinks as much, and the *total energy* E_0, *concomitantly*, increases as much. This *quantum mechanical occurrence* yields, at once, the *invariance* of the *quantity* $E_0M_0\mathcal{R}_0^2$ *with regards to the mass change* in question, the object being overall at rest; this latter quantity is, on the other hand, as induced by the *quantum mechanical framework*, necessarily strapped to h^2, the *square of the Planck Constant*. But this constant is already, *dimension wise*, *Lorentz invariant*. Thus, any quantity bearing the dimension of h^2, is Lorentz invariant, too. So is then, the quantity $E_0M_0\mathcal{R}_0^2$ (*no matter how the size of concern lies with respect to the direction of uniform translational motion*) that would come into play. Thence, the *quantum mechanical invariance of the quantity* $E_0M_0\mathcal{R}_0^2$ with regards to an *arbitrary mass change*, comes to be *identical* to the *Lorentz invariance* of this quantity, were the ob-

Dedicated to the Memory of Professor Engin Arik.

Professor Engin Arik, was tragically lost in a crash nearby İsparta, Turkey, on the 30th of November 2007, on her way to a scientific meeting. She has been an excellent wife to Professor Metin Arik, a wonderful Mother to Yavuz and Yasemin, and an exceptional Grand Mother to Dalya and Berke, an mythologic leader to all of her students and surrounding, along with her outstanding scientific qualities and achievements.

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ject brought to a uniform translational motion. It is this prevalence, which displays, amazingly, the *underlying mechanism*, securing the end results of the STR, and this via quantum mechanics. The *Lorentz invariant quantum mechanical architecture*, $E_0 M_0 \mathcal{R}_0^2 \sim h^2$, more fundamentally, constitutes the answer of the *mystery* drawn by the *GPR*. In this article, we frame the basic assertions, which will be used in a subsequent article, to display the *quantum mechanical machinery* making the GPR, and to draw the bridge between the GPR and the *architecture*, we disclose.

Keywords Principle of relativity · Galileo · Special theory of relativity · General theory of relativity · Quantum mechanics · Universal matter architecture · Planck constant

1 Introduction

Previously we investigated, how an *overall mass change,* within the frame of the quantum mechanical description, *concomitantly* affects, the *total energy* E_0, and the *size* R_0 of the atomistic or molecular object, in hand [1]. An arbitrary "*overall mass change*" in a given entity, up to our approach, seems not to have been considered, perhaps because *no immediate meaningfulness* was attributed to it. Thus far, not only that it provides us, with a *useful relationship,* displaying in an easy manner, *some of the, otherwise, hidden properties of chiefly, complex objects* [2–4], but also the Special Theory of Relativity (STR), as well as the General Theory of Relativity (GTR), involve an *overall mass change* of the object, respectively, brought into a *uniform translational motion,* or *planted into a gravitational field.*

Here, we will chiefly focus on the first case. We spare a similar study, on the basis of the incidences dealt with the GTR, for a different article [5]. What we had originally in mind, was the following. "*Quantum mechanics, somehow ought to work as the internal machinery of the occurrences dealt with both* (*special and general*) *theories of relativity*." Effectively, just by considering *the constancy of the speed of light,* in regards to all inertial frames, one does not develop an understanding toward, for instance, why *all clocks brought to a uniform translational motion together with a* "*light clock*", *shall retard, just as much as this latter does.* The *Galilean Principle of Relativity* [6, 7], or *essentially* the same, the "*second postulate*" of the STR [8, 9], obviously, imposes such a happening, without however providing us with any further grasp.

Note that many authors, like to use the phrasing of "*Principle of Special Relativity*", following Einstein [9], instead of "*Galilean Principle of Relativity*". Some of them would say, straight *"Second Postulate of Special Theory of Relativity"*. We shall use the expression of *Galilean Principle of Relativity,* first of all, to be fair toward Galileo. He is the one who framed by far the fact that, *one is unable to detect how fast he is moving on a uniform translational motion, with regards to say a distant star, without receiving any information from the outside, and via just performing experiments, inside of his ship.* As Einstein himself pointed out [10], the *constancy of the speed of light with regards all inertial frames,* can be deduced as a result of this principle. Also the invariance of the laws of nature can be well established based on the *Galilean Principle of Relativity.* Indeed this principle would be broken if the speed of light did not remain constant inside of a uniformly moving object, for the inside observer, then, being able to measure how much the speed of light varies, can well be able to tell how fast he is cruising (*without receiving any information from the outside*). The same holds for the invariance of the *laws of nature.* If these laws, contrary to what the *Galilean Principle of Relativity* implies, did vary with the motion, then again the inside observer, measuring how much these laws diverge, from what he would have measured *at rest,* would again well be able to tell how fast he is cruising. None of these occur. We can accordingly state that the *Galilean Principle of Relativity* is a *deep-seated principle of*

nature. It yields straight, the *constancy of the speed of light,* also the *invariance of the laws of nature,* as well as other occurrences, such as the invariance of the electric charges, and that of any relative velocity. This is why we feel, we better use the denomination of "*Galilean Principle of Relativity*", instead of "*Principle of Special Relativity*".

In any event, based on the STR, the "*kinetic energy*" of an object brought to a *uniform translational motion,* bears a *mass equivalent,* so that the *entire relativistic mass* of the object, according to the outside observer, is actually, altered. Thus, it becomes worth to examine, on a *quantum mechanical basis,* and this already *at rest,* what happens, when the *total mass* of the object at hand, is overall changed [11–16]. This constituted the *key* of our original motivation, which made us consider the investigation of an *arbitrary overall mass change,* within the frame of the *quantum mechanical description* of a given object [1]. This, in effect, vis-a-vis the STR, represents the *rest mass change,* in accordance with the *relativistic law energy conservation.* When the same is applied to the description of an object embedded in a gravitational field, still on the basis of the *relativistic law energy conservation, a whole new set up, and derivation* regarding the end results of the GTR, is achieved [17, 18].

Below, in Sect. 2, we will state our basic assertion, we derived previously; this will constitute the basis of the subsequent assertions we will introduce. In Sect. 3, we will coin the concept of "*clock mass*", which we denote throughout, by M_0. In short, this is a *mass* we associate with the "*internal dynamics*" of the object, *repeating itself regularly,* thus working as a "*clock*". So, the *clock mass* is the mass carrying the *labor* achieved by the *internal dynamics* in consideration. In different terms, the *repetitive process* the *internal dynamics* displays, is the "*clock labor*". We elaborate on these new concepts we coined, in Sects. 2 and 3. In Sect. 4, regarding the *change of the overall mass* of the object of concern, we prove the *invariance* of the quantity $E_0 M_0 \mathcal{R}_0^2$. Note that, whether we deal with *a relativistic or non-relativistic quantum mechanical description,* whichever is appropriate with regards to the case in hand, the invariance of the quantity $E_0 M_0 \mathcal{R}_0^2$ holds, with respect to an *overall mass variation in the mathematical description of concern.* This quantity, amazingly, constitutes a *relativistic* (*Lorentz*) *invariance* as well, but not noticed as such. A related conclusion is provided in Sect. 5. So much constitutes the content of this article. In a subsequent article, we will show how the quantum mechanical assertions we have proven shape up the Galilean Principle of Relativity, thus the end results of the Special Theory of Relativity, making a *universal matter architecture* (*UMA*), we have disclosed; UMA, in effect, at a deeper level than the end results of the STR, and already at rest, becomes the *mystery* behind the *Galilean Principle of Relativity.* The application of the idea to gravitation, or in fact any field, the object interacts with, is achieved elsewhere [17].

2 In a Quantum Description *if Mass*, Already at Rest, is *Arbitrarily Increased*, then concurrently, the *Space Size Contracts* as Much, and the *Total Energy Expands* in the Same Amount. *If* However, the *Space Size* is Kept *Invariant*, then the *Total Energy Shrinks* as Much

Every wave-like entity (*much contrarily to the reigning wisdom*), including, any *elementary particle* (*no matter how tiny this may be*), is to bear an *internal dynamics.* It seems hard to imagine the opposite, although such a denomination (*i.e.* "*internal dynamics*"), is used nowhere we know of. The *internal dynamics* we refer to, is an *internal activity,* in fact; it is a *motion* that repeats itself *endlessly* and *regularly,* provided that its *identity* is not harmed through a given interaction, that may come into consideration. We anticipate that, even an

electron (*contrary to the general wisdom*) must bear an internal dynamics. It should be essentially pointless to consider the electron (*though, pedagogically useful, to some extent*), as a *point-like particle.*

A complex wave-like entity, may display several *internal motions,* superimposed with each other. But for simplicity, let us focus on just one. The motion in question, takes place in a *given space.* It displays a *given period of time.* It thus works as a *clock,* which can be recognized by a *given labor,* which we call "*clock labor*". A *given mass* turns out to be responsible of carrying out this labor; we call it, "*clock mass*"; we will elaborate on it, below. Thus the clock labor is being carried out, in a *space of size* $\mathcal{R}_0$, which we call *clock characteristic length.* The *clock labor* may be a "*work*" if the clock mass, labors against a force, throughout a given displacement. It may though, embody just a *kinetic energy* (*not involving any work, as such*), the way an electron moves on a circular path around a nucleus, if it really does so.

Anyhow we visualize a *wave-like entity,* which is well described by a corresponding Schrödinger Equation (SE), or a Dirac Equation, whichever is appropriate. This means, if the *internal dynamics* of the object of concern is *slow enough,* of course, it can well be described by a corresponding SE. Then, no matter what the SE is not Lorentz invariant, on the whole, such a description is well valid, were the object brought to a *uniform translational motion,* and we can well reason on its non-relativistic solution, or on the Lorentz transformations of different elements (*i.e. mass, size, and energy*), this solution embodies. We attract *conservative reactions,* when we propose to work with the Schrödinger Equation, for it is not *Lorentz invariant.* But, we have to recall that, frame-wise, its solutions still are, provided that we are satisfied to describe the internal dynamics of the object, with the *rest mass* of the *clock mass* (*and not the relativistic mass of it*), which in return, will of course dilate, if the object brought to a uniform translational motion.

2.1 Modifying the Overall Mass in the Quantum Mechanical Description

Thus, previously we have shown the *following assertion,* on the basis of the Schrödinger Equation, as complex as this may be; we have further extended our derivation to the basis of the Dirac Equation, as well [1].

Assertion 1 Consider a relativistic or non-relativistic quantum mechanical description of a given object, depending on whichever may be appropriate. The description excludes "*artificial potential energies*" (*which may otherwise lead to incompatibilities with the STR*). The quantum mechanical description is supposed to be based on I elementary particles, altogether, of respective masses m_{i0}, $i = 1, \ldots, I$. If then, these masses are overall multiplied by the *arbitrary number* γ, the following two general results, are *conjointly* obtained:

a) The *total energy* E_0 associated with the *given clock's motion* of the object, is increased as much, or the same, the *period* T_0, of the motion associated with this energy, *is decreased* as much.
b) The *characteristic length,* or the *size* $\mathcal{R}_0$ to be associated with the given clock's motion of concern, *contracts* as much.

In *mathematical words* this is:

$$[(m_{i0}, i = 1, \ldots, I) \rightarrow (\gamma m_{i0}, i = 1, \ldots, I)] \quad \Rightarrow \quad \left\{[E_0 \rightarrow \gamma E_0], \left[\mathcal{R}_0 \rightarrow \frac{\mathcal{R}_0}{\gamma}\right]\right\}. \quad (1)$$

Let us accentuate that, if the object is, say an *atom,* then $\mathcal{R}_0$ is (*anyway it may be defined*), the *radius* of it; if the object is a diatomic molecule, $\mathcal{R}_0$ is the *internuclear distance,* etc.;

$\mathcal{R}_0$ in fact, may be just *any length* one may pick up, within the framework of the object in hand, and Assertion 1, would still be valid.

Here is a *simple insight* about Assertion 1. Thus, consider the Schrödinger Equation written for *a hydrogen-like atom,* with the familiar notation:

$$\nabla^2\psi(\underline{r}_0)+\frac{8\pi^2\mu_0}{h^2}\left(E_0+\frac{Ze^2}{r}\right)\psi(\underline{r}_0)=0, \tag{2}$$

where μ_0 is the *reduced mass* of proton and electron at rest, Z the number of proton in the nucleus, h the Planck constant, e the charge intensity of the electron or that of the proton, $\psi(\underline{r}_0)$ the wave function at the location pointed to by the vector $\underline{r}_0$, drawn from the origin of our coordinate system, and E_0 the *total energy* of the atom.

Multiply this equation (now written in polar coordinates r_0,θ,φ), by an *arbitrary positive number* γ^2:

$$\frac{\partial^2\psi(\underline{r}_0)}{\frac{\partial r_0^2}{\gamma^2}}+\frac{2}{\frac{r_0}{\gamma}}\frac{\partial\psi(\underline{r}_0)}{\frac{\partial r_0}{\gamma}}+\frac{1}{\frac{r_0^2}{\gamma^2}\sin\theta}\frac{\partial}{\partial\theta}\left[\sin\theta\frac{\partial\psi(\underline{r}_0)}{\partial\theta}\right]+\frac{1}{\frac{r_0^2}{\gamma^2}\sin^2\theta}\frac{\partial^2\psi(\underline{r}_0)}{\partial\varphi^2}$$
$$+\frac{8\pi^2\gamma\mu_0}{h^2}\left(\gamma E_0+\frac{Ze^2}{\frac{r_0}{\gamma}}\right)\psi(\underline{r}_0)=0. \tag{3}$$

This, clearly displays the results framed by Assertion 1, i.e. if *mass* is multiplied by γ, then concomitantly, *were it set free* to change, *size* in all directions, shrinks just as much, and the *total energy,* increases as much. The wave function $\psi(\underline{r}_0)$, should of course, accordingly be replaced, by $\psi(\underline{r})$, $\underline{r}$ being equal to $\underline{r}_0/\gamma$. The outcome in question, can easily be generalized to much more complex entities, provided that, for example, Coulomb potential energies are used, were the object in consideration, an atomistic or molecular object. In general *artificial potential energies,* must be avoided. Note that what we mean by an *artificial potential energy,* is a potential energy one can achieve via the displacement of an *invented force.* Such *an energy* may not be compatible with the STR. For instance, Coulomb Force or Yukawa Force are well, *allowed forces.* Thus, so are the energies one would calculate based on these forces. On the contrary, an "*elementary force*", behaving as $1/(distance)^{n\neq 2}$, between particles of concern, does not exist in nature; this would not at any rate, be compatible with the STR. In such a case, we call it *artificial.* The magnitude of an overall force such that reigning in between molecules of a gas, may ultimately come to be formulated, in a different form than $1/(distance)^2$, but it should be recalled that such a force too, no matter how it manifests at a macroscopic level, would be based on electric attractions and repulsions, thus Coulomb Forces, every one of which is to behave as $1/(distance)^2$. This is what we mean here.

We would like to emphasize that, while the solution of a SE, embodying an appropriate *potential energy term,* well remains Lorentz invariant, the solution of a *Dirac Equation* in which an *artificial potential energy term* is injected, may very well not be. Note further that in the above analysis, $\mathcal{R}_0$ is *set free* to change; this may not be however the case, if the size of the object of concern may be fixed as a *boundary condition,* for instance, just like is the situation for a particle moving back and forth, in a box of a given size L. So, in this example, there is no room to alter L, with respect to a change in the mass of the particle. It can be shown that, for this example, the *total energy* is decreased as much as, *mass* is increased. We have to specify this. It is that, besides altering masses, we have *one more trick* to alter the results of (2) [1].

2.2 Modifying the Overall Mass, but at the Same Time Keeping the Size Unaltered, in the Quantum Mechanical Description

So, consider once again, (3). Now we propose to multiply this equation, by $1/\beta^2$:

$$\frac{\partial^2\psi(\underline{r}_0)}{\beta^2\frac{\partial r_0^2}{\gamma^2}}+\frac{2}{\beta\frac{r_0}{\gamma}}\frac{\partial\psi(\underline{r}_0)}{\beta\frac{\partial r_0}{\gamma}}+\frac{1}{\beta^2\frac{r_0^2}{\gamma^2}\sin\theta}\frac{\partial}{\partial\theta}\left[\sin\theta\frac{\partial\psi(\underline{r}_0)}{\partial\theta}\right]+\frac{1}{\beta^2\frac{r_0^2}{\gamma^2}\sin^2\theta}\frac{\partial^2\psi(\underline{r}_0)}{\partial\varphi^2}$$
$$+\frac{8\pi^2\gamma\mu_0}{h^2}\left(\frac{\gamma E_0}{\beta^2}+\frac{Ze^2}{\frac{\beta r_0\beta}{\gamma}}\right)\psi(\underline{r}_0)=0. \tag{4}$$

We choose

$$\beta=\gamma. \tag{5}$$

Thus

$$\frac{\partial^2\psi(\underline{r}_0)}{\partial r_0^2}+2\frac{\partial\psi(\underline{r}_0)}{r_0\partial r}+\frac{1}{r_0^2\sin\theta}\frac{\partial}{\partial\theta}\left[\sin\theta\frac{\partial\psi(\underline{r}_0)}{\partial\theta}\right]+\frac{1}{r_0^2\sin^2\theta}\frac{\partial^2\psi(\underline{r}_0)}{\partial\varphi^2}$$
$$+\frac{8\pi^2\gamma\mu_0}{h^2}\left(\frac{E_0}{\gamma}+\frac{\frac{Ze^2}{\gamma}}{r_0}\right)\psi(\underline{r}_0)=0. \tag{6}$$

Hence, we came to the following interesting conclusion: When we inject into the quantum mechanical description of the object in hand, an *increase of mass,* we can at the same time, *block* the change in the *space size.* The total energy, in this case decreases as much. Here, it is useful to differentiate, between two cases: i) The *potential energy* is zero. ii) If not, the Coulomb potential energy term's "*charge product*" $[Ze][e]$ (*were the sample of concern, an atomistic or a molecular object*), is reduced by the same amount the mass is increased. This latter argument may seem *artificial* at a first strike, and in reality we do not intend to alter the electric charges, whatsoever. But as we will see, our *maneuver* turns to be a *useful procedure.* Let us offer a *quick insight* about it. If the object moves in a uniform translational motion, the intensity of the Coulomb Force exerted by the proton, on the electron, on a direction perpendicular to the direction of motion, is reduced by the Lorentz factor.[1]

This occurrence can well be represented by a frame *at rest,* where Ze^2 is *hypothetically* reduced by the same amount. Note further that the procedure about hypothetically blocking

[1] Consider a dipole, made of Q and q, sitting at a distance d_0 from each other. The force intensity F_0, reigning between the poles, at rest, is as usual (*in CGS unit system*)

$$F_0=\frac{Qq}{d_0^2}. \tag{i}$$

Suppose the dipole is translationally displaced with a uniform velocity $\mathcal{V}$, on a direction perpendicular to d_0. Then F_0, according to the outside fixed observer, becomes

$$F=\frac{Qq}{d_0^2}\sqrt{1-\frac{\mathcal{V}^2}{c^2}}; \tag{ii}$$

c is the velocity of light. Recall that in this case d_0 is not altered.

Note further that the *change* coming into play, is nothing else, but a piece of strength amounting to the intensity of the magnetic force, created due to the motion.

the size change due to a mass change introduced in the quantum mechanical description of the object in hand, can be well kept *operational* in a given direction only, if desired so.

Let us thus summarize our results (*which can be easily generalized*), in the following two assertions

Assertion 2 Consider a relativistic or non-relativistic quantum mechanical description of a given object, depending on, whichever may be appropriate. Suppose that the *potential energy* term input to it, is null. If different masses coming into play are overall multiplied by the *arbitrary number* γ, but at the same time sizes reigning originally, are, via a similar operation, kept unaltered, then, the eigenvalue E_0 associated with the *given clock's motion* of the object, is decreased as much. In *mathematical words* this is:

$$\{[(m_{i0}, i = 1, \ldots, I) \rightarrow (\gamma m_{i0}, i = 1, \ldots, I)], [\mathcal{R}_0 \rightarrow \mathcal{R}_0]\} \quad \Rightarrow \quad \left[E_0 \rightarrow \frac{E_0}{\gamma}\right]. \tag{7}$$

Assertion 3 Consider a relativistic or non-relativistic quantum mechanical description of a given object, depending on whichever may be appropriate. We suppose that the potential energy terms input to it, are made of *relativistically compatible terms,* such as Coulomb Potential energy terms, $Z_j e Z_k e/d_{jk}$ $(j = 1, \ldots, J)$, $(k = 1, \ldots, K)$, were the object in hand, an atomistic or a molecular object. If different masses coming into play, are overall multiplied by the *arbitrary number* γ, but one wishes at the same time, not to alter the sizes, the object assumed originally, this can be achieved by reducing the products $Z_j e Z_k e/d_{jk}$, of charges of concern, by γ. The eigenvalue E_0 associated with the *given clock's motion* of the object, is accordingly decreased as much. In *mathematical words* this is:

$$\left\{[(m_{i0}, i = 1, \ldots, I) \rightarrow (\gamma m_{i0}, i = 1, \ldots, I)], [\mathcal{R}_0 \rightarrow \mathcal{R}_0], \right.$$
$$\left.\left[(Z_j e)(Z_k e) \rightarrow \frac{(Z_j e)(Z_k e)}{\gamma}, j = 1, \ldots, J, k = 1, \ldots, K\right]\right\} \quad \Rightarrow \quad \left[E_0 \rightarrow \frac{E_0}{\gamma}\right]. \tag{8}$$

3 The Clock Mass

The "*clock mass*" is a concept, we would like to introduce, to represent the "*compound mass*" doing the "*clock labor*" we associate with the internal dynamics of a given *complex object.* One may define different *clock masses* for the same object, in regards to different *motions,* i.e. different *internal dynamics* the object displays.

The *clock mass* regarding the rotation of the electron around the nucleus supposed to be very massive, within the frame of the *Bohr Atom Model,* is just the *electron mass,* which we will call m_e.

The clock mass is the *reduced mass* of the proton and the electron, within the frame of the *hydrogen atom's Schrödinger description.* The *clock mass* turns out to be the *reduced mass* M_0, of the *nuclei* regarding the *rotational motion of a diatomic molecule.* In this context the *clock mass*, is the *mass,* one comes out with, via reducing, say the Schrödinger description of a many-body system, to that of a *one-particle system.* In the case of the *vibrational motion of a diatomic molecule,* this is more peculiar; the *clock mass of the vibrational motion,* thus can be formulated as $m_e\,(M_0/m_e)^{1/2}$ (based on the electron mass, m_e), etc. [2].

On the other hand, the *clock mass* to be associated with *the electronic motion of a diatomic molecule,* with fixed nuclei, shall be just [a *dimensionless quantity,* related to the electronic configuration of the molecule] $\times$ $[m_e]$.

Below, as mentioned, we shall denote the *clock mass,* by M_0. Note that, since the "*clock mass*", is a *mass* manufactured out of different masses the object involves, the *mass transformation* we considered as the basis of Assertion 1 (*we stated above*), implies that, the *clock mass* M_0 (*anyway, we choose to define it*), undergoes the same transformation, i.e. $M_0 \to \gamma M_0$.

4 The Invariance of the Quantity {(*total energy*) × (*clock mass*) × (*size*)^2} in Regards to the Change in Mass

Via Assertion 1, through the transformation $[M_0 \to \gamma M_0]$, the quantity $E_0 M_0 \mathcal{R}_0^2$, becomes $[\gamma E_0][\gamma M_0][\mathcal{R}_0^2/\gamma^2]$, hence remains *invariant* (*with regards to an arbitrary mass change*). Therefore, we establish *at once,* our next assertion.

Assertion 4 The application of the arbitrary transformation $[M_0 \to \gamma M_0]$, to a quantum mechanical description, at rest, in cases the sizes are set free to change, leaves the product $E_0 M_0 \mathcal{R}_0^2$ invariant.

This assertion would not hold, if *artificial potential energies* are used in our original Schrödinger or even Dirac description. And the reason is simply that, in order to arrive at the results displayed by Assertion 1, say, for atomistic and molecular objects, the *potential energy terms* to be input to the quantum mechanical description, must be made of Coulomb potential energies.

Assertion 4, on the other hand, well holds, if the size $\mathcal{R}_0$ is, for any reason, kept *constant.* In this latter case however, E_0, as we have just revealed (cf. (6)), decreases, were the clock mass increased. Let us frame the related results as our next assertions.

Assertion 5 The application of the arbitrary transformation $[M_0 \to \gamma M_0]$, to a quantum mechanical description, at rest, in cases the sizes are not allowed to change, leaves the product $E_0 M_0$ *invariant,* no matter what the potential energy terms input to the description are, provided that these terms are relativistically compatible.

Assertion 6 The application of the arbitrary transformation $[M_0 \to \gamma M_0]$, to a quantum mechanical description, at rest, in cases the sizes are blocked to change, on a given direction, still leaves the product $E_0 M_0 \mathcal{R}_0^2$ *invariant,* for now E_0 is decreased as much.

Thus, we land at the following general assertion.

Assertion 7 The application of the arbitrary transformation $[M_0 \to \gamma M_0]$, to a quantum mechanical description, at rest, no matter what the sizes are allowed to change, or blocked, leaves the product $E_0 M_0 \mathcal{R}_0^2$ *universally invariant.*

This is deep, and as we will elaborate on soon, what lies under the relativistic transformations, were the object at hand brought to a uniform translational motion (*or even, planted into a gravitational field, or in fact any field the object can interact with, which we leave though outside of this manuscript*). Actually, under the overall mass transformation we have considered, we have to note that the *quantum mechanical invariance* of [total energy × mass × length^2], holds for a *given total energy,* not only for the pair M_0 and $\mathcal{R}_0$, but also for *any pair* made of *any mass* m_0, and *any piece of length* r_0 (*the total energy,*

as mentioned, remaining the same), one may pick up, from the framework of the object in consideration.

Furthermore, it is interesting to note that, the quantity [*total energy* × *mass* × *length*^{2}], happens to be, not only a *relativistic or non-relativistic quantum mechanical invariance, regarding an arbitrary mass change,* but also a *Lorentz invariance* delineated by the STR (*were the object brought to a uniform translational motion*).

In any case, amongst all of possible $E_0 m_0 r_0^2$'s we can compose, based on *pairs* picked from respectively *different masses* m_0, and *different pieces of length* r_0 the object depicts, obviously the special combination $E_0 M_0 \mathcal{R}_0^2$ too, exhibits the concurrent *quantum mechanical* and *Lorentz* invariances (*in the former case, with regards to a mass change, and in the latter, with regards to a uniform translational motion*).

This seems to bear a profound meaning, for (amongst all possible $E_0 m_0 r_0^2$'s), $E_0 M_0 \mathcal{R}_0^2$ constitutes a particular combination. Whereas E_0, on the one hand, and any pair m_0 and r_0, on the other, may very well not be interrelated; E_0, M_0, and R_0, certainly are. Indeed, the product $E_0 M_0 \mathcal{R}_0^2$ is fundamentally, nailed to h^2, which is in return, Lorentz invariant. It is this identification the author made, which, at the very beginning, constituted the seed of this work.

Thus, our original idea, was as follows. In order to insure the *necessary concordat* along with the occurrences dealt with the STR (*also with those dealt with the GTR*); "*mass*" (*i.e. clock mass*), "*space*" (*i.e. size*) and "*time*" (*i.e. period of time*), or "*energy*" (*i.e. total energy*), to be associated with *the internal dynamics* of any entity, must be structured (*and this, already at rest*), in just a "*given way*" [1–3, 10–12, 17–19], i.e. that displayed by the *invariance* stated in Assertion 7.

Or vice versa, because matter is built in just a unique way, clocks brought into a uniform translational motion, well delineate the known Lorentz transformations.

It is precisely that, the *special product* $E_0 M_0 \mathcal{R}_0^2$, owing to the related quantum mechanical description, is to be strapped to a *Lorentz invariant, universal constant* (*and this, already at rest*).

The fact that any product [*energy* × *mass* × *length*^{2}] manufactured out of any *given mass,* any *ordinary wall clock* of given *energy,* and any *stick meter,* put next to each other (*when brought to a uniform translational motion*), relativistically remains *invariant*; does not of course, induce any *given interrelation* in between these *three* totally *independent* quantities. But, the Lorentz invariance of $E_0 M_0 \mathcal{R}_0^2$ is different, since the *three quantities* coming into play, are now, *quantum mechanically* interrelated with each other. It is that, the product $E_0 M_0 \mathcal{R}_0^2$, emerges as *plainly* entrenched to the *universal* (*Lorentz invariant*) *constant* h^2 (*encompassed by the description of any quantum mechanical entity*). It occurs indeed to be proportional to h^2, through a rather complex, dimensionless, and relativistically invariant quantity, which is somewhat a *characteristic* of the complex structure of the quantum mechanical object, in hand) [1].

5 Conclusion

It is the relationship $E_0 M_0 \mathcal{R}_0^2 \sim h^2$, holding already for the object, at rest, which constitutes the *underlying mechanism* of the end results of the STR. This constitutes the key finding of this article. It is worth to formulate, as a next assertion, the *framework,* we have thus far revealed [1–4, 10–12].

Assertion 8 In any object, the *clock mass* M_0, carrying the *internal motion* of the object, the *size* $\mathcal{R}_0$ of the *space* in which this motion takes place, and the *total energy* E_0, or accordingly the *period of time* T_0, delineated by this motion, are *architectured* in relation with each other, in such manner that, when a *change* in M_0 is arbitrarily input to the *quantum mechanical description* of the object; the transformations that E_0, T_0, and if allowed $\mathcal{R}_0$, accordingly undergo, happen to be the *underlying transformations* that *mass, size, energy,* and thus *period of time,* would display when the object is brought to a *uniform translational motion.* In other words, it is the *quantum mechanical, Lorentz invariant relationship* $E_0 M_0 \mathcal{R}_0^2 \sim h^2$, holding already at rest, which constitutes the *underlying mechanism* of the end results of the STR.

We have to stress that, the *assertions* we have disclosed, would not hold, if *artificial potential energies* were used, throughout. In a subsequent article, we will elaborate on, how the above concluding *quantum mechanical* assertion (briefly, $E_0 M_0 \mathcal{R}_0^2 \sim h^2$), works as the machinery of the end results of the STR. It is that, the structure of any entity delineates a *universal matter architecture* (*UMA*), and this is the "*mystery*" of the *Galilean Principle of Relativity.*

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