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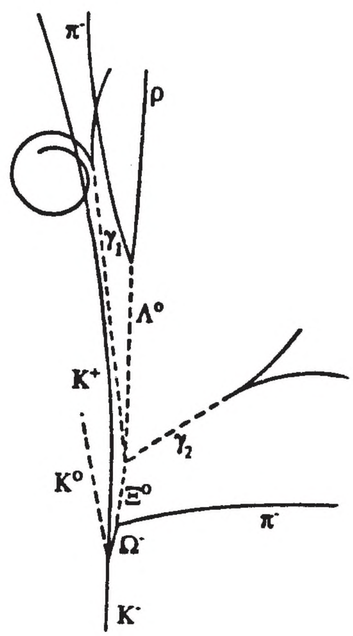

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COMPARISON OF PROPORTIONAL TIME DILATION AND REMOTE NON-SIMULTANEITY: PROOF THAT THE LORENTZ TRANSFORMATION IS SELF-CONTRADICTORY

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Abstract

A review of the predictions of Einstein's Special Theory of Relativity (STR) shows that two of them, remote non-simultaneity and time dilation, are incompatible with each other. It is claimed thereby that two numbers, time differences for the same event that are measured by observers in different states of motion, always occur with a fixed ratio, but that one of them can be zero (simultaneous observation) without the other being so as well. It is impossible that both of these conditions can each be met in any given case, and this constitutes proof that the Lorentz transformation (LT), from which both effects are derived in STR, is not a physically valid set of space-time equations. It is further pointed out that a clock moving through space in the complete absence of unbalanced external forces, in accordance with Newton's Law of Inertia and the Law of Causality, must be expected to have a constant rate. As a consequence, elapsed times Δt and $\Delta t'$ measured by two such (inertial) clocks for the same event should always occur in a fixed ratio, as expressed by the following relation: $\Delta t'=\Delta t/Q$, where Q is a constant fully determined by the above ratio.

Keywords: Time dilation, remote non-simultaneity, Lorentz transformation (LT), Universal Time-dilation Law (UTDL), Global Positioning System-Lorentz transformation (GPS-LT)

1. Introduction

Two of the most significant predictions stemming from the Lorentz transformation (LT) of relativity theory are time dilation and remote non-simultaneity. Both have to do with the behavior of clocks in motion with respect to each other. The latter indicates that events which are simultaneous for one observer may not be so for another. This possibility was first discussed by Poincaré in 1898 [1]. He simply noted that such a phenomenon was an unavoidable consequence of the LT because of its mixing of space and time coordinates. He realized that this proposition ran counter to centuries of scientific opinion going back at the least to the work of Sir Isaac Newton, but he pointed out that there was no incontrovertible evidence which definitively ruled out such an occurrence of non-simultaneity in natural processes,

The phenomenon of time dilation seems to have been first discussed by Einstein in his landmark 1905 paper [2], in which he introduced his Special Theory of Relativity (STR) [2]. He pointed out that according to the LT, a moving clock always runs slower than a stationary one. More quantitatively, he derived a simple formula for a proportionality factor that specifies the ratio of the rates of two such clocks as a function of their speed relative to one another. As will be discussed in the following, however, it will be shown that the latter proportionality relationship is actually incompatible with remote non-simultaneity. Moreover, this circumstance proves that the LT itself is not a physically valid set of equations since both of these contradictory effects are derived from it.

2. Newton's Law of Inertia and its consequences for relativity theory

The derivations of the above two predictions both start with the LT equation given below:

$$\Delta t' = \gamma\left(\Delta t - vc^{-2}\Delta x\right) = \gamma\eta^{-1}\Delta t, \tag{1}$$

$\gamma = \left(1 - v^2c^{-2}\right)^{-0.5}$ and $\eta = \left(1 - vc^{-2}\dfrac{\Delta x}{\Delta t}\right)^{-1}$. It is assumed thereby that two observers, O and O', are separating from each other along their mutual x,x' axis with relative speed v (c is the speed of light in free space, 299792458 ms^{-1}). They each observe two events such as lightning strikes and measure the time difference between them to be Δt and $\Delta t'$, respectively. The distance separating the events along the x axis is measured to be Δx by observer O. Reference to eq. (1) shows that if the events occur simultaneously for him, i.e. $\Delta t=0$, and both v and Δx are non-zero, the corresponding time difference for observer O' will not also be equal to zero ($\Delta t' \neq 0$). This LT prediction is referred to as *remote non-simultaneity*.

The phenomenon of time dilation is derived [3] by considering a different application of eq. (1). In this case, attention is centered on the stationary clocks in the two rest frames. The travel times for the clock of O' to travel between two fixed points in the rest frame of O are measured to be Δt and $\Delta t'$, respectively. The distance traveled by the latter clock is $\Delta x = v\Delta t$, since by construction it moves with constant speed v along the x axis from the vantage point of observer O. Substitution of this relation in eq. (1) gives:

$$\Delta t' = \gamma(v)\left(\Delta t - v^2 c^{-2} \Delta t\right) = \gamma^{-1} \Delta t . \qquad (2)$$

This equation states that the moving clock from the standpoint of observer O *always* runs slower than his by a factor of $\gamma(v)$. The proportionality of the two time differences is key in the present discussion, however. It clearly demands that if the lightning strikes in the first example occur simultaneously for one of the observers ($\Delta t=0$), they also must occur simultaneously for the other as well, i.e. $\Delta t'=0$. Multiplication of zero with any finite number, in this case $\gamma^{-1}(v)$, must give a product of zero. This prediction therefore runs contrary to the claim of non-simultaneity in the first example.

The fact that the LT is responsible for both the predictions of *proportional* time dilation and remote non-simultaneity proves unequivocally that this set of equations is not a valid space-time transformation. At this point in the discussion, it is not possible to say if either of the predictions is false, only that they can't both be true for the same set of circumstances. The question is therefore whether there is another space-time transformation that is not self-contradictory, but one that at the same time satisfies the other constraints put on relativity theory by virtue of experimental observations.

To consider this goal it is helpful to take a careful look at the characteristics of an earlier transformation introduced by Voigt in 1887 [4]:

$$\Delta t' = \Delta t - vc^{-2}\Delta x = \eta^{-1}\Delta t \tag{3a}$$

$$\Delta x' = \Delta x - v\Delta t \tag{3b}$$

$$\Delta y' = \gamma^{-1}\Delta y \tag{3c}$$

$$\Delta z' = \gamma^{-1}\Delta z\,. \tag{3d}$$

His main accomplishment was to adjust the classical (Galilean) transformation in such a way that it becomes consistent with experimental observations which seemed to indicate that the speed of light in free space is independent of the state of motion of the observer. The transformation in eqs. (3a-d) succeeds in this goal, as can be seen by forming the following relationship between the squares of its various quantities:

$$\Delta x'^2 + \Delta y'^2 + \Delta z'^2 - c^2\Delta t'^2 = \gamma^{-2}(\Delta x^2 + \Delta y^2 + \Delta z^2 - c^2\Delta t^2)\,. \tag{4}$$

It shows that if the speed of a light pulse is equal to c in the rest frame of observer O', it is also equal to c in the rest frame of another observer O moving with speed v relative to him.

To arrive at this transformation, Voigt first added a distance-dependent term, $vc^{-2}\Delta x$, to the classical equation which assumes that the clocks of both observers run at exactly the same rate, i.e. $\Delta t'=\Delta t$. In addition, in eqs. (3c-d) he added a factor of γ^{-1} to the classical relations for motion in directions that are perpendicular to the relative velocity of the two observers. The mixing of space and time coordinates in eq. (3a) amounts to a clear break with accepted views of the time. *It was based on a conclusion that such mixing is essential for arriving at a set of space-time equations that is consistent with light-speed constancy.*

There is nonetheless something unacceptable about the Voigt transformation. This is because it does not satisfy the conditions required by the Relativity Principle (RP) and its assertion that the laws of physics are the same in all inertial systems. One can simulate the exchange of observers in these equations by interchanging the primed and unprimed coordinates and reversing the sign of the relative speed v of the two observers.

The RP requires that when this procedure is employed, which will henceforth be referred to as *Galilean inversion*, the resulting set of equations must be the exact inverse transformation of the original. This means, for example, that eq. (3c) is changed to $\Delta y=\gamma^{-1}\Delta y'$ (note that changing the sign of v has no effect on the value of γ). Substitution of the latter relation back into eq. (3c) gives the nonsensical result of $\Delta y'=\gamma^{-2}\Delta y'$.

Lorentz [5] subsequently provided a means of improving upon Voigt's transformation. He pointed out there is a degree freedom in any such transformation because of the fact that multiplying the right-hand sides of all four equations by the same factor has no effect on the *ratio* of its space and time intervals. The condition of light-speed constancy can therefore be satisfied with the choice of any finite value for this factor. This conclusion thus leads to a more general version of the Voigt transformation which is given below, where the aforementioned factor is designated as φ:

$$\Delta t' = \varphi(\Delta t - vc^{-2}\Delta x) = \varphi\eta^{-1}\Delta t \tag{5a}$$

$$\Delta x' = \varphi(\Delta x - v\Delta t) \tag{5b}$$

$$\Delta y' = \varphi\gamma^{-1}\Delta y \tag{5c}$$

$$\Delta z' = \varphi\gamma^{-1}\Delta z. \tag{5d}$$

In particular, the factor of γ^{-2} in eq. (4) is thus changed to $\varphi^2\gamma^{-2}$ based on the new transformation, without therefore affecting the light-speed constancy condition in any way.

It is a simple matter to take advantage of the above degree of freedom in order to satisfy the RP. One merely has to choose φ to be equal to γ in eqs. (5a-d). The result is the LT, with the adjusted eq. (5a) becoming identical to eq. (1). The LT does satisfy the RP. For example, it removes the problem with the result of applying Galilean inversion to eq. (3c). With $\varphi=\gamma$, eq. (5c) simply becomes $\Delta y'=\Delta y$, which relation is obviously unchanged by interchanging the primed and unprimed subscripts.

Nevertheless, as has been shown above, the LT is also unsatisfactory because its eq. (1) leads to completely incompatible predictions of remote non-simultaneity and time dilation. The present discussion shows that the two conditions of light-speed constancy and the RP, which are Einstein's two postulates of relativity [2], are not sufficient to determine the true space-time transformation.

It also indicates that another characteristic of time measurements would be helpful in this respect. Consider, for example, the role of inertial clocks in the above discussion. According to Newton's First Law of Motion (Law of Inertia), all such clocks will continue moving indefinitely in a straight line with constant speed. Because of the assumed complete absence of unbalanced external forces, it can be assumed with great confidence based on the Law of Causality that the *properties of these clocks* will be unchanged for the duration of their flight. In particular, one should expect *that their rates remain constant* under these circumstances. Just as the speeds and directions of the various clocks do not have to be the same, it seems equally reasonable to conclude that the rates of the clocks can also be different. The key point in the present discussion, however, is that the *ratio of the rates of any two inertial clocks will also be constant* and that the same holds true for their respective elapsed times for the same event. These considerations lead unambiguously to the following simple relation, which should hold true as long as no change in the states of motion of either occurs:

$$\Delta t' = \frac{\Delta t}{Q}, \tag{6}$$

where Q is a constant proportionality factor.

The question clearly arises whether eq. (6) is compatible with the other two conditions of light-speed constancy and the RP. To answer it, one need only go back to the general space-time transformation in eqs. (5a-d). To begin with, it is necessary to choose a suitable value for the degree-of-freedom parameter φ. A solution is readily found from eq. (5a):

$$\Delta t' = \varphi\eta^{-1}\Delta t = \frac{\Delta t}{Q}, \tag{7}$$

from which one obtains the following value for φ, namely

$$\varphi = \frac{\eta}{Q}. \tag{8}$$

Substitution of this value in each of eqs. (5a-d) then leads to the following transformation:

$$\Delta t' = \eta \frac{\Delta t - vc^{-2}\Delta x}{Q} = \frac{\Delta t}{Q} \tag{9a}$$

$$\Delta x' = \eta \frac{\Delta x - v\Delta t}{Q} \tag{9b}$$

$$\Delta y' = \left(\frac{\eta}{\gamma Q}\right)\Delta y \tag{9c}$$

$$\Delta z' = \left(\frac{\eta}{\gamma Q}\right)\Delta z. \tag{9d}$$

Because of its relation to the general transformation in eqs. (5a-d), it is clear that the new transformation satisfies the light-speed constancy condition. It is also clear that it satisfies the proportional time condition of eq. (8) since this appears directly as its eq. (9a). It remains to be shown that it also satisfies the RP, however.

To this end, it is helpful to consider the effect of applying Galilean inversion to its various equations. First of all, the inverse of eq. (9a) must be $\Delta t = \Delta t'/Q'$, where Q' is not defined initially. It is easy to satisfy this condition, however, by requiring that $Q' = 1/Q$. The corresponding condition for eqs. (9c-d) is $\eta\eta'/\gamma^2 QQ' = 1$, or simply $\eta\eta' = \gamma^2$ because of the reciprocal relationship of Q an Q' already determined. Proof of this equality is given below [7]. It also can be used to show that Galilean inversion leads to the inverse of eq. (9b). In summary, the transformation of eqs. (9a-d) satisfies all three of the required conditions, unlike either the LT or the original Voigt transformation [4].

The same transformation can be obtained by another route that does not involve explicit consideration of the degree of freedom discussed above in eqs. (5a-d). The transformation of the velocity components $u_x = \Delta x/\Delta t$, $u_x' = \Delta x'/\Delta t'$ etc. for the two observers results from division of each of eqs. (5b-d) by eq. (5a):

$$u_x' = \left(1 - vu_x c^{-2}\right)^{-1}\left(u_x - v\right) = \eta\left(u_x - v\right) \tag{10a}$$

$$u_y' = \gamma^{-1}\left(1 - vu_x c^{-2}\right)^{-1} u_y = \eta\gamma^{-1}u_y \tag{10b}$$

$$u_z' = \gamma^{-1}\left(1 - vu_x c^{-2}\right)^{-1} u_z = \eta\gamma^{-1}u_z. \tag{10c}$$

Exactly the same velocity transformation (RVT) is obtained by carrying out the analogous divisions for the original Voigt transformation of eqs. (3a-d) as well as for the LT. Multiplication of each of these three equations by the Newtonian proportional time relation of eq. (6) leads directly to eqs. (9b-d).

The RVT satisfies the RP, as can be seen by applying the identity relation already discussed. The proof of the latter is given below in terms of the velocity components:

$$\eta\eta' = \left[\left(1-u_x vc^{-2}\right)\left(1+u_x' vc^{-2}\right)\right]^{-1} = \left[\left(1-u_x vc^{-2}\right)\left(1+\eta vc^{-2}\left(u_x - v\right)\right)\right]^{-1}$$
$$= \left[\left(1-u_x vc^{-2}\right)\frac{1-u_x vc^{-2}+vc^{-2}u_x - v^2c^{-2}}{1-u_x vc^{-2}}\right]^{-1} \qquad (11)$$
$$= \left(1- v^2c^{-2}\right)^{-1} = \gamma^2 .$$

Applying Galilean inversion to eq. (9c), for example, and substituting this result for the u_y component leads back directly to the value of u_y' required to satisfy the RP by making use of eq. (11).

3. Comparison with experiment

The transformation in eqs. (9a-d) differs in a number of significant ways from the LT. The proportionality relationship between measured elapsed times given in its first equation clearly supports the original Newtonian view of absolute simultaneity for all events throughout the universe. At the same time, it leaves open the possibility that the rates of clocks depend on their state of motion. While it is necessary to reject the LT as a valid space-time transformation because of its two predictions of remote non-simultaneity and proportional time dilation, the same cannot therefore be said about that in eqs. (9a-d).

Recognition of this point opens up the broader question of whether the latter transformation is consistent with all available experimental findings. It also remains to be shown how the constant Q in eq. (9a) can be determined, since lack of a concrete means of accomplishing this goal would obviously severely limit the transformation's potential advantages in practical applications.
A good place to begin in this regard is the experiment with circumnavigating atomic clocks carried out by Hafele and Keating in 1971 [8,9]. It was found that the rates of the clocks decreased as their speed v relative to the earth's center of mass (ECM) increased.

A correction based on the gravitational red shift was also applied to account for differences in the altitudes of the clocks. Specifically, the authors found that the rates of the clocks are inversely proportional to $\gamma(v) \approx 1+0.5v^2c^{-2}$. As a result the relationship between measured elapsed times Δt and $\Delta t'$ for any given portion of the flight of two clocks with respective speeds u and u' relative to the ECM is given by the following equation:

$$\Delta t' \gamma(u') = \Delta t \gamma(u). \tag{12}$$

Experiments carried out a decade earlier with high-speed rotors [10-12] can be described by eq. (12) as well. In this case the absorber and detector of an x-ray source were mounted on the rotor and it was found that the rate/frequency of each such clock decreased with its speed u relative to the rotor axis [11]. A key aspect of eq. (12) is that a definite rest frame needs to be designated from which to compute the speeds u and u' to be inserted into it. It is the rotor axis in the x-ray frequency study and the ECM in the case of the Hafele-Keating experiment, for example. In previous work [13], this reference frame has been referred to as the objective rest system (ORS). Einstein mentioned a related application in his 1905 paper [2] according to which a clock located at the Equator was expected to run at a slower rate that an identical counterpart at one of the earth's Poles. More generally, the ORS is the rest frame from which an object undergoes an applied force which causes it to be accelerated to a given speed.

The developers of the Global Positioning System (GPS) have made use of eq. (12) in order to adjust the rates of atomic clocks located on orbiting satellites so that they are equal to those of identical clocks located on the earth's surface. The ratio of the rates of two such clocks is accordingly computed on the basis of their respective speeds relative to the ECM. A pre-correction procedure [14,15] is applied to the satellite clock prior to launch so that its rate is increased artificially by the above ratio. The effect of time dilation on this clock counter-balances the latter adjustment, with the desired result that it runs at nearly the same rate as earthbound clocks after it reaches its prescribed orbit.

There is also a gravitational effect which needs to be considered in order to achieve the desired level of accuracy for GPS distance measurements. The fact that eq. (12) is applicable to all the above situations, and especially that there are no known exceptions to it, indicates that it is a fundamental law of physics. It is therefore deserving of the designation: Universal Law of Time Dilation (UTDL [16,17]). Because of the application of eqs. (9a-d) to the adjustment of the rates of satellite clocks, they have been designated as the Global Positioning System-Lorentz Transformation (GPS-LT) [18-20].

Moreover, eq. (12) can be used directly to quantitatively determine the value of the parameter Q in the Newtonian elapsed time proportionality of eq. (6), namely as:

$$Q = \frac{\gamma(u')}{\gamma(u)}. \tag{13}$$

This parameter is also used in all four equations of the alternative space-time transformation of eqs. (9a-d). It is also important to apply the Galilean inversion procedure to eq. (13) to see how the corresponding relationship is perceived by O'. The result is:

$$Q' = \frac{\gamma(u)}{\gamma(u')} = \frac{1}{Q}, \tag{14}$$

in agreement with the requirement mentioned in the previous section: it is essential to have the inverse transformation of eqs. (9a-d) be obtained by simply reversing the roles of the two observers, in accordance with the RP.

It is helpful to look upon Q and Q' as conversion factors for the different units of time employed in the two rest frames. The parameter Q is needed in order to convert elapsed times measured by O' to the corresponding unit employed by observer O. The conversion factor in the reverse direction is simply the reciprocal of Q, analogous to the conventional case in which cm are to be converted to m and vice-versa.

4. Conclusion

The Lorentz transformation (LT) is not a valid component of relativity theory because it leads to two predictions which are hopelessly incompatible with each other: remote non-simultaneity and time dilation. The latter requires that time differences for the same event that are measured by two observers in constant relative motion with speed v always occur in the same proportion [$\Delta t'=\gamma(v)\Delta t$], whereas the non-simultaneity prediction claims that one of the time differences can be zero without the other being so as well. To believe in both relationships requires that one disregard the axiom of algebra which states that the product of any finite number with zero is itself equal to zero, and that is clearly unacceptable for any theory of physics.

The space-time mixing character of eq. (1) of the LT is responsible for the above conflict. Consideration of Newton's Law of Inertia also indicates that space and time are not mixed. A straightforward extension indicates that any clock which is moving under the absence of external forces should not only move at constant velocity, but also that its rate should remain the same indefinitely as well. On this basis the only reasonable conclusion is that the ratio of the rates of any two such clocks should be constant as well, which leads to a simple alternative to eq. (1), namely the proportionality relation of eq. (6). The latter also leaves open the possibility of time dilation, but in contrast to the LT, it removes any chance that observers could each find that it is the other's clock that is running slower. Remote non-simultaneity is also ruled out by this relation.

Experimental tests of time dilation have always been perfectly consistent with eq. (6). Their results can be formulated in another proportionality relationship, the Universal Time-dilation Law (UTDL) of eq. (12). The latter allows for a straightforward prediction of the constant Q in eq. (6) in terms of the speeds of any two such clocks relative to a specific frame of reference. The latter is the earth's center of mass in the study of circumnavigating atomic clocks carried out in 1971 [8,9], for example. Specifically, the value of Q is given by eq. (13). It shows that the clock which runs faster relative to the above rest system has a slower rate than its counterpart. A useful means of describing the role of the constant Q is as a conversion factor between elapsed times measured on different clocks. The asymmetry of the above relationship again stands in stark contrast to the LT version of time dilation.

The constant ratio of inertial clock rates expressed in eq. (6) serves as a third postulate of relativity. In particular, the support it has received from experiment in the form of the UTDL of eq. (12) makes it quite difficult to argue for a version of the theory which ignores it. Such a postulate goes along with the two Einstein used in his derivation of the LT [2], the Relativity Principle and the constancy of the speed of light in free space. The GPS-LT of eqs. (9a-d) succeeds in incorporating all three. This set of equations is perfectly self-consistent, unlike the LT, and also leads directly to the same relativistic velocity transformation (RVT) as has long been accepted by the physics community. The latter is sufficient by itself to explain the occurrence of the aberration of starlight at the zenith and the characteristics of the Fresnel light-drag experiment, for example, so this characteristic of the GPS-LT shows that *the LT is not essential for the description of these effects*. The concrete indications from both experiment and theory of the validity of the GPS-LT suggest that it is highly desirable to carry out new experiments in future work to further test the accuracy of eq. (12).

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HOW TO BREAK THE LIGHT SPEED BARRIER IN A PARTICLE ACCELERATOR

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Abstract

Relativistic mechanics differs from classical mechanics by the presence of the gamma factor in the equation of motion of a charged particle. This gamma factor results from experimental measurements done in the laboratory frame when one observes the acceleration of charged particles in a particle accelerator. This gamma factor has nothing to do with the gamma factor of the special relativity theory used in a Lorentz transformation done between inertial frames in relative motion where the velocity is constant in this transformation.

We will show in this paper that one can rewrite the relativistic motion equation as a classical motion equation plus a braking force. This allows to calculate the variation of the kinetic energy of the charged particles in a classical way where the work of the braking force appears now as a dissipative term in the energy equation. By using a very old physical principle and a stepping method, one demonstrates how we can cancel the dissipative term opening the way to break the light speed limit for the motion of charged particles in a particle accelerator.

Keywords: Light speed limit; Capacitor problem; Energy transfer; Special relativity theory

1 INTRODUCTION

The gamma factor $\gamma[\mathbf{U(t)}]$ in the equation of motion of a charged particle accelerated in a particle accelerator has no relation with the gamma factor $\gamma[\mathbf{V}]$ of the special relativity theory used in a Lorentz transformation.

We recall that this transformation is defined for a change of reference frame between two inertial frames in relative motion where the velocity $\mathbf{V}$ is uniform. Moreover, the transformation implies also a change of the space-time units in order to obtain the presence of the gamma factor in the transformation. We must point out that in all experiments done in a particle accelerator as in the case of the Bertozzi's experiment [1], all the measurements are done by an observer located in the laboratory reference frame, therefore no change of reference frame and space-time units is implied in the experimental measurements.

All the mathematical formulation explicated in this paper is written for quantities defined with respect to the laboratory reference frame. Therefore, we shall propose another explanation to understand why there is a speed limit for a charged particle accelerated in particle accelerators. In a first step, we prove that the relativistic equation of motion can be written in a classical way if a braking force is introduced in the equation. In a second step, we present a general equation of motion for a charged particle with a mass depending on time where the relation $m(t) = \gamma(t)\, m_0$ is a special case obtained if we apply a given constraint which was first introduced in our paper [2].

2 PHYSICAL ASPECTS ON THE ROLE PLAYED BY VACUUM

The fact that a particle is not a point particle has been proved by electron scattering experiments done by Hofstadter [3] in 1956 who proved that all elementary particles have a measurable finite size, an internal charge distribution and can deform themselves in interaction. Hofstadter received the Nobel Prize in 1961 for his important discovery.

With a different approach, the structure of an elementary particle was analyzed by H. Dehmelt [4] from 1976 to 1990. In these experiments, an electron, almost at rest, was isolated and closely confined in a ultrahigh-vacuum

Penning trap. These experiments permitted to measure the dimensionless gyromagnetic factor g with an incredible accuracy.

We can find in the literature only a few model of the electron morphology, the first one by Parson [5] in 1915 where the author proposed a model for the electron with a ring-shaped geometry where an elementary charge moves around the ring with the speed of light generating a magnetic field.

We have to wait until 1985, to see the ring electron model revisited by Bostick [6] where the angular momentum of the electron or spin has for value $\hbar/2 = \alpha\hbar\, ln[R/r]$ where $2r$ is the diameter of the toroidal shell and R the radius of the toroid and α the fine-structure constant. A ring electron model was also presented by Bergman [7] in 1990 where the spin has now for value $\hbar/2 = \alpha\hbar\, ln[8R/r]/2\pi$. In this last model, the instability of the electron is cancelled by the presence of a magnetic Pinch effect where the magnetic pressure compensates exactly the electrostatic pressure. Several researchers, such as Jennison [8], Kanarev [9], and Lucas [10] proposed similar models. More recently Consa [11] in 2018 proposed an helical solenoid electron model where the electron has a toroidal moment, a feature that is not predicted by quantum mechanics.

A more complete wave model of the electron was developed by Mills [12] in 2003 where the classical wave equation is solved with the constraint that the bound state electron cannot radiate energy. With the assumption that physical laws including Maxwell's equation apply to bound electrons, the hydrogen atom was solved exactly from first principles. The remarkable agreement across the spectrum of experimental results indicates that this is the correct model of the hydrogen atom. In a second paper [13], the physical approach was applied to multi-electron atoms that were solved exactly. The general solutions for one-through twenty-electron atoms are given. The predictions of the ionization energies are in remarkable agreement with the experimental values known for 400 atoms and ions.

This paper does not deal with several experiments [14-19] done from 1983 to 1993 to demonstrate that superluminal speeds do exist. The light speed barrier is an experimental fact in particle accelerators which must be understood if one wish to break it. The subject has been already discussed by Santilli [20] who reviews the compatibility of superluminal speeds with special relativity. The author made some interesting remarks that are worth to be analyzed again. First, the author insists on the fact that nucleons must be deformable charge distributions and he points out rightfully that there is no point like wave packet in nature.

In a second step, Santilli conceives space as an universal substratum for all electromagnetic waves and all particles. He tries to explain the reason why the rest energy of the neutron is $0.78\,MeV$ bigger than the sum of the rest energies of the proton and electron. To solve this problem, he supposes that energy is transmitted from space to the neutron via a longitudinal impulse.

Santilli [21] was also the first physicist to raise the question of the rigidity of space in 1957 to explain the high value of the speed of light, a problem that most physicists avoid to speak since they are unable to explain how vacuum can sustain the propagation of transverse electromagnetic waves. A transverse wave can only travel through solid, then why transverse light wave can travel through air and vacuum. This implies that vacuum must behave as if it were an elastic solid with a rigidity which had to be incredibly high in order to transmit waves at the fantastic speed of light. On logical grounds, such a medium was compelled to slow down planetary motions around the Sun.

A search in the scientific literature concerning the answer to that question was given by Bekefi [22,p.150] in plasma physics where the author notes that a longitudinal wave can create a transverse wave: *In an infinite homogeneous plasma, the energy exchange between longitudinal and transverse waves occurs at the microscopic level, and is essentially the result of the medium's grainy nature.* Thus, it is not necessary to consider the vacuum as a kind of elastic solid to sustain transverse waves. We give a more complete answer to this question in two papers published in 1990 and 1994 [23-26] where we assume the presence of scalar inhomogeneous waves in vacuum. This scalar longitudinal field is characterized by the definition of the phase

$$\varphi(\mathbf{r},t) = \int_{t_0}^{t} \alpha(\mathbf{r},t')\omega(\mathbf{r},t')dt' - \int_{\mathbf{r}_0}^{\mathbf{r}} \alpha(\mathbf{r}',t_0)\mathbf{k}(\mathbf{r}',t_0)\cdot d\mathbf{r}' \qquad (1)$$

where the quantity $\alpha(\mathbf{r},t)$ is an integrating factor. In this approach, there is no space-time curvature of vacuum but a space-time deformation of the standing longitudinal waves making the vacuum. This approach has two merits: first if a Fourier mode is solution of a scalar wave equation, then one can deduce the Maxwell's equations [27,p.356] by using successively more complicated potential definitions, hence sound generates light so to speak. Secondly, we prove that the deformation of the scalar wave is quantized. Thus the picture of light as a transverse vibration in the ether, analogous to transverse waves on a string, can be reconciled with the existence of the ether. We can conclude this section by pointing out the fact that numerous experiments have proved that vacuum is a vibrational medium able to explain the Casimir effect, the Lamb shift and the Van de Waals forces.

3 RELATIVISTIC ENERGY LAW WRITTEN IN A CLASSICAL FORM

The fact that a particle has an internal structure implies that this particle can have an interaction with the medium which is taken into account by the existence of an internal force. The splitting of forces between internal and applied forces is examined in the appendix. The existence of the internal force is taken into account by considering that the mass of a particle is a function of time where the momentum is now $\mathbf{P} = m(t)\mathbf{U}$. It is important to point out again that all the following calculation is done in the laboratory reference frame where the particle velocity $\mathbf{U}$ is also defined. The equation of motion of this particle has for expression:

$$\frac{d\mathbf{P}}{dt} = \mathbf{F} \tag{2}$$

where the force $\mathbf{F}$ is applied to the particle which is accelerated in an electrostatic accelerator. If the preceding equation is scalarly multiplied by $\mathbf{U}$, then we obtain

$$\mathbf{U} \cdot \frac{d\mathbf{P}}{dt} = m\mathbf{U} \cdot \frac{d\mathbf{U}}{dt} + \frac{dm}{dt}\mathbf{U}^2 = \mathbf{F} \cdot \mathbf{U} \tag{3}$$

We have the identity:

$$\frac{1}{2}\frac{dm\mathbf{U}^2}{dt} = m\mathbf{U} \cdot \frac{d\mathbf{U}}{dt} + \frac{1}{2}\frac{dm}{dt}\mathbf{U}^2 \tag{4}$$

The second term in the right hand side of the preceding equation is a dissipative term if we verify the condition $dm/dt > 0$.

If we substitute the preceding equation in equation 2 and integrate, we get the relation:

$$\frac{1}{2}\int_0^T \frac{dm\mathbf{U}^2}{dt}\,dt + \frac{1}{2}\int_0^T \frac{dm}{dt}\,\mathbf{U}^2\,dt = \int_0^T \mathbf{F}\cdot\mathbf{U} \tag{5}$$

The preceding equation is an exact mathematical formulation where the first term in the left hand side of the equation is the classical variation of the kinetic energy of the particle while the second term is a dissipative term. In the right hand side, we have the work of the external force. The speed limit results from the braking force included in the dissipative term if the condition $dm/dt > 0$ is verified.

3 STUDY OF THE GAMMA FACTOR

The experimental fact that an elementary particle has a structure justifies the definition of an internal kinetic energy which is the sum of the vibrational energy $E_V = 0.5 * m_0 c^2$ and the rotational energy $E_R = 0.5 * m_0 c^2$ in the reference frame where the center of mass of the particle is at rest. Therefore, the total internal kinetic energy of the particle has for value $E_K = m_0 c^2$ in the rest frame of the particle or in the laboratory frame for the initial condition $\mathbf{U}(0) = 0$. We can easily calculate the frequency of the oscillatory motion of the electron with the formula $m_0 c^2/2 = \hbar\omega$ which gives $F = 0.62\,10^{10} Hz$.

Let us now assume that the internal kinetic energy of the particle in the laboratory reference frame is $E_K(t) = m(t)c^2$ and we impose the constraint [2]

$$\mathbf{U}\cdot\frac{d\mathbf{P}}{dt} = \frac{dE_K}{dt} \tag{6}$$

The preceding equation means that both the internal and external kinetic energies of the particle increase at the same rate. We must point out that the quantity $m[t]$ is an unknown function. Therefore, equation 5 imposes a relation between two independent functions $m(t)$ and $\mathbf{U}(t)$ which can be solved by adding equation 1. Knowing that $\beta = U/c$, the above equation can be written in the form:

$$\frac{m}{2}\frac{d\beta^2}{dt} = \frac{dm}{dt}\,(1-\beta^2) \tag{7}$$

The above equation has many important consequences that will be now examined. First, we note that any increase of mass is the consequence of the acceleration of the particle. The equation 6 is very clear: no acceleration no mass increment. We can demonstrate how the function $m(t) = \gamma(t)m_0$ is obtained in relativistic mechanics. If we define the gamma factor as usual $\gamma(t)^2 = 1/(1-\beta^2)$, we get:

$$\frac{\gamma^2}{2}\frac{d\beta^2}{dt} = \frac{1}{\gamma}\frac{d\gamma}{dt} = \frac{1}{m}\frac{dm}{dt} \tag{8}$$

it results the definition:

$$Log[\gamma] = Log\frac{m}{m_0} \quad \Rightarrow \quad m(t) = \gamma(t)m_0 \tag{9}$$

Provided we use the initial condition $m(0) = m_0$ for $\mathbf{U}(0) = 0$. Therefore, the mass function $m(t) = m_0\gamma(t)$ results from the definition of equation 5 but we need equation 1 to calculate the numerical velue of the gamma factor. It follows the relation:

$$\Big[E_K\Big]_0^T = m_0c^2\,(\gamma - 1) \approx \frac{1}{2}\,m_0\,\mathbf{U}^2 \tag{10}$$

Bertozzi [1] performed an experiment in 1964 in which the speed of electrons with kinetic energies in the range 0.5 to 15 MeV was determined by measuring the time required for the electrons to traverse a given distance while the kinetic energy $E_K = m_0c^2(\gamma - 1)$ was determined by calorimetry measurements. His result shows that the dependence of the kinetic energy on the speed of the electrons is in good agreement with the above formula:

$$\beta^2 = 1 - \left[\frac{1}{1 + E_K/m_0c^2}\right]^2 \tag{11}$$

The experiment demonstrates without ambiguity that accelerated charged particles gain large kinetic energies as they approach the speed of light which results in an apparent increase of mass $m = \gamma\, m_0$. This variation of mass with respect to the velocity of the particle is certainly not a consequence of the special relativity theory since all the measurements are done in the laboratory frame. This conclusion cannot be challenged from an experimental point of view.

The equation 6 imposes that the derivatives of the speed and the mass have the same sign. It is now interesting to consider the opposite case where the derivatives of both the speed and the gamma factor are negative in experiments relating to the dilation effect for a radioactive clock.

Time dilation has been experimentally verified by means of a first experiment performed by Rossi and Hall in 1941 [28] with particles called mu-mesons or muons which are generated by cosmic rays impacting the Earth atmosphere. These particles move with velocities close to the speed of light. However, most of these particles shortly disintegrate. Thus what can be expected is that a few of them survive long enough to reach the Earth surface. However, this is not what happens and this can be understood if we admit that the muon disintegration process is in fact a measurement of the time flow modified by the motion of the particle. Indeed, the unstable particles disintegrate following an exponential law having the form $N(t) = N_0 e^{-t/\Delta t_0}$ where N_0 is the number of particles present at instant $t = 0$ and Δt_0 the mean lifespan of the unstable particle in the reference frame where it is at rest. If the disintegration rate of the muons decreases, this means that their lifespan has increased and thus, that they could travel further and farther. The comparison of the mean lifespan of moving muon Δt with muons at rest Δt_0 allows to verify the time dilation formula $\Delta t = \gamma \Delta t_0$ where both measurements Δt and Δt_0 are performed in the Earth reference frame.

The dilation formulation above predicts that if, after a measurement on the moving muons has been made, we slow down them to rest, then we will recover the lifetime of muons at rest. This experiment has been done in 1963 [29] and confirms the validity of the deceleration effect, let us quote the authors:

"In addition, actually simultaneously, we slowed down and stopped a sample of m-mesons and measured the distribution of their decay times when they were at rest relative to us. Comparison of their rate of decay at rest with their rate of decay in flight showed that the moving mesons decay much more slowly". The experiment by Frisch indicates without ambiguity that the time behavior of the radioactive clock, once brought to rest, is the rest time in the laboratory frame where $\mathbf{U}(0) = 0$. That is the reason why we think that the result of the twin paradox must be zero as explained in our paper [30].

4 STEPPING METHOD TO CANCEL THE DISSIPATION TERM

We can use equation 2 to rewrite equation 4 in the form:

$$\frac{1}{2}\int_0^T \frac{dm\mathbf{U}^2}{dt}\,dt + \frac{1}{2}\int_0^T \frac{dm}{dt}\mathbf{U}^2\,dt = \int_0^T \mathbf{U}\cdot\frac{dm\mathbf{U}}{dt}\,dt \tag{12}$$

By definition, we have:

$$E_K[T] + E_D[T] = E_W[T] \tag{13}$$

Where $E_K[T]$ is the classical kinetic energy of the particle, $E_D[T]$ is the dissipative term and $E_W[t]$ is the work term.

Hereafter, we will examine how to decrease the dissipative term $E_D[T]$ by using a very old physical principle which was examined in a recent paper [31]. In this paper, we discussed the transfer of energy between a power supply and a capacitor when a dissipative term such as the resistance R of the wires is present. We demonstrated that one can minimize the heat losses during the transfer of energy between a power supply and a capacitor by processing the energy transfer by small steps. A fact which has been known for a long time but not often quoted in modern physic textbooks in spite of the fact that this principle has many important applications. Indeed, any dissipative system which is irreversible can become reversible if the transformation involved in the system is carried out by a stepping process as the number of steps N increases to infinity.

Gupta [32] in 1984 did an experiment where a linear spring is loaded with a total mass M but in N equal steps each time by a mass $m = M/N$ to demonstrate that the energy dissipated in the form of heat is given by the relation $E_D[N] = MgH/2N$.

Therefore, we can split the integrals of equation 11 in N equal time steps $dt = t_n - t_{n-1} = T/N$ as follows:

$$\frac{1}{2}\sum_{n=1}^{N}\int_{t_{n-1}}^{t_n} \frac{dm\mathbf{U}^2}{dt}\,dt + \frac{1}{2}\sum_{n=1}^{N}\int_{t_{n-1}}^{t_n} \frac{dm}{dt}\mathbf{U}^2\,dt = \sum_{n=1}^{N}\int_{t_{n-1}}^{t_n} \mathbf{U}\cdot\frac{dm\mathbf{U}}{dt}\,dt \tag{14}$$

We can now proceed in the same manner as in Gupta experiment where the mass of the particle is increased in small and equal step dm during each time step dt with the definition $m[n] = mo + n * dm$ while for the velocity, we have $\mathbf{U}[n] = \mathbf{U}[n-1] + d\mathbf{U}$. By taking into account these definitions, the relation above can be rewritten in the form

$$E_K[N] = \frac{1}{2}\sum_{n=1}^{N}[m[n]\mathbf{U}^2[n] - m[n-1]\mathbf{U}^2[n-1]] \tag{15}$$

$$E_D[N] = \frac{1}{2}\sum_{n=1}^{N}\int_{t_{n-1}}^{t_n}\frac{dm}{dt}\mathbf{U}^2\,dt \tag{16}$$

$$E_W[N] = \frac{1}{2}\sum_{n=1}^{N}[\mathbf{U}[n] + \mathbf{U}[n-1]]\cdot[m[n]\mathbf{U}[n] - m[n-1]\mathbf{U}[n-1]] \tag{17}$$

After calculation, we have:

$$E_K[N] = 0.5 * m_0 * d\mathbf{U}^2 N^2 - 0.5 * dm * d\mathbf{U}^2 * N^3 \tag{18}$$

$$E_W[N] = 0.5 * m_0 * d\mathbf{U}^2 N^2 - dm * d\mathbf{U}^2 * [4 * N^3 - N]/6 \tag{19}$$

$$E_D[N] = E_W[N] - E_K[N] \tag{20}$$

The quantities dm and $d\mathbf{U}$ are function of N and must be determined from the solution of the two coupled differential equations on the interval $dt = T/N$:

$$m\,\frac{d\mathbf{U}}{dt} + \frac{dm}{dt}\,\mathbf{U} = \mathbf{F} \tag{21}$$

$$m\,\mathbf{U}\cdot\frac{d\mathbf{U}}{dt} + \frac{dm}{dt}\,[\mathbf{U}^2 - c^2] = 0 \tag{22}$$

An electrostatic accelerator used a high voltage V to accelerate charged particles in an evacuated tube with an electrode at either end which are the plates of a capacitor. Since the charged particle passed only once through the potential difference, the output energy is determined by the accelerating voltage of the machine. In a stepping process, the constant electrostatic force has for expression $F(dt) = qV * dt/[T * D]$, knowing that q is the electron charge and V the voltage applied to the plates of the capacitor separated by the distance D. We use Mathematica to calculate the functions $m(t)$ and $\mathbf{U}(t)$ and their derivative over the interval

dt. Finally, the quantities dm and $d\mathbf{U}$ and are obtained from the relations $dm[N] = [dm(dt)/dt] * T/N$ and $d\mathbf{U}[N] = [d\mathbf{U}(dt)/dt] * T/N$.

The time T required for an electron to traverse the distance $D = cT = 30\,m$ at the speed of light $c = 3 * 10^8 m/s$ is about $T = 100\,ns$. Since the sampling time of the stepping process must be at least 10 times lower than this amount of time, we get a switching frequency about $100\,Mhz$ which is not an easy task to do from a technical point of view.

$T = 100\,ns$	$N = 10$	$N = 20$	$N = 30$	$N = 40$	Rel
$\mathbf{U} * 10^8\,m/s$	3.49	1.75	1.17	0.88	2.95
$\mathbf{R}\,m$	9.65	4.61	3.02	2.25	19.59
$m * 10^{-31}\,g$	9.70	9.17	9.12	9.10	54.28
$E_K\,MeV$	0.372	0.0886	0.0391	0.0220	1.47
$E_W\,MeV$	0.380	0.0888	0.0392	0.0220	2.52
E_D/E_K	0.02	0.0028	0.00085	0.00036	0.713

$T = 200\,ns$	$N = 10$	$N = 20$	$N = 30$	$N = 40$	Rel
$\mathbf{U} * 10^8\,m/s$	6.89	3.51	2.34	1.75	2.98
$\mathbf{R}\,m$	38.41	18.45	12.11	9.01	45.09
$m * 10^{-31}\,g$	11.60	9.41	9.19	9.14	107.41
$E_K\,MeV$	1.72	0.362	0.157	0.0882	2.98
$E_W\,MeV$	1.84	0.366	0.158	0.0884	5.49
E_D/E_K	0.0664	0.0109	0.0033	0.0014	0.844

In the two preceding tables, we calculate with Mathematica several quantities versus the number of steps N for two values of the final time T. In the last column, we give the corresponding values for the relativistic case with no stepping knowing that the force has for expression $F(t) = qV * t/[T * D]$ with $V = 4\,10^6$ Volt. The numerical calculations in the above tables prove that the ratio E_D/E_K decreases when N increases which is expected from the theory.

5 CONCLUSION

In the present paper, we proved that the relativistic equation of energy can be written in a classical way if we take into account the existence of a braking force resulting from the interaction of the accelerated particle with the medium. We have presented in this paper a rigorous mathematical demonstration showing that the dissipative term can be cancelled if we used a stepping process which allows the speed of the particle to break the speed of light.

6 APPENDIX:SPLITTING OF THE FORCES IN A PARTICLE ACCELERATOR

We can use the analogy with solid state physics to explain the apparent mass increased in a particle accelerator. It is a well-known fact that only external forces to the point particles are considered as applied forces in the equation of motion for electrons moving in a solid. The force which originates from the lattice periodic field remains hidden in the electron effective mass. The electron moving in a solid obeys a law of motion which is given by the equation:

$$\overleftrightarrow{\mathbf{M}} \cdot \frac{d\mathbf{U}}{dt} = \mathbf{F} \tag{23}$$

where $\overleftrightarrow{\mathbf{M}}$ is the effective mass dyadic and $\mathbf{F}$ the force applied to the electron which seems to be the only force taken into account in the calculation. However, we know that the electron is subjected to strong forces from the solid lattice which are hidden in the definition of the effective mass.

In vacuum, the motion of a massive particle, with a rest mass m_0, submitted to a Lorentz force $\mathbf{F}$ is described by the relativistic dynamic equation

$$\frac{d}{dt}\left[m_0\gamma \mathbf{U}\right] = \mathbf{F} \tag{24}$$

with the definition $\gamma^2 = [1 - \mathbf{U}^2/c^2]^{-1}$ which gives the following relation:

$$\frac{d\gamma}{dt} = \frac{\gamma^3}{c^2}\frac{d}{dt}\left[\frac{\mathbf{U}^2}{2}\right] \tag{25}$$

By using the preceding relation, we can rewrite equation 23 in a dyadic form

$$\frac{d\mathbf{U}}{dt} = [\overleftrightarrow{\mathbf{M}}]^{-1} \cdot \mathbf{F} \Rightarrow \overleftrightarrow{\mathbf{M}} \cdot \frac{d\mathbf{U}}{dt} = \mathbf{F} \tag{26}$$

where the direct and inverse mass dyads have for definitions:

$$\overleftrightarrow{\mathbf{M}} = m_0\gamma\,[\overleftrightarrow{\mathbf{I}} + \frac{\gamma^2}{c^2}\mathbf{UU}] \Rightarrow [\overleftrightarrow{\mathbf{M}}]^{-1} = \frac{1}{m_0\gamma}[\overleftrightarrow{\mathbf{I}} - \frac{1}{c^2}\mathbf{UU}] \tag{27}$$

where $\overleftrightarrow{\mathbf{I}}$ is the unit dyadic. The equation 25 shows that the force and acceleration are generally non-collinear in the high velocity motion of a point particle. The fact that the velocity of a material particle submitted to a constant force does not increase linearly with time means that the particle is submitted to a braking force from the medium. In solid-state physics, this braking force results from the interaction between the free moving particles and the lattice periodic field.

By analogy with the effective mass concept in solids, we can assume that the dyadic mass of an electron moving in the vacuum and the dependence of its mass upon velocity can be explained in the framework of classical mechanics. The analogy between solid state physics and the relativistic motion of an electron in the vacuum is a useful concept which has already been used by Dirac [33] to explain the so-called Dirac sea of electrons by regarding the vacuum as a close analog of a semi-conductor with two bands separated with an energy gap $2m_0c^2$.

The dyadic masses may be diagonalized, for a velocity $\mathbf{U}$ directed along the $\mathbf{x}$ axis, we get:

$$\overleftrightarrow{\mathbf{M}} = m_0 \begin{pmatrix} \gamma^3 & 0 & 0 \\ 0 & \gamma & 0 \\ 0 & 0 & \gamma \end{pmatrix} \qquad [\overleftrightarrow{\mathbf{M}}]^{-1} = \frac{1}{m_0}\begin{pmatrix} \gamma^{-3} & 0 & 0 \\ 0 & \gamma^{-1} & 0 \\ 0 & 0 & \gamma^{-1} \end{pmatrix} \tag{28}$$

We recover the so-called longitudinal $m_l = \gamma^3 m_0$ and transverse $m_t = \gamma m_0$ masses of the particle. There is no direct proof that the relativistic dependence of mass on velocity has been established since one can transform the above equation of motion written in dyadic form as a classical equation of motion:

$$\frac{d}{dt} m_0 \mathbf{U} = m_0 \, [\overleftrightarrow{\mathbf{M}}]^{-1} \cdot \mathbf{F} = \mathbf{F}_e + \mathbf{F}_b \tag{29}$$

where the force applied to the particle has been partitioned in two forces, one is the applied force $\mathbf{F}_e = \mathbf{F}$ and the other one is the braking force $\mathbf{F}_b = \overleftrightarrow{\mathbf{G}} \cdot \mathbf{F}$ with the definition:

$$\overleftrightarrow{\mathbf{G}} = \begin{pmatrix} \gamma^{-3} - 1 & 0 & 0 \\ 0 & \gamma^{-1} - 1 & 0 \\ 0 & 0 & \gamma^{-1} - 1 \end{pmatrix} \tag{30}$$

which is a velocity depending force tending to zero then we have $U \to 0$.

Since the braking force depends on the velocity, it is therefore a magnetic force. This force cannot be a magnetic Lorentz force since the Lorentz force is transverse to the direction of motion of an electron as shown in the pinch-effect.

However, we know that the Ampère force has a longitudinal component along the direction of motion of the electron. Bush [34] was the first author to use the Ampère force for calculating the transverse motion of a charged particle in Bucherer's experiment. Later, Moon and Spencer [35] and Assis [36] rediscovered the same calculation. These authors were able to explain the Bucherer's experiment with a calculation valid up to second-order in U/c. However, their calculation concerns the transverse mass and they did not verify that this calculation applies also to the case of the longitudinal mass.

We can explain the mass velocity law from a classical point of view by using the Weber theory as demonstrated by Cornille [2,27]. However, this theory faces a difficulty since the demonstration depends on a parameter a which is not the same for both the transverse and longitudinal masses. The braking force and the non-isotropic effective mass seem to provide support for a medium in space having a lattice structure. One could quote the "epola" model of Simhony [37] concerning an electron-positron lattice with a NaCl structure.

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MASS PREDICTIONS AND LIFETIME FORMULAS OF HEAVY FLAVOR HADRONS, AND SIMPLIFY OF SUPERSYMMETRY

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Abstract

First, we discuss the modified accurate mass formula, and applied to heavy flavor hadrons, and derive some predictions, m(Ω^{+}_{cc})=3950.7 or 3908*MeV*, and $m(\Xi_{bb})$=10396.8 or 10348.9*MeV*, etc. It is a quantitative and testable theory. Next, based on the new data, we propose various lifetime formulas of heavy flavor hadrons, which very agree with experiments. This is a new method on lifetime of hadrons described by quantum numbers, and can be unified for mass and lifetime. Finally, we discuss an approximate simplified supersymmetry theory based on the known symmetrical particles and their excited states.

Keywords: particle, mass formula, lifetime formula, heavy flavor hadron, supersymmetry.
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I. Introduction

It is well-known that the theoretical base of particles is the standard model:

$$\begin{array}{cccc} q=(2/3)e & -(1/3)e & -e & 0 \\ \begin{pmatrix} u \\ c \\ t \end{pmatrix} & \begin{pmatrix} d \\ s \\ b \end{pmatrix} & \begin{pmatrix} e \\ \mu \\ \tau \end{pmatrix} & \begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} \end{array}. \qquad (1)$$

The total charge number of per generation quarks is 3(2/3-1/3)=1, and the total charge number of per generation leptons is yet (-1+0)=-1. The total charge of per generation quark-lepton is 0. This is very symmetrical and beautiful theory.

After particles are classified, mass and lifetime are two main characters for any particles. In this paper, we discuss various mass and lifetime formulas, esp., for heavy flavor hadrons, and a simplified supersymmetry theory.

2. Accurate Mass Formula of Hadrons and Prediction

Based on two moving states of the emergence string: oscillation and rotation, we derived its quantum potential and the equation, whose energy spectrum is the GMO mass formula:

$$M = M_0 + AS + B[I(I+1) - \frac{S^2}{4})], \qquad (2)$$

in which must assume that $M = m^2$ for mesons, and its modified accurate mass formula [1-3]:

$$M = M_0 + AS + B[I(I+1) - \frac{S^2}{2}]. \qquad (3)$$

Based on the standard model and on the symmetry of s and c quarks in the same generation, we supposed that the hadrons, which made of u, d and c quarks, are also the SU(3) symmetry and are classified by octet and decuplet [4,2,3]. It is a subgroup of SU(4) of u, d, s and c quarks. Such we assume that these masses of the octet obey the corresponding simple mass formulas only by S→C in Eqs.(2) and (3):

$$M = M_0 + AC + B[I(I+1) - (C^2/4)], \qquad (4)$$

or $$M = M_0 + AC + B[I(I+1) - (C^2/2)]. \qquad (5)$$

Since when m(N)=939, $m(\Lambda_c^+) = 2285, m(\Sigma_c) = 2453\, MeV$, from the two corresponding mass formulas (4) and (5) we predicted $m(\Xi_{cc}) =$ 3715 or 3673*MeV* [4,2,3]. In 10 July 2017 LHC announced to observe a new doubly charmed baryon $\Xi_{cc}^{++} = ucc$, whose mass is 3621.4±0.8*MeV*, and decay mode is $\Xi_{cc}^{++} \to \Lambda_c^+ K^- \pi^+ \pi^+$ [5,6]. New experimental data agree more on Eq.(5) and (3), whose error only is (3673–3621)/3621=1.4%. Moreover, there should have $\Xi_{cc}^{+} = dcc$, both form I=1/2 doublet with near mass, and one of decay modes is $\Xi_{cc}^{+} \to \Lambda_c^+ K^- \pi^+ \pi^0$ [7]. In 1994 we predicted that "if the experiments derive this mass, it will show that our theory (hadrons made of u, d and c quarks are the SU(3) symmetry) is right"[4].

According new experimental data m(*p*)=938.3, $m(\Lambda_c^+) = 2286.5$, $m(\Sigma_c^+) = 2452.9$ and $m(\Xi_{cc}^{++}) = 3621.4$ *MeV*[6], it agrees with the mass relation

$4(p+\Xi)=7\Lambda+\Sigma$ (18238.8= 18458.4), (6)

whose error is (18458.4–18238.8)/ 18458.4=1.19%.

Further, for the $J^P=3^+/2$ baryons form also a decuplet:

$\Delta^{++},\Delta^{+},\Delta^{0},\Delta^{-}$ (I=3/2); $\Sigma_c^{++},\Sigma_c^{+},\Sigma_c^{0}$ (I=1); $\Xi_{cc}^{++},\Xi_{cc}^{+}$ (I=1/2)

and Ω_{ccc}^{++}=ccc (I=0).

Their masses are possibly an equal-spacing rule, i.e.

$M=M_0+aC$. (7)

Of course, these baryons obey probably the more accurate mass formulas

$M=M_0+aC+bC^2, M=M_0+a'I+b'I^2$, (8)

which correspond to Eqs.(2) and (5).

The $J^P=0^-$ octet of heavy flavor mesons are $\pi^{+,-},\pi^0(I=1);D^+=c\bar{d}$, $D^0=c\bar{u}(I=1/2)$ and their antiparticles; $\eta'_c=a(u\bar{u}+d\bar{d})+b(c\bar{c})$. If their mass relation is:

4m(D)=$m(\pi)+3m(\eta'_c)$ or 8m(D)=$m(\pi)+7m(\eta'_c)$, (9)

so $m(\eta'_c)$ =2444 or 2114*MeV* since m(π)=137, m(D) =1867*MeV*. For the $J^P=1^-$ octet, $m(\rho)=770, m(D^+)=2010$ *MeV*, so $m(\eta'_c)$ =2423 or 2187*MeV*.

For the $J^P=1^+/2$ baryons, m($\Xi_c^+(usc)$)=2467.7*MeV*, m($\Xi_c^0(dsc)$)= 2471.7*MeV* (I=1/2), m($\Omega_c(ssc)$)=2695.2*MeV*.

These octets and decuplet are a certain cross section of the diagrams of the SU(4) multiplets, respectively. For the $J^P=3^+/2$ baryons, probably, the masses of the triplet $\Sigma^+,\Sigma^0,\Sigma^-$ (I=1), the doublet $\Xi_c^+(usc)$, $\Xi_c^0(dsc)$ (I=1/2), and the singlet $\Omega_{cc}^+=scc$ (I=0) are approximately an equal-spacing rule, it is the second series of series of heavy flavor baryons. Then the masses of $\Omega^-=sss,\Omega_c^0=ssc,\Omega_{cc}^+$ and Ω_{ccc}^{++} are only four hadrons for mixtures of second generation, and their masses are should be equal-spacing too. It is the third series of heavy flavor baryons. For the $J^P=3^+/2$ baryons, m(Σ_c)=2518, m(Ξ_c)=2646, so m($\Omega_c(ssc)$)=2766*MeV*, these masses obey equal-spacing rule. Such based on the known masses of $3^+/2$ baryons including c quark [6], other masses of baryons will be able to be estimated. Because Σ_c(uuc,2518)–Δ(uuu,1232)= 1286≌m(c)–m(u), so m(Ξ_{cc})=3804 and m(Ω_{ccc}^{++})=5090. From the third series, we obtain m(Ω^-)=1672.1, m(Ω_c^0)=2811.4, m(Ω_{cc}^+)=3950.7 and m(Ω_{ccc}^{++})=5090. But, from the second series the known m(Σ)=1385 and. m(Ξ_c)=2646.6, so c–u≌1261.6 and m(Ω_{cc}^+)=3908.2. Both m(Ω_{cc}^+) are different due to different of spin. Of course, these baryons obey probably the more accurate mass formulas (8).

Such any one of masses of $3^+/2$ baryons including c quark is known again, for example, for $\Sigma_c(2518.1)$ *MeV* ($J^P=3^+/2$) [6], then other five masses of other baryons will be able to be estimated.

baryon	Ω^-	Ξ_c	Δ	Σ_c	Ξ_{cc}	Ω_c	Ω_{cc}^+	Ω_{ccc}^{+++}
m(exp)	1672	2646	1232	2518				
$m(est)$	*input*	2646	*input*	*input*	3804	2811	3951	5090

Therefore, by using different ways we predict different m(Ω_{cc}^+)=3950.7, or 3908*MeV*, etc.

For the doublet $\Xi_c^+ = usc, \Xi_c^0 = dsc$ (I=1/2, S= –1, C=1) and both masses are 2467.9 and 2471.9*MeV*, the singlet $\Omega_c^0 = ssc$ (I=0, S= –2, C=1) and its mass is 2695.2±1.7*MeV*, and the singlet $\Omega_{cc}^+ = scc$ (I=0, S= –1, C=2), we can assume that the simplest mass formula is:

$$M = M_0 + A(C-S) + B[I(I+1) - (C-S)^2/2], \quad (10)$$

or $$M = M_0 + A(C-S) + B[I(I+1) - (C^2+S^2)/2]. \quad (11)$$

Some similar multiplets and mass formulas exist possibly in baryons and mesons including b or t quarks. For instance, both mass spectra of $\psi = c\bar{c}$ and $\Upsilon = b\bar{b}$ are similar; as in the neutral kaon system, $D^0 - \overline{D^0}$ and $B^0 - \overline{B^0}$ mixings should exist.

Further, this method will be able to be extended to other potentials and other heavy flavor hadrons. For example, based on the symmetry of quarks model, we may suppose that the hadrons, which made of u, d and b quarks, and of u, d and t all are the SU(3) symmetry. It is a subgroup of SU(4) of u, d, b and t quarks. Such the eight $J^P = 1^+/2$ baryons form also an octet:

p=uud, n=udd (I=1/2); $\Lambda_b^0 = udb$ (I=0); $\Sigma_b^+ = uub, \Sigma_b^0 = udb, \Sigma_b^- = ddb$ (I=1); and $\Xi_b^0 = ubb, \Xi_b^- = dbb$ (I=1/2).

Such the corresponding mass formulas are:

$$M = M_0 + aB + b[I(I+1) - (B^2/4)], \quad (12)$$

or $$M = M_0 + aB + b[I(I+1) - (B^2/2)]. \quad (13)$$

It is known the m(Λ_b)=5620, m(Σ_b)=5811.5(5811.3, 5815.5)*MeV* [6]. From the two corresponding mass formulas, we may predict $m(\Xi_{bb})$ =10396.8 or 10348.9*MeV*, whose error is probably bigger due to weaker symmetry between first (u,d) and third generations (t,b).

Generally, based on the symmetry of quark model we can suppose that the hadrons, which made of s, c and b quarks are the SU(3) symmetry. Similar, the hadrons made of s, c and t quark are also the SU(3) symmetry. Both are two subgroups of SU(4) of s, c, b and t quarks, but these quarks are all I=0 and very unstable. These mass formulas are possibly:

$$M = M_0 + aS + a'C + a''B + bS^2 + b'C^2 + b''B^2, \quad (14)$$

or $$M = M_0 + aS + a'C + a''B + b(S+C+B)^2. \quad (15)$$

The mixtures of three generations are m($\Xi_b^0 = usb$)=5791.9*MeV*, m($\Xi_b^- = dsb$)=5797.0 *MeV*(I=1/2). Other hadrons are m($\Lambda_b^0(udb)$)=5619.6*MeV*, m(Ω_b^- (ssb))=6046.1*MeV*, etc[6].

In a word, our research based some symmetries among different generations is a quantitative and testable theory [8].

3. Lifetime Formulas of Heavy Flavor Hadrons

Based on the Y-Q and I-U symmetries between mass and lifetime on the general SU(3) theory, we obtained the lifetime formulas of hyperons and mesons [1-3]:

$$\tau = A[2U(U+1) - Q/2], \quad (16)$$

and $$\tau = A'[(1/2) + 2U(U+1) - Q/2 - Q^2/3]. \quad (17)$$

They agree better with experiments [6].

Generally, lifetime of various hadrons can be classified by different times:

Lifetimes of mesons K_L^0, π^-, K^+ are 10^{-8} sec.

Lifetimes of hyperons $\Xi^0, \Xi^-, \Sigma^-, \Sigma^+$ and K_S^0, Ω^- are 10^{-10} sec.

Lifetimes of heavy flavor hadrons mainly are 10^{-13} sec.

Lifetime of π^0 is 8.4×10^{-17} sec.

Lifetime of Σ^0 is 7.4×10^{-20} sec.

Lifetimes of J/ψ and Υ are KeV.

Lifetimes of other hadron-resonances mainly all are MeV.

For heavy flavor hadrons we propose their lifetime formulas. For Ξ_c^+ (usc), Λ_c^+ (udc), Ξ_c^0 (dsc) and Ω_c^0 (ssc), it is:

$$\tau = [1.4(2I - C^2) - S + 3.4Q]\times10^{-13}. \quad (18)$$

Then $\tau(\Xi_c^+)$=4.4, $\tau(\Lambda_c^+)$=2, $\tau(\Xi_c^0)$=1 and $\tau(\Omega_c^0)$=0.6, and the experimental data are (4.42 ± 0.26), (2.00 ± 0.06), (1.12 ± 0.13) and $(0.69\pm0.12)\times10^{-13}$ [6]. They all agree within the range of error. Further, for $\tau(\Xi_{cc}^{++}, ucc)$=2.6 by this formula (18), it agrees accurately with the experimental data $(2.56\pm0.37)\times10^{-13}$ [9].

For Λ_b^0 (udb), Ξ_b^- (usb), Ξ_b^0 (dsb) and Ω_b^- (ssb), we propose the lifetime formula:

$$\tau = [14.8B^2 - (I + Q - \frac{1}{2}S)]\times10^{-13}. \quad (19)$$

Then $\tau(\Lambda_b^0)$=14.8, $\tau(\Xi_b^-)$=15.8, $\tau(\Xi_b^0)$=14.8 and $\tau(\Omega_b^-)$=16.8, and the experimental data are (14.70 ± 0.10), (15.71 ± 0.40), (14.79 ± 0.31) and $(16.4\pm1.8)\times10^{-13}$ [6]. They all agree within the range of error.

For $D^+(c\bar{d}), D^0(c\bar{u})$ and $D_s^+(c\bar{s})$, we propose the lifetime formula:

$$\tau = [4.1 + 6.3(2I - C^2 + Q) - S]\times10^{-13}. \quad (20)$$

Then $\tau(D^+)$=10.4, $\tau(D^0)$=4.1 and $\tau(D_s^+)$=5.1, and the experimental data are (10.4 ± 0.07), (4.101 ± 0.015) and $(5.04\pm0.04)\times10^{-13}$ [6]. They all agree within the range of error.

For $B^+(u\bar{b}), B^0(d\bar{b})$, $B_s^0(s\bar{b})$ and $B_b^+(c\bar{b})$, we propose the lifetime formula:

$$\tau = [15 + 5.5(2I - C^2 - B^2 - S) + Q] \times 10^{-13}. \qquad (21)$$

Then $\tau(B^+)$=16, $\tau(B^0)$=15, $\tau(B_s^0)$=15 and $\tau(B_b^+)$=5, and the experimental data are (16.38 ± 0.04), (15.20 ± 0.04), (15.09 ± 0.04) and $(5.07 \pm 0.09) \times 10^{-13}$ [6]. They all very agree.

We may unify these lifetime formulas for the heavy flavor hadrons to:

$$\tau = [\tau_0 + a(2I - C^2 - B^2) - bS + cQ] \times 10^{-13}. \qquad (22)$$

It is a new method on lifetime of hadrons described by quantum numbers. They are symmetrical with the corresponding mass formulas, and can be unified for mass and lifetime.

4. Supersymmetry and Its Simplify

Supersymmetry is a very beautiful theory, and it combines string, and derives the superstring. But so far any particles of supersymmetry are not observed. We derived some new representations of the supersymmetric transformations, and introduced the supermultiplets. Based on these representations, Graded Lie Algebras and various formulations (equations, commutation relations, propagators, Jacobi identities, etc.) of bosons and fermions may be unified. On the one hand, the mathematical characteristic of particles is proposed: bosons correspond to real number, and fermions correspond to imaginary number, respectively. Such fermions of even (or odd) number form bosons (or fermions), which is just consistent with a relation between imaginary and real number. The imaginary number is only included in the equations, forms, and matrixes of fermions. It is connected with relativity. On the other hand, the unified forms of supersymmetry are also connected with the statistics unifying Bose-Einstein and Fermi-Dirac statistics, and with the possible violation of Pauli exclusion principle; and a unified partition function is obtained [10,11]. Moreover, three quarks may be described by the Borromean rings [12]. We discussed some unifications in particle physics. The quantum statistics is unified by the nonlinear equations. Based on the gauge groups, various unifications of interactions are researched. A developed direction of particle physics and modern science is possibly the higher dimensional complex space [10-12].

Now we discuss an approximate simplified supersymmetry theory based on the known symmetrical particles and their excited states, and the Regge trajectory formula S=AJ+B.

It is known that baryons (J=1/2,3/2) and mesons (J=0,1) possess symmetry.

For SU(3) octet of u,d,s and their excited states:

J=1/2	$p, n; \Lambda, \Sigma^+, \Sigma^0, \Sigma^-; \Xi^0, \Xi^-$ (in octet baryons first generation 2, second generation 6)
J=0	$\pi^0, \pi^\pm; K^\pm, K^0; \eta$ (in five mesons first generation 2, second generation 3)

J=3/2	$\Delta; \Sigma^*; \Xi^*; \Omega(sss)$ (in decuplet baryons first generation 4, second generation 6)
J=1	$\rho(770), \omega(782)$; $(s\bar{s})$

For leptons there are:

J=1/2	$e, \nu; \mu, \tau, \nu_\mu, \nu_\tau$ (six leptons first generation 2, second-third generation 4)
J=1	$\gamma; W^{\pm}, Z^0$ (1 and 2)

J=2，graviton.

In a word, bosons are all the degenerate states.

For SU(3) octet of u,d,c and their excited states possess structures of complete symmetry:

J=1/2	$p, n; \Lambda_c^+, \Sigma_c^{++}, \Sigma_c^+, \Sigma_c^0; \Xi_c^+, \Xi_c^0$(in octet baryons first generation 2, second generation 6)
J=0	$\pi^0, \pi^{\pm}; D^0, D^{\pm}; \eta_c(c\bar{c})$ (in five mesons first generation 2, second generation 3)

Second generation has the mixtures $\Omega_c^0(ssc)$, and (scc), (ccc) for J=1/2; $D_s^+(c\bar{s})$ for J=0.

For SU(3) octet of u,d,b and their excited states possess structures of complete symmetry:

J=1/2, known baryons are $p, n; \Lambda_b^0(udb); \Xi_b^0(usb), \Xi_b^-(dsb)$; should yet have $\Sigma(uub, udb, ddb)$. (in octet baryons first generation 2, third generation 6);

J=0, $\pi^0, \pi^{\pm}; B^+(u\bar{b}), B^0(d\bar{b})$ (in four mesons first generation 2, second generation 2).

Moreover, J=1, $\Upsilon(b\bar{b})$.

We combine supersymmetry and the standard model (1). Suppose the second and third generations of quark-lepton are the different excited states of the first generation. This will be the simplest particle model.

First generation

J=1/2	p(uud), n(udd) are stable	J=3/2	$\Delta^{++}(uuu), \Delta^-(ddd)$
J=0	$\pi^+(u\bar{d}), \pi^0(u\bar{u}, d\bar{d})$		

Second generation

J=1/2	$\Omega_c^0(ssc)$, (scc)	J=3/2	$\Omega^-(sss), X^{++}(ccc)$
J=0	$D_s^+(c\bar{s}), (s\bar{s}), \eta_c(c\bar{c})$	J=1	$J/\psi(c\bar{c})$

Third generation

J=1/2	(bbt), (btt)	J=3/2	They are probably (bbb), (ttt)
J=0	$(t\bar{b}), (b\bar{b}), (t\bar{t})$	J=1	$\Upsilon(b\bar{b})$

Therefore, the second and third generations are completely similar to the first generation. Three quarks are the same, probably all J=3/2.

From the second generation begins, some mixing states of first and second generations exist:

J=1/2	(uus), (uds), (dds); (uss), (dss)	And (uuc), (udc), (ddc); (ucc), (dcc)
J=0	$K^+(u\bar{s}), K^0(d\bar{s})$	And $D^+(c\bar{d}), D^0(c\bar{u})$

From this begins existence of the substable states.

Further, some mixing states of first and third generations exist:

J=1/2	(uub), $\Lambda_b^0(udb)$, (ddb); (ubb), (dbb)	And (uut), (udt), (ddt); (utt), (dtt)
J=0	$B^+(u\bar{b}), B^0(d\bar{b})$	And $(u\bar{t}),(d\bar{t})$

And there are some mixing states of second and third generations:

J=1/2	(ssb), (scb), (ccb); (sbb), (cbb)	And (sst), (sct), (cct); (stt), (ctt)
J=0	$B_s^0(s\bar{b})$, $B_b^+(c\bar{b})$	And $(s\bar{t}),(c\bar{t})$

Moreover, there are some mixtures of first-second-third generations: $\Xi_b^0(usb),\Xi_b^-(dsb)$, etc.

Quarks have three generations, gluons should have three generations. Or second and third generation quarks are excited states of the first generation quarks, so the corresponding second and third generation gluons will also be the first generation excited states.

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AT ULTRA-LOW ENERGY POSSIBLE VIOLATION OF PAULI EXCLUSION PRINCIPLE AND ITS POSSIBLE MECHANISM AND PREDICTIONS

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Abstract

So far the universality of Pauli exclusion principle (PEP) was queried some times. First, we look out some hypothesizes of violation of PEP (VIP), and proposed violation at high energy and some tests. Next, we discuss another possibility on VIP at ultra-low energy, which is similar to superconductivity, superfluids and Bose-Einstein condensation (BEC), etc. Further, we propose a possible mechanism of VIP: Cooper pairs extend to general fermion pairs, so they transform to bosons with VIP. From this we may predict some characters of this like-boson, as in nuclei and atoms, etc. Moreover, we research some possible VIP in mathematics and physics. Based on the extensive quantum theory, its PEP may be violated.

Keywords: violation of Pauli exclusion principle; ultra-low energy; high energy; mechanism; prediction.
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I. Introduction

The Pauli exclusion principle (PEP) is a very important natural rule, and is theoretical foundation of atomic structure. It is a well-known principle in quantum mechanics, and is widely applied and may explain from the periodic table of elements to neutron stars, etc.

But, some scientists queried the universality of PEP some times. First in 1978-1980 Santilli proposed the rest of PEP, in particular, for strong interactions, and the structure of hadrons, nuclei and stars [1-3]. Further, Santilli researched inapplicable of PEP in numerous experiments [4]. Based on some experiments and theories of particles at high energy, we investigated violation of PEP at high energy begin from 1984 [5-14], and researched some possible tests of violation of PEP [6,10,11]. Then in 1987-1989 Ignatiev-Kuzmin and Greenberg-Mohapatra [15-17] proposed that PEP has a small violation for any natural substance, which contains a fraction of order β^2 of anomalous atoms and nucleons.

So far the experimental tests have proved high precisely the validity of the in usual cases. Kekez, et al., discussed an upper limit to violations of PEP [18], and searched violation of PEP in nuclear decays [19]. Thoma, et al., researched limits on small violations of PEP in the primordial nucleosynthesis [20]. Tsipenyuka, et al., discussed experimental test of the possible violation of PEP by photo-activation analysis of carbon content in pure boron [21]. Javorsek, et al., searched new experimental test of PEP using accelerator mass spectrometry [22].

Recent, the violation of PEP (VIP) aroused again attention, which poses a special word VIP. VIP Collaboration searched new experimental limit on VIP by electrons [23-25], and experimental tests of quantum mechanics on VIP and future perspectives [26]. Chakraborty, et al., discussed sufficient condition for the openness of a many-electron quantum system from the violation of a generalized PEP [27]. Abgrall, et al., researched new limits on bosonic dark matter, solar axions, PEP violation, and electron decay from the low-energy spectrum [28]. Shi, et al., searched experiments for VIP [29]. In this paper, we discuss another possibility of VIP, at ultra-low energy, and propose its possible mechanism on VIP.

2. Possible Violation of PEP at Ultra-Low Temperature

The future experiments on VIP should be combined widely with various theories of hidden and obvious violation of PEP. Author think that known experiments and theories seem to imply VIP at high energy. Some possible tests have been proposed in particle physics, nuclei at high energy and astrophysics, etc., in particular, the excited high-n atoms, the various nuclei at high energy, dineutrons in extremely neutron-rich nuclei, and gamma ray sources, black hole in high energy astrophysics, etc [6,10,11].

The most notable and realizable test is in the excited high-n atoms. For atomic electrons, if PEP is violated, the K shell will be able to accommodate more than two electrons. Rinneberg, et al., obtained high-n Rydberg atoms with the principal quantum number n=290 for in the laboratory [30]. Then they obtained again atoms with n=520. Ling, et al., observed Rydberg state with n=1000 [31,32]. In last case, its high energy level is 10^6 times as large as "normal" atom at low energy, and the effective radius is

$$a_n = n^2\hbar^2 / \mu e^2 = 5.29\times 10^{-3} cm . \qquad (1)$$

It is already a near-macroscopic scale. According to quantum mechanics, the electron number in atom must be either two for usual orbit or infinite for ionized state. I believe that there is third possibility: For very high excited atoms, at above near-macroscopic orbit three electrons seems to be able to coexist, at least in a short time interval, which just corresponds to high energy. Moreover, in highly excited atom the effect of spin can be neglected [30], it is just that I expected the condition of the unified statistics and of the inapplicability of PEP at high energy [5]. Further, it is validated that "magic" Rydberg states with n=150 possess enough long lifetimes [33,34].

Mohapatra [35] predicted the presence of a neutral spin-3/2 hadron with mass in the 1-2 GeV range by using infinite statistics. It implies VIP at 1-2 GeV. According to the uncertainty principle we expected that usual high energy is about 2-20 GeV for particles [5]. In different regions, for instance, nuclei, multiplicity and celestial body, etc., there should be corresponding threshold values for high energy.

Several groups (LEPS, DIANA, CLAS and BES Collaborations) observed some multi-quark resonances at high energy [36-38]. For example, an exotic baryon Θ^+(1540) with the quantum numbers of K^+n has been reported, in which five-quark($qqqq\bar{q}$) configurations are mixed with the standard three-quark valence configuration. These multi-quark states coexist inside a short time, which increases a possibility of VIP.

At ultra-cold there are three well-known superconductivity, superfluids and Bose-Einstein condensation (BEC) [39]. They are macroscopic quantum phenomena in essence. In ultra-low temperature two fermions can constitute a boson like the Cooper pair, and perform BEC [14]. It is the fermion degeneracy, and forms the Fermi-Dirac condensation (FDC). This is also a unification between BE and FD statistics [5]. Further, we predict that the high-T_c superfluidity should exist, which corresponds to the high-T_c superconductivity. Moreover, the new charge cluster, no matter as negative or positive charge, seems to have implied VIP.

In 1995, the condensation numbers of ^{87}Rb and ^{7}Li atoms may be high as 10^5 under this extreme condition [40]. In 1999 DeMarco and Jin cooled the potassium atomic gas with fermion characteristics to 10^{-9} K, so that the potassium atom pairs to realize quantum degeneracy to Fermi atomic gas [41]. Its quantum effects are different from Bose atomic gas, such as Fermi pressure, Pauli blocking and superfluid, etc. The interaction leads to the formation of Cooper pairs by Fermi atoms and the change of resonance interaction to realize the phase transition from the supercurrent of BCS to BEC [42-44]. At ultra-low temperature fermion pairs can VIP. Contrarily, in 1960 Girardeau proposed a gas model under the hard core boson limit, that is, Tonks-Girardeau gas, at this case the boson is confined to one-dimensional space and the repulsion is very strong. It is similar to PEP. In 2004 Paredes, et al., confirmed this case by cold atomic experiments [45]. This is a boson similar to a fermion. So boson and fermion are symmetry and unification. In this case PEP has not played a role in the ultra-cold structure, and VIP may be tested.

3. A Possible Mechanism on VIP, and Predictions

For superconductivity a well-known theory is Bardeen-Cooper-Schrieffer (BCS) theory, whose base is Cooper pairs, which interacts through phonon. Cooper pairs are extended to the electron bag model, which may possibly describe superconductivity at high temperature. Further, we propose a possible mechanism on VIP: It is similar to Cooper pairs, and can extend to general fermion pairs, which is base of VIP. Its key is that fermion pairs transform to boson, and may obtain various similar characters of bosons.

From this we may predict: 1). Existence of various fermion pairs. They are mainly proton pairs and neutron pairs, i.e., nucleon pairs. Others are atom with semi-integer spin pairs, molecule with semi-integer spin pairs, etc. It is known that the spin wave function includes a spin singlet:

$$\varphi^{spin}_{n_1,n_2} = \frac{1}{\sqrt{2}}(|\uparrow\downarrow> - |\downarrow\uparrow>). \tag{2}$$

Since the spin singlet is an odd function of two nucleons n_1, n_2, the wave function $\varphi(r_1 - r_2)$ must be even, this is, $\varphi(r_1 - r_2) = +\varphi(r_2 - r_1)$.

The pair creation operator in a momentum space k is:

$$\hat{P}^+_k = c^+_{k\uparrow} c^+_{-k\downarrow}. \tag{3}$$

The many-body wave function of coherent state is:

$$|\psi_{BCS}> = C\exp(\sum_k \alpha_k \hat{P}^+_k)|0>. \tag{4}$$

2). Fermion pairs condensation (FDC). For BEC, the critical temperature is:

$$T_c = \frac{2\pi\hbar^2}{k_B m}\left(\frac{n}{2.612}\right)^{2/3}. \quad (5)$$

Here the particle density is:

$$n = \frac{1}{(2\pi)^3}\int \frac{1}{e^{\beta(\varepsilon_k-\mu)}-1}dk^3. \quad (6)$$

For fermions the particle density should be:

$$n_f = \frac{1}{(2\pi)^3}\int \frac{1}{e^{\beta(\varepsilon_k-\mu)}+1}dk^3. \quad (7)$$

The corresponding critical temperature of FDPC is probably:

$$T_c^{FDPC} = \frac{2\pi\hbar^2}{k_B(2m_f)}\left(\frac{n_f}{2.612}\right)^{2/3}. \quad (8)$$

3). For atom if Cooper pairs exist in electron orbit, it will form a new chemical element.

4). For nuclei if nucleon pairs exist, it will form new nucleus, or it is known α -particle (He cluster) model of nuclei, and corresponds to four electron creation operators for the same k point,

$$\hat{P}_k^+\hat{P}_k^+ = (\hat{P}_k^+)^2 = c_{k\uparrow}^+ c_{-k\downarrow}^+ c_{k\uparrow}^+ c_{-k\downarrow}^+ = 0. \quad (9)$$

It corresponds to the even-even nuclei (whose basic state has spin J=0), and relates magic number, and stable magic nucleus and double magic nuclei with spin J=0 in the nuclear shell model.

And 3) and 4) relate atom and nucleus at ultra-cold. In nuclei the strong interactions exist between nucleons, so $(p\uparrow p\downarrow),(n\uparrow n\downarrow)$ is formed easier, and become the similar boson and the simplest α -particle model and general more stable even-even nuclei. In a certain extent nuclei are FDPC. Further, it is namely neutron star.

5). Different energy levels of the same structure exist in atoms and nuclei, etc. For example, for He nucleus the energy level of $(p\uparrow p\downarrow),(n\uparrow n\downarrow)$ is the lowest than $(p\uparrow p\uparrow),(n\uparrow n\downarrow)$ and so on. For water molecule the energy level of $H\uparrow OH\downarrow$ is the lowest.

6). Probably, the fermion laser exists.

4. Possible Violation of PEP in Mathematics and Physics

We suggested that particles at high energy possess a new statistics unifying BE and FD statistics [5], for example, a possible unified distribution is:

$$y_{\Gamma} = \frac{\beta^{\alpha}}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x} . \quad (10)$$

This agrees quantitatively with scaling, the multiplicity and its distribution, and large transverse momentum, etc., which are independent of the types of particles.

In fact, the parastatistics, the fractional statistics [46], anyon, and the fractional quantum Hall effect, etc., have some contradictions with the standard theory in which two types of different particles and their properties are distinguished from the spin-statistics stringently. Even in the nonabelian gauge field theory there is the ghost particle whose spin is zero, but which agrees with anticommutation relation. They correlate to various theories relevant to possible VIP, including some obvious and hidden ones [9,10].

Some experiments and theories implied VIP at high energy [5,6], etc. This is related with the nonlinear theory [8]. Haldane discussed the fractional statistics in arbitrary dimensions has a generalization of PEP [47]. It is applied to the vortex-like quasiparticles of the fractional quantum Hall effect, and gives the same result as that based on the braid-group. It is also used to classify spinons in gapless spin-1/2 antiferromagnetic chains as semions. Greenberg and Mishra demonstrated that parastatistics can be quantized using path integrals by calculating the generating functionals for time-ordered products of both free and interacting parabose and parafermi fields in terms of path integrals, and gave a convenient form of the commutation relations for the Green components of the parabose and parafermi operators in both the canonical and path integral formalisms [48]. Moreover, the ghost field, anyon, some abnormal phenomena, spin, polarization and collisions, etc., are correlated closely with possible VIP and unified quantum statistics.

5. Extensive Quantum Theory and Corresponding VIP

Feynman pointed out: "There are certain situations in which the peculiarities of quantum mechanics can come out in a special way on large scale." In a special situation "quantum mechanics will produce its own characteristic effects on a large or 'macroscopic' scale" [49]. The Titius-Bode (TB) law describes approximately the average distances between the Sun and various planets in the solar system. The law has implied a quantized phenomenon in the solar system. We developed the TB law to a new form [50,51]:

$$r_n = an^2 . \quad (11)$$

From this we derived a similar theory with the Bohr atom model, and obtained the quantum constants $H = (aGM_O)^{1/2}$ of the solar system and corresponding Schrödinger equation. Some exoplanets and ten satellite galaxies of Galaxy, etc. agree with the same form. Further, we proposed the extensive quantum theory and its three laws: 1. Extensive quantum is its element in any system. 2. Its theory has similar quantum formulations with different quantum constants H. 3. Evolutions of systems may be continuous, but stable states are quantized [52]. Its mathematical base is fractal. Using the geometric average method, three different values of the quantum constants of man, cell and macromolecule may be derived for biological, chemical and physical discrete systems with different scales. Using this theory we researched superconductivity, superfluidity, BEC, and various macroscopic quantum phenomena. Alexandrov researched an extensive theory from weak to strong coupling superconductivity [53].

We searched that the extensive quantum theory is applied to various macroscopic quantum phenomena [54,55], and proposed the extensive quantum biology and its application in DNA [56-58]. We researched the extensive quantum social sciences [59-61], in which the social entangled states and exclusion exist, and the cooper pair corresponds to husband and wife. In a word, the extensive quantum theory agrees with symmetry, and it has corresponding PEP, but this can be violated under some conditions.

6. Conclusion

Through the experiments provides high precisely tests on PEP in usual cases, but we may research some possible violations of PEP (VIP) under some special conditions, for example, high energy and/or ultra-low energy, etc. Further, we should investigate possible mechanism on VIP, which relates usually nonlinear theory and so on.

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RELATIVE MATERIAL PARAMETERS αE, αH, ϑG, ϑF, ξE, ξF, βH, βG, ζE, ζG, λH, AND λF FOR MAGNETOELECTROELASTICS TO MODEL ACOUSTIC WAVE PROPAGATION INCORPORATING GRAVITATIONAL PHENOMENA

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Abstract

Regarding solid materials of symmetry class 6 *mm*, it is natural to deal with mechanical, electrical, magnetic, gravitational, and cogravitational properties. In addition to the electromagnetic α and gravitocogravitic ϑ constants, the incorporation of gravitational phenomena for these smart magnetoelectroelastics adds the gravitoelectric ζ, cogravitoelectric ξ, gravitomagnetic β, and cogravitomagnetic λ constants. All of them contribute to the value of the coefficient of the electromagnetogravitocogravitomechanical coupling (CEMGCMC). The CEMGCMC represents one of very important material characteristics because the dynamic characteristics such as the bulk and surface acoustic wave speeds depend on it. Therefore, it requires experimental determinations of the α, ϑ, ζ, ξ, β, and λ. In addition to the well-known relative parameters α_E and α_H, this report introduces the relative material parameters ϑ_G, ϑ_F, ξ_E, ξ_F, β_H, β_G, ζ_E, ζ_G, λ_H, and λ_F, where the subscripts "*E*", "*H*", "*G*", "*F*" relate to the electrical, magnetic, gravitational, and cogravitational subsystems, respectively. It is expected that their measurements can be preferable due to the successful measurements of α_E and α_M during the last six decades. The knowledge of the complete set of the material parameters for different magnetoelectroelastics can provide a class of commercially fitting materials to constitute various technical devices with suitable characteristics. This can actually contribute to the development of infrastructure for signal processing based on the new fast waves that can propagate in the solids at the speeds $\Lambda_1 = (\zeta\lambda)^{-1/2} \rightarrow \sim 10^{13}C_L$ and $\Lambda_2 = (\xi\beta)^{-1/2} \rightarrow \sim 10^{13}C_L$, where C_L is the light speed in a vacuum. Also, the new fast waves can propagate in a vacuum at the speeds $\Lambda_{01} = (\zeta_0\lambda_0)^{-1/2} \rightarrow \sim 10^{13}C_L$ and $\Lambda_{02} = (\xi_0\beta_0)^{-1/2} \rightarrow \sim 10^{13}C_L$. These speeds Λ_{01} and Λ_{02} are already apt for development of the instant interplanetary communication.

Keywords: Continuous media; Magnetoelectric and gravitational effects; Four potential coupling problem; Exchange material parameters.

1 Introduction

The recently developed theory [1, 2] of the acoustic wave propagation coupled with the electrical, magnetic, gravitational, and cogravitational potentials (i.e. the four-potential acoustic wave) has provided some theoretical, mathematical, experimental, and engineering problems. Successful developments towards resolving all these problems can result in appearance of infrastructure, with which it will be possible to have the instant interplanetary communication based on some gravitational phenomena. This communication is possible because theory [1] has introduced two new fast waves that can propagate in both solids and a vacuum at speeds thirteen orders faster than the speed of light in a vacuum, $C_L = (\varepsilon_0\mu_0)^{-1/2} \sim (\gamma_0\eta_0)^{-1/2} \sim 3 \times 10^8$ [m/s]. Here it is worth noting that Abbott *et al.* [3] have found in 2016 that the gravitational waves can also propagate in a vacuum with the speed of light $C_L \sim (\gamma_0\eta_0)^{-1/2}$. Therefore, both the electromagnetic and gravitational waves are unsuitable for the instant interplanetary communication. These new fast speeds $\Lambda_{01} = (\zeta_0\lambda_0)^{-1/2} \rightarrow 10^{13}C_L$ and $\Lambda_{02} = (\xi_0\beta_0)^{-1/2} \rightarrow 10^{13}C_L$ for signal processing are already enough for the instant interplanetary (interstellar and even intergalactic) communication. For this purpose, it is necessary to know measured values of the following parameters for a vacuum: the electric constant ε_0, magnetic constant μ_0, gravitic constant γ_0, cogravitic constant η_0, gravitoelectric constant ζ_0, cogravitoelectric constant ξ_0, gravitomagnetic constant β_0, and cogravitomagnetic constant λ_0.

The measurement tools are currently well-developed for determination of the vacuum parameters ε_0 and μ_0. For a vacuum [4], the magnetic permeability constant (magnetic constant) $\mu_0 = 4\pi \times 10^{-7}$ [H/m] $= 1.25663706144 \times 10^{-6}$ [H/m] and the dielectric permittivity constant (electric constant) $\varepsilon_0 = 10^{-7}/(4\pi C_L^2) = 8.854187817 \times 10^{-12}$ [F/m] because $C_L = 2.99782458 \times 10^8$ [m/s]. For solids, the electrical properties are known for many materials [5] and the experimental tools [6] for determination of magnetic properties are also well-developed. There are magnetoelectric solids [7, 8, 9] that possess the magnetoelectric effect characterized by the electromagnetic constant α. The magnetoelectric materials are suitable candidates for spintronics. For the magnetoelectric materials there is the following condition of thermodynamic stability: $\alpha^2 < \varepsilon\mu$ [7, 8], where ε and μ are the electric and magnetic constants for solids, respectively. To enhance the value of the electromagnetic constant α, composite materials are created [7, 8]. However there are hexagonal monocrystals [9] that can commercially compete with the composites. For the solids there is always $\alpha^2 << \varepsilon\mu$ that can be readily rewritten as follows: $V_\alpha >> V_{EM}$, where $V_\alpha = 1/\alpha$ and $V_{EM} = (\varepsilon\mu)^{-1/2}$ stand for the exchange speed and the speed of the electromagnetic wave, respectively. For the solids, the magnetoelectric effect is so small that there is even $V_\alpha >> C_L$. This is an evidence that the exchange speed can be significantly faster than the speed of the electromagnetic wave propagating in a solid or a vacuum.

According to theory [1], the taking into account some gravitational phenomena in the theory of the acoustic wave propagation in the magnetoelectric materials can result in interactions of extra two subsystems (gravitational and cogravitational) with the electrical and magnetic subsystems. This theory uses the centennial postulation by Einstein that any kind of energy (and any change in energy) is coupled with gravitation. In 1916, Einstein [10] has used an analogy between the gravitation and electromagnetism that was first mentioned by Heaviside [11] in 1893. This analogy was studied by many theoreticians. For instance, Jefimenko in his book [12] has studied the gravitation and cogravitation that are also called the gravitoelectricity and gravitomagnetism in the theory of the gravitoelectromagnetism representing the purely gravitational theory. So, it is natural that theory [1] uses the gravitational and cogravitational subsystems. As a result, developed theory [1] leads to the appearance of two new fast waves propagating at the following speeds in the solids: $A_1 = (\zeta\lambda)^{-1/2}$ and $A_2 = (\xi\beta)^{-1/2}$, where ζ, λ, ξ, and β are the gravitoelectric, cogravitomagnetic, cogravitoelectric, and gravitomagnetic constants for the solid, respectively. These two exchange speeds can propagate thirteen orders faster than the speed of light, C_L. It is possible to write the following thermodynamic stability condition: $A_1 >> V_\alpha$ and $A_2 >> V_\alpha$. Therefore, $A_1 >> C_L$ and $A_2 >> C_L$. Also, it is natural to write down for a vacuum: $A_{01} >> C_L$ and $A_{02} >> C_L$. These means that the parameters $\{\zeta_0, \xi_0, \beta_0, \lambda_0\}$ for a vacuum and the corresponding material parameters $\{\zeta, \xi, \beta, \lambda\}$ for the solids must be known in order to evaluate the corresponding exchange speeds.

This report offers for the reader to deal with relative material parameters instead of $\{\zeta, \xi, \beta, \lambda\}$ for the solids. These relative material parameters will be introduced in the following section. Each of them is relevant to one of the following aforementioned material parameters for the solids: electric constant ε, magnetic constant μ, gravitic constant γ, cogravitic constant η. For the solids, the constants ε and μ are well-determinable in the corresponding experiments that was mentioned at the beginning of this section. Concerning the constants γ and η, Li and Torr [13] in 1991 have presented Maxwell's equations for gravitation in a form, where the cogravitic constant η of a superconductor is different from the parameter η_0 for a vacuum. One year later, Li and Torr [14] have discussed the interrelationship between the magnetic and cogravitational fields in superconductors and estimated the value of the relative cogravitic constant η of a superconductor. In 1993, Torr and Li [15] have continued their analysis of gravitational effects in superconductors and studied some coupling between the gravitational and electric subsystems via superconductivity. In 2016, Füzfa [16] has studied weak interactions in solids between the electric or magnetic subsystem on one side and the gravitational or cogravitational subsystem on the other side. Therefore, it is necessary to state that the parameters ε, μ, γ, and η can be readily evaluated for various solids and naturally used for determination of the material parameters $\{\zeta, \xi, \beta, \lambda\}$. These last four parameters can be obtained with known values of the relative material parameters introduced in the following section. The third section provides some discussions.

2 The relative material parameters

In the transversely isotropic solid materials of symmetry class 6 *mm*, the velocity of the anti-plane polarized bulk acoustic wave can be calculated with the following expression [1]:

$$V_{temgc} = \sqrt{C\left(1 + K_{emgc}^2\right)/\rho} \tag{1}$$

In definition (1), the material parameters C and ρ are listed in table 1. Also, the nondimensional parameter K_{emgc}^2 is called the coefficient of the electromagnetogravitocogravitomechanical coupling (CEMGCMC). This coefficient can be calculated with the following formulae [1, 17, 18, 19]:

$$K_{emgc}^2 = \frac{Z_1}{CZ_2} \tag{2}$$

where

$$Z_1 = e^2(\mu\gamma\eta + 2\beta\lambda\vartheta - \lambda^2\gamma - \beta^2\eta - \vartheta^2\mu) + h^2(\varepsilon\gamma\eta + 2\zeta\xi\vartheta - \vartheta^2\varepsilon - \zeta^2\eta - \xi^2\gamma) + g^2(\varepsilon\mu\eta + 2\alpha\xi\lambda - \lambda^2\varepsilon - \alpha^2\eta - \xi^2\mu) + f^2(\varepsilon\mu\gamma + 2\alpha\beta\zeta -$$

$$\beta^2\varepsilon - \alpha^2\gamma - \zeta^2\mu) + 2eh(\zeta\beta\eta + \xi\gamma\lambda + \vartheta^2\alpha - \alpha\gamma\eta - \zeta\lambda\vartheta - \xi\beta\vartheta) + 2eg(\alpha\beta\eta + \xi\vartheta\mu + \lambda^2\zeta - \alpha\lambda\vartheta - \zeta\mu\eta - \xi\beta\lambda) + 2ef(\alpha\gamma\lambda + \zeta\vartheta\mu + \beta^2\xi - \alpha\beta\vartheta - \zeta\beta\lambda - \xi\mu\gamma) + 2hg(\varepsilon\lambda\vartheta + \zeta\alpha\eta + \xi^2\beta - \alpha\xi\vartheta - \zeta\lambda\xi - \varepsilon\eta\beta) + 2hf(\varepsilon\beta\vartheta + \xi\alpha\gamma + \zeta^2\lambda - \alpha\zeta\vartheta - \zeta\xi\beta - \varepsilon\lambda\gamma) + 2gf(\varepsilon\beta\lambda + \xi\mu\zeta + \alpha^2\vartheta - \alpha\zeta\lambda - \alpha\beta\xi - \varepsilon\mu\vartheta) \tag{3}$$

$$Z_2 = (\varepsilon\mu - \alpha^2)(\gamma\eta - \vartheta^2) + (\beta\xi - \lambda\zeta)^2 - (\xi^2\mu\gamma + \beta^2\varepsilon\eta + \lambda^2\varepsilon\gamma + \zeta^2\mu\eta) + 2(\gamma\alpha\xi\lambda + \eta\alpha\beta\zeta + \varepsilon\beta\lambda\vartheta + \mu\zeta\xi\vartheta - \alpha\zeta\lambda\vartheta - \alpha\beta\xi\vartheta) \tag{4}$$

Table 1: The material parameters of the magnetoelectroelastic solid, their fundamental physical dimensions, and estimated values.

Material parameter, symbol	Dimension	Estimated values
Mass density, ρ	kg/m^3	10^3
Elastic stiffness constant, C	kg/(m×s^2)	10^9 to 10^{11}
Piezoelectric constant, e	kg$^{1/2}$/m$^{3/2}$	0.1 to 10
Piezomagnetic coefficient, h	kg$^{1/2}$/(m$^{1/2}$×s)	0.1 to 10^3
Piezogravitic constant, g	kg/m^2	10^5 to 10^{10}
Piezocogravitic coefficient, f	s^{-1}	10^{-16} to 10^{-8}
Electric constant, ε	s^2/m^2	10^{-10} to 10^{-8}
Magnetic constant, μ	-	10^{-6} to 10^{-3}
Electromagnetic constant, α	s/m	10^{-16} to 10^{-12}
Gravitic constant, γ	kg×s^2/m^3	10^{10} to 10^{11}
Cogravitic constant, η	m/kg	10^{-28} to 10^{-27}
Gravitocogravitic constant, ϑ	s/m	10^{-16} to 10^{-12}
Gravitoelectric constant, ζ	kg$^{1/2}$×s^2/m$^{5/2}$	10^{-8} to 10^{-2}
Cogravitoelectric constant, ξ	s/(kg$^{1/2}$×m$^{1/2}$)	10^{-45} to 10^{-40}
Gravitomagnetic constant, β	kg$^{1/2}$×s/m$^{3/2}$	10^{-6} to 10
Cogravitomagnetic constant, λ	m$^{1/2}$/kg$^{1/2}$	10^{-40} to 10^{-35}

All the material parameters present in (3) and (4) are listed in table 1. This form (4) can be naturally rewritten in the following forms [19]:

$$Z_2 = (\varepsilon\eta - \xi^2)(\mu\gamma - \beta^2) + (\alpha\vartheta - \lambda\zeta)^2 - (\vartheta^2\varepsilon\mu + \alpha^2\gamma\eta + \lambda^2\varepsilon\gamma + \zeta^2\mu\eta) + 2(\gamma\alpha\xi\lambda + \eta\alpha\beta\zeta + \varepsilon\beta\lambda\vartheta + \mu\zeta\xi\vartheta - \zeta\xi\beta\lambda - \alpha\beta\xi\vartheta) \tag{5}$$

$$Z_2 = (\varepsilon\gamma - \zeta^2)(\mu\eta - \lambda^2) + (\alpha\vartheta - \beta\xi)^2 - (\vartheta^2\varepsilon\mu + \alpha^2\gamma\eta + \xi^2\mu\gamma + \beta^2\varepsilon\eta) + 2(\gamma\alpha\xi\lambda + \eta\alpha\beta\zeta + \varepsilon\beta\lambda\vartheta + \mu\zeta\xi\vartheta - \zeta\xi\beta\lambda - \alpha\zeta\lambda\vartheta) \tag{6}$$

It is necessary to state that forms (4), (5), and (6) are equivalent. It is also necessary here to mention useful physical dimensions of some combinations of the material parameters. With table 1, one can find the following equalities: $[\rho/C] = [\varepsilon\mu] = [\gamma\eta] = [\alpha^2] = [\vartheta^2] = [\alpha\vartheta] = [\zeta\lambda] = [\xi\beta] = [s^2/m^2]$. These two parameters (1) and (2) are very important. Indeed, the speeds of both the new interfacial acoustic SH-wave [17] and the new dispersive acoustic SH-waves [18] in plates (thin films) actually depend on them. In equivalent forms (4), (5), and (6), the reader must focus on the first two terms on the right-hand side. It is clearly seen that in each equivalent form there are two first terms that consist of two cofactors. Using these two terms, it is possible to borrow the following inequalities from work [19]:

$$0 < \frac{\alpha^2\vartheta^2}{\varepsilon\mu\gamma\eta} < 1,\ 0 < \frac{\alpha^2}{\varepsilon\mu} < 1,\ 0 < \frac{\vartheta^2}{\gamma\eta} < 1 \tag{7}$$

$$0 < \frac{\xi^2\beta^2}{\varepsilon\mu\gamma\eta} < 1,\ 0 < \frac{\xi^2}{\varepsilon\eta} < 1,\ 0 < \frac{\beta^2}{\mu\gamma} < 1 \tag{8}$$

$$0 < \frac{\zeta^2\lambda^2}{\varepsilon\mu\gamma\eta} < 1,\ 0 < \frac{\zeta^2}{\varepsilon\gamma} < 1,\ 0 < \frac{\lambda^2}{\mu\eta} < 1 \tag{9}$$

Using inequalities (7), it is possible to write down the following relative magnetoelectric (ME) coefficients [20] listed in table 2:

$$\alpha_E = \frac{\partial E}{\partial H} = \frac{\alpha}{\varepsilon} \tag{10}$$

$$\alpha_H = \frac{\partial H}{\partial E} = \frac{\alpha}{\mu} \tag{11}$$

because it is convenient to deal with the following dimensionless parameter listed in table 2:

$$\alpha_E\alpha_H = \frac{\partial E}{\partial H}\frac{\partial H}{\partial E} = \frac{\alpha^2}{\varepsilon\mu} \tag{12}$$

Table 2: The relative material parameters α_E, α_H, ϑ_G, ϑ_F, ξ_E, ξ_F, β_H, β_G, ζ_E, ζ_G, λ_H, and λ_F, their fundamental physical dimensions, and estimated values.

Material parameter	Dimension	Estimated values
α_E	m/s	10^{-6} to 10^{-4}
α_H	s/m	10^{-10} to 10^{-8}
ϑ_G	$m^2/(kg\times s)$	10^{-26} to 10^{-22}
ϑ_F	$kg\times s/m^2$	10^{11} to 10^{15}
ζ_E	$kg^{1/2}/m^{1/2}$	10^{2} to 10^{6}
ζ_G	$m^{1/2}/kg^{1/2}$	10^{-18} to 10^{-12}
ξ_E	$m^{3/2}/(kg^{1/2}\times s)$	10^{-35} to 10^{-22}
ξ_F	$kg^{1/2}\times s/m^{3/2}$	10^{-17} to 10^{-13}
β_H	$kg^{1/2}\times s/m^{3/2}$	1 to 10^{4}
β_G	$m^{3/2}/(kg^{1/2}\times s)$	10^{-16} to 10^{-10}
λ_H	$m^{1/2}/kg^{1/2}$	10^{-34} to 10^{-32}
λ_F	$kg^{1/2}/m^{1/2}$	10^{-12} to 10^{-8}
$\alpha_E\alpha_H$, $\vartheta_G\vartheta_F$, $\beta_H\beta_G$, $\zeta_E\zeta_G$	-	$> 10^{-16}$
$\xi_E\xi_F$	-	$> 10^{-52}$
$\lambda_H\lambda_F$	-	$> 10^{-46}$
$\alpha_E\alpha_H\vartheta_G\vartheta_F$	-	$> 10^{-32}$
$\xi_E\xi_F\beta_H\beta_G$	-	$> 10^{-68}$
$\zeta_E\zeta_G\lambda_H\lambda_F$	-	$> 10^{-62}$

In (10) and (11) there are the partial first derivatives $\partial E/\partial H$ and $\partial H/\partial E$, respectively, where E and H stand for the electric and magnetic fields. Relative parameter α_E (10) is called the linear ME voltage coefficient that is the quantity generally measured during experiments [7, 21, 22]. The ME coefficients α_E (10) and α_H (11) are for the direct and converse ME effects [20]. The ME voltage coefficient α_E can be defined under the open electric circuit condition and expressed as $\alpha_E = \alpha/\varepsilon$, where ε is the effective permittivity (electric constant) for a solid. Similarly, the converse ME coefficient α_H (11) can be determined under the open magnetic circuit condition and expressed as follows: $\alpha_H = \alpha/\mu$, where μ is the effective permeability (magnetic constant). The ME coefficient α_H can be easily found in experiments similarly to the ME voltage coefficient. For instance, the dielectric constant $\varepsilon = 11.9\varepsilon_0$ for Cr_2O_3 [20] and therefore, the measured value of $\alpha = 2.67 \times 10^{-12}$ [s/m]. This means that the exchange speed $V_\alpha = 1/\alpha$ for monocrystal Cr_2O_3 is equal to $V_\alpha = 3.75 \times 10^{11}$ [m/s] > $C_L = 2.99782458 \times 10^8$ [m/s] and even $V_\alpha >> C_L$. With the effective permittivity ε and the effective permeability μ, the value of α can be measured for composites that can provide significantly stronger ME coupling. For composites, the effective parameters ε and μ can have very complicated forms [20].

Similar to the exchange between the electric and magnetic subsystems in the treated solids, an exchange between the gravitational and cogravitational subsystems can exist. Exploiting inequalities (7), it is therefore natural to introduce the following relative cogravitogravitic (CG) coefficients listed in table 2:

$$\vartheta_G = \frac{\partial G}{\partial F} = \frac{\vartheta}{\gamma} \tag{13}$$

$$\vartheta_F = \frac{\partial F}{\partial G} = \frac{\vartheta}{\eta} \tag{14}$$

Therefore there is the following dimensionless parameter:

$$\vartheta_G \vartheta_F = \frac{\partial G}{\partial F}\frac{\partial F}{\partial G} = \frac{\vartheta^2}{\gamma\eta} \tag{15}$$

In (13) and (14) there are the partial first derivatives $\partial G/\partial F$ and $\partial F/\partial G$, respectively, where G and F stand for the gravitational and cogravitational fields. Expressions (13) and (14) for the direct and converse CG effects can be used for experimental measurements of the gravitocogravitic constant ϑ for both monocrystals and composites. For composites however, the forms for the effective gravitic constant γ and the effective cogravitic constant η can be found for an individual composite and can be very complicated.

Similarly, it is possible now to utilize inequalities (8). So, it is also natural to introduce the following relative cogravitoelectric (CE) coefficients that are listed in table 2:

$$\xi_E = \frac{\partial E}{\partial F} = \frac{\xi}{\varepsilon} \tag{16}$$

$$\xi_F = \frac{\partial F}{\partial E} = \frac{\xi}{\eta} \tag{17}$$

As a result, the following expression can be written:

$$\xi_E \xi_F = \frac{\partial E}{\partial F}\frac{\partial F}{\partial E} = \frac{\xi^2}{\varepsilon\eta} \tag{18}$$

Using inequalities (8), it is also possible to introduce the following relative gravitomagnetic (GM) coefficients listed in table 2:

$$\beta_H = \frac{\partial H}{\partial G} = \frac{\beta}{\mu} \tag{19}$$

$$\beta_G = \frac{\partial G}{\partial H} = \frac{\beta}{\gamma} \tag{20}$$

Coefficients (19) and (20) as the cofactors represent the following dimensionless form present in inequalities (8):

$$\beta_H \beta_G = \frac{\partial H}{\partial G}\frac{\partial G}{\partial H} = \frac{\beta^2}{\mu\gamma} \tag{21}$$

Finally, it is possible to employ inequalities (9). Therefore, to introduce the following relative gravitoelectric (GE) coefficients listed in table 2 is natural:

$$\zeta_E = \frac{\partial E}{\partial G} = \frac{\zeta}{\varepsilon} \tag{22}$$

$$\zeta_G = \frac{\partial G}{\partial E} = \frac{\zeta}{\gamma} \tag{23}$$

These coefficients produce the following form present in inequalities (9):

$$\zeta_E \zeta_G = \frac{\partial E}{\partial G}\frac{\partial G}{\partial E} = \frac{\zeta^2}{\varepsilon\gamma} \tag{24}$$

With inequalities (9), it is natural to introduce the following relative cogravitomagnetic (CM) coefficients listed in table 2:

$$\lambda_H = \frac{\partial H}{\partial F} = \frac{\lambda}{\mu} \tag{25}$$

$$\lambda_F = \frac{\partial F}{\partial H} = \frac{\lambda}{\eta} \tag{26}$$

These relative cogravitomagnetic coefficients provide the following form in inequalities (9):

$$\lambda_H \lambda_F = \frac{\partial H}{\partial F}\frac{\partial F}{\partial H} = \frac{\lambda^2}{\mu\eta} \tag{27}$$

3 Discussion

The physical dimensions of all the relative material parameters are listed in table 2. It is expected that all of them can be measured for both monocrystals and composite materials. However, the experimental determination of the introduced material parameters requires creation of proper experimental tools. So, a lot of experimental setups must be combined in order to measure all the material parameters of the smart magnetoelectric materials incorporating the gravitational phenomena. This is suitable for a large research organization. All the material parameters for the treated case, namely $\{\rho, C, e, h, g, f, \varepsilon, \mu, \gamma, \eta, \alpha, \vartheta, \zeta, \lambda, \xi, \beta\}$ listed in table 1 are necessary to calculate propagation speeds of various acoustic waves. It is expected that one, two, or several parameters of $\{\alpha, \vartheta, \zeta, \lambda, \xi, \beta\}$ can be crucial for the existence of some (surface) acoustic waves. It is also expected that the experimental determination of the relative parameters $\{\vartheta_G, \vartheta_F, \xi_E, \xi_F, \beta_H, \beta_G, \zeta_E, \zeta_G, \lambda_H, \lambda_F\}$ listed in table 2 is preferable because there are successful measurements of relative magnetoelectric coefficients (10) and (11) [20] during the last several decades. Indeed, Astrov [23] has experimentally determined the electromagnetic constant α for the monocrystal Cr_2O_3 in 1960. However, many composite materials show significantly stronger ME interactions. This allows the manufacture of various magnetoelectric technical devices such as the wireless powering systems [24, 25], energy harvesting [26], tunable inductors [27], magnetic-field sensors [28-35], gyrators and transformers [36, 37], dual electric-field- and magnetic-field-tunable microwave and millimeter-wave devices [38-42], and miniature antennas [43-46]. It is expected that using suitable monocrystals or created composites with the electric, magnetic, gravitational, and cogravitational effects, it also is possible to constitute, for instance, gravitational-field and cogravitational-field sensors, etc. It is also natural to utilize them for the energy harvesting instead of the conventional piezoelectrics [47-50].

Concerning the infrastructure development for the instant interplanetary communication, some schemes were discussed in paper [51]. It is assumed that planetary colonists between each other can have conventional L-communication at the speed of light on the guest planet. However, the Λ-communication must be used when there is a necessity to communicate with the home planet because the Λ-communication based on the new fast waves propagating at the speeds $\Lambda_{01} = (\zeta_0\lambda_0)^{-1/2} \rightarrow 10^{13}C_L$ and $\Lambda_{02} = (\xi_0\beta_0)^{-1/2} \rightarrow 10^{13}C_L$ can already provide the instant interplanetary communication. This can be useful for the remote health monitoring of the planetary colonists. For this new communication era based on the symbiosis of the electromagnetic and gravitational phenomena, the parameters $\{\varepsilon_0, \mu_0, \gamma_0, \eta_0, \alpha_0, \vartheta_0, \zeta_0, \lambda_0, \xi_0, \beta_0\}$ for a vacuum must be also known. Today, only the values of the parameters $\{\varepsilon_0, \mu_0, \gamma_0, \eta_0\}$ for a vacuum are well-known. Therefore, the rest parameters $\{\alpha_0, \vartheta_0, \zeta_0, \lambda_0, \xi_0, \beta_0\}$ representing the exchange constants must be also determined in proper experiments. It is expected that these parameters for a vacuum can be determined when the experimental techniques will be successfully developed for measurements of the material parameters for the solids. According to the evaluations done in table 2, the values of $\alpha_E\alpha_H$, $\vartheta_G\vartheta_F$, $\beta_H\beta_G$, and $\zeta_E\zeta_G$ are larger than 10^{-16}. Therefore there are possibilities to properly measure the values of the relative parameters ϑ_G, ϑ_F, β_H, β_G, ζ_E, and ζ_G because the values of α_E and α_H are precisely measured for the last several decades. For the proper measurements of the rest parameters ξ_E, ξ_F, λ_H, and λ_F ($\xi_E\xi_F > 10^{-52}$ and $\lambda_H\lambda_F > 10^{-46}$ in table 2) it is expected that more sensitive experimental tools must be created.

4 Conclusion

Incorporating gravitational phenomena for the magnetoelectroelastic materials, this report has introduced the relative material parameters ϑ_G, ϑ_F, ξ_E, ξ_F, β_H, β_G, ζ_E, ζ_G, λ_H, and λ_F defined by formulas (13)-(27) and listed in table 2. These parameters are natural implement to the well-known relative material parameters α_E and α_M that are successfully measured during the last several decades. Experimental determinations of all the aforementioned relative material parameters lead to the utilization of the complete set of the material parameters

$\{\rho, C, e, h, g, f, \varepsilon, \mu, \gamma, \eta, \alpha, \vartheta, \zeta, \lambda, \xi, \beta\}$ listed in table 1. The complete set of the material parameters will allow for the researchers and engineers to study the acoustic wave propagation in the (composite) solids. Also, this will actually contribute to the development of the instant interplanetary communication based on the new fast waves propagating in both the solids and a vacuum at the speeds thirteen orders faster than the speed of light in a vacuum. So, it is possible to state that this work has touched some gravitational engineering research arenas for new communication era based on gravitational phenomena.

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ETHER AND SCHRÖDINGER'S WAVE FUNCTION ψ

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Abstract

It shall be shown that the „ominous" wave function ψ, which is still disputed today, can be interpreted not only as the amplitude of probability waves, without any physical basis (neither material nor energetic), but also as a normalised, quantitative description of the electromagnetic fields of an (ether-) carrier medium, in accordance with the Maxwell equations and the (until today worldwide suppressed) original ideas of Erwin Schrödinger.

Keywords: Maxwell, de Broglie, Schrödinger, Dirac, Santilli, Laughlin, wave function, ether, ether waves, probability, material waves, psi

A NEW APPROACH TO ETHER RESEARCH:

The fundamental question of quantum mechanics.

Can one hope for an atomic theory that **avoids** the **Copenhagen** interpretation? Answer from a proven „quantum expert“: [1]

> **In principle, yes, – but then** all current **quantum field theories** (QED, QCD, etc.), which so well reflect the structure of matter, **had** to be **abandoned**.

As **a supplement** to the Copenhagen interpretation of ψ – and in accordance with Erwin Schrödinger's original view[2] – the following **thesis** is presented and explained below:

The *psi* - Thesis

Schrödinger's **wave function** ψ means: the **electromagnetic field state** – of the ever omnipresent **ether**.

Erwin Schrodinger: the "secret" ether physicist.

Erwin Schrödinger was – with certainty – a completely "convinced ether physicist", for life.

This statement is a fact, practically unknown today, but it is very easy to understand, because Schrödinger worked for a whole decade as assistant of Franz Exner (1910 until Exner's retirement in 1920)[3] and was there in charge of his students, for whom Prof. Exner gave **each** year **nineteen** fully elaborated **lectures** on **ether physics.**[4]

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[1] **Frage** u. Antwort von **Helmut Rechenberg** (1937-2016) in: Meyenn (1998), (15), **2. Bd.**: Quantenfelder und Kausalität, S. 299-300.

[2] Kumar (2009), (12), „Ein später erotischer Ausbruch", S. 257.

[3] Moore (2012), (16), Der Hochschulstudent, S. 52, Doktorarbeit, S. 59, Assistentenstelle, S. 62.

[4] These nineteen lectures are documented in detail. See: Exner (1919), (7), **Physik Vorlesung**.

In this sense, Schrödinger wrote at that time, among others, a great **treatise** on **dielectrics**, "naturally" (at that time still) **based** on an **ether**.[5]

From about 1920 onwards Schrödinger hardly ever said anything about this "delicate" subject, because from then on,[6] (at the latest) classical mechanical ether theories were generally considered to be overcome, contradictory, etc.[7]

Nevertheless, Schrödinger remained an "ether-believer" throughout his life, in later years especially in the sense of Einstein's unified field theory.[8]

The great ψ-puzzle.

Schrödinger's ominous wave function ψ was introduced in 1926,[9] but even though almost a century has passed since then, its significance remains one of the greatest puzzles in physics to this day, especially the fact that ψ must be described with strangely complex numbers. For example, it has even been claimed that the imaginary part of ψ has no physical meaning.[10]

ψ was - and still is today - regarded as something intangible, even ghostly, but above all immeasurable. Heisenberg found Schrödinger's theory to be "crap", indeed.

It was in this sense that the following, often quoted mocking poem was

[5] Schrödinger (1914), (20), „Die Maxwellsche Theorie der Dielektrika", S. 157.

[6] 1909 e.g. already Einstein (1909), (6), Zum ... Strahlungsproblem, S. 718. – **Ätherhypothese**: ein **überwundener** Standpunkt.

[7] This view was significantly influenced around **1920** (a) by the Naturalists' Meeting in Bad Nauheim on 23 Sept. **1920**, see Wazeck (2009), (26), 3.2.2 Anschaulichkeit, S. 183-190, and (b) by a book of **Max Born** also published in **1920** (many new editions later): Born (1920), (2), siehe z.B. 15. Die Kontraktionshypothese, S. 192-193.

[8] This is clearly shown by Schrödinger's private correspondence with Born, Einstein and others. See Meyenn (2011), (23), Div. Auszüge von Briefen – From 1917, however, these ideas were probably of a relativistic nature and ended about three decades later – then called affine field theory by him – in an abrupt manner, without any further development. See Moore (2012), (16), Allgemeine Relativität (ab 1917), S. 100-101 – **Das Einstein-Debakel** (um 1946) und die „**Einstein-Schweinerei**"', S. 368-373.

[9] Schrödinger (1926), (21), Quantisierung als Eigenwertproblem.

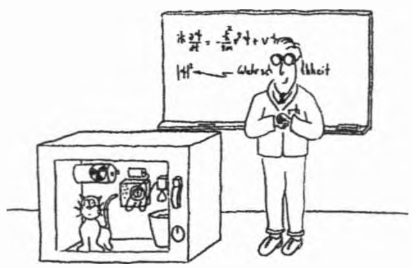
[10] Gassner/Müller (2019), (9), 7.10 Zeitabhängige Schrödingergl., S. 382 / Einschub: Komplexe Zahlen, S. 389.

written at that time in "honour of Erwin":[11]

> Erwin with his "psi" can do,
> Calculations many – quit a few.
> But one thing yet, has not been seen:
> What does this "psi" – actually mean?[12]

Finally, Schrödinger's wave function was interpreted as a "**complex-valued probability wave**" – meaning an abstract wave that, **does not even** move **in normal** three-dimensional **space.**[13]

Robert B. Laughlin about Schrödinger's cat:
The ludicrousness of <u>this</u> idea is self-evident.



From **Robert Laughlin**'s book (2005), (13):
A Different Universe – Reinventing Physics
Chapter 5: **Schrödinger's Cat**, p. 47-57.

The decision in favour of this "**probability-definition**" proposed by Max Born (at the Solvay Conference 1927) was made against **massive** resistance from Schrödinger, de Broglie, Böhm, Einstein, and others.[14]

[11] Kumar (2009), (12), Die Wirren um Schrödingers ψ, Mist: S. 262, Gedicht: S. 264, Geisterhaftes: S. 274.

[12] German Poem by **Erich Hückel** – (partly special translation by GZ.)

[13] Kumar (2009), (12), „Ein später erotischer Ausbruch", S. 271 – und: Die Bellsche Ungleichung, S. 402.

[14] Kumar (2009), (12), **Einwände gegen die Kopenhagener Deutung von ψ**, S. 10, Bild 23, 304-305, 314, 318-321, 327, 333, 335, 337, 340, 347, usw., usw.

Nevertheless, it is still **the only** officially **recognized** definition, so that practically all universities – worldwide – still teach today:[15]

> Schrödinger's wave function ψ means the "probability amplitude" of the electron's "whereabouts".[16]

The problem of the "Schrödinger cat", for example, is a direct consequence of this "probability" interpretation[17] (also known as the measurement problem), which involves an, up to today, open question:[18]

When, where and **how** does the probability wave, **resp.** ψ,
… **collapse** … ? [19]

Surprisingly, the Schrödinger equation remained indispensable up to now and became, among other things, the prototype of all quantum mechanical wave equations.[20]

Schrödinger's original, intuitive derivation.

The actual origin of the renown Schrödinger equation was Schrödinger's idea that, atoms are oscillating systems, whose electrons oscillate around their nucleus in spherical **resonance** with the **ether medium**.[21]

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[15] Bleck-Neuhaus (2013), (1), Der „**überzeugende Beleg**" für die Wahrscheinlichkeits-**Deutung** der Wellenfunktion ψ, S. 156, Fn. 56: Dieser Fehlschluss liegt nicht fern, S. 205.

[16] Meschede (2010), (14), 15.1.2 Quanten-Fluktuationen stabilisieren die Atome, S. 717 / 15.2.2 Schrödinger-Gleichung, S. 719. / Interpretation als Wahrscheinlichkeitsamplitude, S. 722.

[17] Gassner/Müller (2019), (9), Schrödingers Katze, S. 338.

[18] Mehrere Bücher wurde dazu verfasst, z.B. David Peat (1997) Who is afraid of Schrödinger's Cat?

[19] Kumar (2009), (12), Solvay 1927, S. 323-324. / siehe auch **Gassner/Müller** (2019), (9), **Kann man die Quantenmechanik auch anders verstehen**, S. 400-406.

[20] Meyenn (1998), (15), **2. Bd.**: Schrödingers Wellenmechanik, Quantenfeldtheorie und Kausalität, S. 296-300.

[21] Schrödinger (1926), (21), Quantisierung als Eigenwertproblem: Die Vorstellung, dass die Elektronen von Atomen schwingen, S. 375.

The decisive impetus for this was provided by de Broglie's dissertation,[22] according to which Schrödinger – as Schrödinger's notebooks show – first derived the new wave equation by means of the usual wave equation and the de Broglie relationship $p = h/\lambda$ (which is still unexplained today), **"purely classical"**. Since Schrödingers classical derivation is rarely shown nowadays,[23] it is briefly reproduced here.

Starting point is the classical **equation** for **waves of all kinds** (sound waves, electromagnetic waves, etc.)

$$\nabla^2\Phi - \frac{1}{c^2}\,\ddot{\Phi} = 0. \tag{1}$$

For harmonic waves (linear elastic type) generally applies: $\Phi = e^{i\omega t}$, $\dot{\Phi} = i\omega\, e^{i\omega t}$ and $\ddot{\Phi} = -\omega^2\, e^{i\omega t}$.

The following applies too: $c = \lambda\nu$, $k = 2\pi/\lambda$ und $\omega = 2\pi\nu$, also $c = \omega/k$, thus $1/c^2 = k^2/\omega^2$.

Used in (1), these two relationships result in the so-called time-**independent** wave equation:[24]

$$\nabla^2\Phi + k^2\Phi = 0. \tag{2}$$

From the total energy of all mechanical systems $E = T + V = (mv^2/2) + V = (p^2/2m) + V$ **follows** immediately $p^2 = 2m(E - V)$.

From de Broglie's wavelength $\lambda = h/p$ and $k = 2\pi/\lambda$ **follows** $k^2 = 4\pi^2p^2/h^2$.

The last two relationships together yield $k^2 = (4\pi^2 2m(E - V))/h^2$.

Inserting k^2 into the wave equation (2) (with replacement of $\Phi \rightarrow \psi$), immediately results the important **time-in**dependent **Schrödinger** equation – where '**as**' stands for atomic system, 'ee' for electrostatic (potential).

$$\nabla^2\psi + \frac{8\pi^2 m}{h^2}(E_{as} - \Phi_{ee})\psi = 0 \tag{3}$$

[22] Kumar (2009), (12), der Dualitäts-Prinz, S. 186-189 – und: Ein später erotischer Ausbruch, S. 254-255.

[23] Eine der seltenen Ausnahmen ist das Mechanik-Lehrbuch von **Goldstein**, jedoch **nur** die **Auflage von 1972**, siehe Goldstein (1972) (10), 9-8 Wellenmechanik, S. 346-347.

[24] Sommerfeld (1969), (25), Band 2: I. 1.1.11 Das Fundament der Wellenmechanik, S. 5. **Gl. (11)**.

The solution of the ψ-puzzle.

The ground state of the ether, which Schrödinger originally (certainly still 1926) assumed,[25] shall be called z_0. Then deviations from z_0 cause different scalar potentials Φ_i, whose gradients are called field vectors F_i. All Φ_i can then be represented by the dimensionless space function $0 \leq \psi(x,y,z) \leq 1$ as $\Phi_i = \Phi_0\,\psi$, similarly F_i by $F_i = F_0\,\psi$.

The charge e of electrons causes an electric potential, but if their mass m represents electromagnetic energy,[26] it also represents a charge-related **electric mass potential** $\Phi_{me} = mc^2/e$, increasing the normal zero potential of the ether and enabling "special atomic waves".

With Φ_{me}, equation (3) results the following **"atomic wave equation"**:

$$-\nabla^2(\Phi_{me}\psi) = -\frac{h^2}{8\pi^2 m}\nabla^2\psi = (E_{as} - \Phi_{ee})\psi \qquad (4)$$

On the right in (4) is the kinetic energy of the matter waves – i.e. the difference between the total energy of the atomic system E_{as} and the electrostatic potential Φ_{ee}) –, whose amplitude varies in space (especially radially) according to ψ.

On the left side of (4) is the negative gradient or force increase which "drives" the **atomic waves** of the ether – in accordance with the **electric mass potential** ($\Phi_{me}\,\psi$) of the **electron mass** m acting in an atom.

The usual electromagnetic energy **density** e does not cause any change anywhere, also not inside atoms. Only the force fields E and H do this according to **Maxwell's equations**.[27] Correspondingly, e ought to be a function of these two fields (E und H).

The energy density e of the fields **E and H**, which is significant for electromagnetic waves (e.g. light) – but also that within atoms – can

[25] Schrödinger did not miss the opportunity to refer in his "Heisenberg work"(from March **1926) twice explicitly** to **ether-wave lengths**. See Schrödinger (1926), (22), *Über das Verhältnis der Heisenberg-Born-Jordanschen Quantenmechanik zu der meinen* – Schlussteil der Abhandlung, S. 755-756.

[26] Feynman considered an inverse possibility, see Feynman (1972), (8), **3. Band**, 28.3 **Elektromagnetische** Masse, S. 520-521.

[27] Equations (25) und (26) on the following page 14 show one of the possible representations.

(and often is) represented, taking into account the relations $D = \varepsilon_0 E$ and $B = \mu_0 H$, by the two vectors **E and H**, as follows:[28]

$$e = \frac{1}{2}(ED + HB) = \tag{5}$$

$$= \left(\sqrt{\frac{\varepsilon_0}{2}}E\right)^2 + \left(\sqrt{\frac{\mu_0}{2}}H\right)^2 = \frac{\varepsilon_0}{2}E^2 + \frac{\mu_0}{2}H^2 \tag{6}$$

Since the two vectorial fields $\vec{E}$ and $\vec{H}$ (according to Maxwell's equations) are strictly **perpendicular to each other,** the overall state of an electromagnetic field can also be represented by combining the two field variables E and H into a **single complex-valued** field variable $\psi\,(E, H)$ – (**attention!**) with an "**unreal** complex" **physical** unit:

$$\psi = \left(\sqrt{\frac{\varepsilon_0}{2}}\,E + i\,\sqrt{\frac{\mu_0}{2}}\,H\right) / \sqrt{\Phi_{me}} \tag{7}$$

The conjugate-complex product (resp. square) $\psi^*\psi$ (for ψ^2) then gives for the energy density $e\,(E, H)$ of the ether – now again with **correct** and real **physical** unit [E/Q]):[29]

$$e = \Phi_{me}\,(\psi\,\psi^*) = \Phi_{me}\,\psi^*\psi = \tag{8}$$

$$= \left(\sqrt{\frac{\varepsilon_0}{2}}\,E + i\,\sqrt{\frac{\mu_0}{2}}\,H\right)\left(\sqrt{\frac{\varepsilon_0}{2}}\,E - i\,\sqrt{\frac{\mu_0}{2}}\,H\right) \tag{9}$$

$$= \left(\sqrt{\frac{\varepsilon_0}{2}}E\right)^2 + \left(\sqrt{\frac{\mu_0}{2}}H\right)^2 = \frac{\varepsilon_0}{2}E^2 + \frac{\mu_0}{2}H^2. \tag{10}$$

According to **exactly this mathematical method** of conjugated complex multiplication[30] – referring to the wave function of Schrödinger $\psi(r, t)$ –

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[28] Meschede (2010), (14), 8.4.4 Energiedichte und Energieströmung, S. 448 – Erste (nicht nummerierte) Gleichung für e. – Unter Bezugnahme auf Gl. (7.36) oder (7.54) auf S. 334 bzw. 338 und Gl. (8.12), S. 400.

[29] Meschede (2010), (14), 8.4.4 Die Energiedichte, S. 448.

[30] Meschede (2010), (14), 14.6 Grundzüge der Quantenmechanik, siehe dort bezüglich Matrizen, Vektoren und Operatoren, S. 698.

the so-called **probability density** $P(r,t) = \psi^*\psi = |\psi(r,t)|^2$ is defined and calculated.[31]

This **perfect analogy** of the calculation method, as well as the equality of the results for e shown in (6) und (10), leads to the following **conjecture**:

Schrödinger's wave function ψ can **not only** be interpreted "exclusively" as the probability amplitude[32] ψ of a complex-valued probability density $P(\psi)$ of so-called probability waves $P(\psi)$,[33] **but also** – according to (7) and fully in the sense of Schrödinger – as a very **real electromagnetic state** of the omnipresent material **ether**, which is elegantly represented in form of a single **complex-value**d variable $\psi(x,y,z,t)$ – representing an "**energy distribution factor**", normalised to 1.[34]

Now it could be argued that the complex-valued combination of two field strengths of fundamentally different nature is inadmissible, because this would "lump apples and pears"together – whereby the latter is actually true. In this respect, however, it should be noted that the sign (+ or -) of complex-valued numbers **does not** mean **addition or subtraction**, but is merely intended to represent the fact of combined or **joint action**, in this case with respect to the **acting energy** of an **electromagnetic** field.

What really matters in the context of Schrödinger's wave mechanics of **matter waves** is **the energy** acting in electromagnetic fields, which is simply given, completely "legal" and correct – as shown above –, by the usual conjugate complex multiplication of Schrödinger's complex-valued wave function ψ.

This fact means among others: The matter waves postulated by de Broglie, which shortly afterwards were also theoretically explained by

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[31] In this sense $P(r,t)$ is the probability of finding an electron or other particle at the locationis the probability of finding an electron or other particle at the location t at Ort r. See Meschede (2010), (14),15.2.2 Schrödinger-Gleichung für das Wasserstoffatom, S. 719, und auch 15.6 Wie strahlen Atome, S. 740-742.

[32] Meschede (2010), (14), 15.2.2 Schrödinger-Gleichung für das Wasserstoffatom, S. 719, eine Gleichung vor (15.8): ψ als Amplitude elektronischer Wahrscheinlichkeitsverteilung.

[33] For reasons of experimental experience, it is impossible to dispute the so-called Copenhagen interpretation according to Max Born, which is currently the only accepted one – it is even indispensable for experimental physics.

[34] This is, in short, exactly what the "psi-Thesis" (on page 2) says.

Schrödinger, are **scalar energy waves** with properties completely different from the vectorial electromagnetic waves. The equations of Maxwell resp. Schrödinger describe two different fields (of the ether) – roughly comparable with speed- and temperature-fields of any gas.

This essential difference between the two states (of the ether) just considered, is clearly shown by the fact that, Schrödinger's "wave packets" – unlike electromagnetic waves, which is often regretted – dissolve rapidly and are thus inconsistent. The cause of this kind of behaviour is simple:

Schrödingers more general, time-**dependent** wave-equation[35], describes the equalisation process of differing energy states (of the ether) and therefore is of a mathematical form similar the general diffusion-equation (for gases and liquids).[36]

Also within atoms electromagnetic fields waves of different material density in form of small vibrations (of ether) do exist, similar to sound vibrations of common substances. The accumulations of increased material density (of the material ether), which vibrations always produce, can be interpreted as masses, quite in line with Einstein's idea of matter. Einstein distinguished matter and fields as follows:

> **Matter is** where **much energy** is **concentrated;**
> a field is where there is little energy.[37]

Actually – in accordance with Einstein's so-called energy-**mass** equivalence **E = mc2** – Einstein should have said:[38]

Mass is where there is **much energy** – because the matter of the omnipresent ether medium is not only the base of all fields, **but also** the base of **all masses**.

This possibility of confusion is a consequence of the currently common refusal of authoritative physicists to accept or acknowledge the existence of a material ether medium, so that even famous physicists – also e.g.

[35] Meschede (2010), (14), 15.6.1 Atomare Antennen, S. 743, Gl. (15.47).

[36] Meschede (2010), (14), 6.5.5. Diffusion in Gasen und Lösungen, S. 278, Gl. (6.49).

[37] Infeld (1969), (11), Feld un Materie, S. 223.

[38] Meschede (2010), (14), 13.8.2 Der 4-Impuls, S. 649, nach Gl. (13.34), siehe auch S. 617 unten.

Einstein and Heisenberg – often "lump together" the two actually very different terms **mass** and **matter**, leading to general confusion.[39]

The hardly known „Maxwell-Dirac-Analogy".

The Dirac equation represents a significant improvement of the Schrödinger equation.[40] However, in standard textbooks of physics this theoretically very important equation only in exceptional cases is assigned a similarly high significance as the world-famous equation of Schrödinger.[41]

Therefore, a brief formal overview of the Dirac equation will be given here, also showing a following surprising fact: The **Dirac-equation** with $m = 0$, i.e. for an atom without electron, represents nothing else but an alternative formulation of **Maxwell's equations** for the "empty space" – respectively the empty **ether**.

The "original" Dirac equation.

Dirac chose the following mathematically very elegant and compact formulation for his relativistic wave equation of quantum mechanics:[42]

$$[p_0 + \rho_1(\sigma, p) + \rho_3 mc]\,\psi = 0. \qquad (11)$$

The usual quantum mechanical operator definitions for momentum p and energy W ($W \equiv p_0$) were used (in the spatial representation).

$$p = -i\hbar\frac{\partial}{\partial x} \quad \text{and} \quad W = i\hbar\frac{\partial}{\partial t}, \quad \text{with} \quad \hbar = \frac{h}{2\pi} \qquad (12)$$

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[39] See Mutschler (2002), (17), 3.4 Der Begriff der Materie, S. 108-110 – Here, among other things, the fact is regretted that, physics does not know, or more precisely **physicists do not know**, what matter is. The philosopher Stegmüller called this the "staircase **joke" of the 20th century**. Schrödinger, Debye and other famous physicists wrote long treatises on the topic "What is matter? – but a conclusive answer to this question is still missing. See e.g. Schrödinger (1953), (24), 8. Conclusions, p. 145.

[40] Explained in detail in the great Monography of Sommerfeld (1969), (25), Band 2: 4. Kapitel, Die Diracsche Theorie des Elektrons, S. 209-341 – 42 pages just on the Dirac Equation.

[41] A typical example is the 1100-page compendium **Meschede** (2010), (14), Dircs euqtion is only mentioned twice: 4.5.2 Klein-Gordon-Gleichung, S. 183 – und 15.4.3 Feinstruktur im Einelektronen-Atom, S. 732.

[42] Dirac (1928), (5), § 2.The Hamiltonian for No Field, S. 615, – Gl. (9)

Thus, this relativistic wave equation (11) for an electron with rest mass m_0 reads – somewhat less compactly expressed:[43]

$$\frac{h}{2\pi i}\left\{a_1\frac{\partial\Psi}{\partial x}+a_2\frac{\partial\Psi}{\partial y}+a_3\frac{\partial\Psi}{\partial z}-\frac{1}{c}\frac{\partial\Psi}{\partial t}\right\}+m_0c\;a_4\Psi=0, \tag{13}$$

The four expressions $a_1 \ldots a_4$ mean the four-row Dirac matrices shown immediately below.[44]

$$\begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{pmatrix};\begin{pmatrix} 0 & 0 & 0 & -i \\ 0 & 0 & +i & 0 \\ 0 & -i & 0 & 0 \\ +i & 0 & 0 & 0 \end{pmatrix}; \tag{14}$$

$$\begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \\ 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \end{pmatrix};\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}. \tag{15}$$

These four-row matrices (14) and (15) are complex-valued and were first derived by Dirac based on sophisticated mathematical considerations from the following three two-row spin variables σ_1, σ_2 und σ_3.[45]

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} \text{ und } \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \tag{16}$$

[43] Schaefer (1937), (19) Relativist. Verallgem. d. Wellenmechanik: Diracsche Theorie, S. 451, Gl. (17)

[44] Schaefer (1937), (19) Relativist. Verallgem. d. Wellenmechanik: Diracsche Theorie, S. 451, Gl. (16)

[45] Dirac (1928), (5), Introduction S. 610 und § 2.The Hamiltonian for No Field, S. 613 resp. Equ. (7[-1]) — Dirac was very familiar with these Spin or Pauli matrices – as they are usually called today – because he himself had introduced them together with Pauli on the occasion of a discussion held in Copenhagen in early 1927 in order to be able to describe the three components of the angular momentum or spin of electrons. Pauli carried out this project immediately afterwards in a non-relativistic theory, Dirac, however, only a little later, but then within the framework of his relativistic quantum theory. – See Dirac (1972), (4), Recollections of an Exiting Era, S. 138

The *empty* Dirac equation.

If in Dirac's equation of the form (13) the parameter $m_0 = 0$ is set, i.e. the Dirac equation without electron is considered, the **empty Dirac equation** results.

Because the four Dirac matrices (14) and (15) each have four rows and are of complex-valued type, the Dirac equation (13) represents a system of four complex-valued equations for four complex-valued components $\Psi_1 \ldots \Psi_4$ of a complex wave vector (resp. spinor) $\mathbf{\Psi}$.

Accordingly (because of $m_0 = 0$), the "empty" system of equations Dirac's reads (fully expressed):[46]

$$-\frac{1}{c}\frac{\partial\Psi_1}{\partial t} + \frac{\partial\Psi_4}{\partial x} - i\frac{\partial\Psi_4}{\partial x} + \frac{\partial\Psi_3}{\partial z} = 0, \tag{17}$$

$$-\frac{1}{c}\frac{\partial\Psi_2}{\partial t} + \frac{\partial\Psi_3}{\partial x} + i\frac{\partial\Psi_3}{\partial x} - \frac{\partial\Psi_4}{\partial z} = 0, \tag{18}$$

$$-\frac{1}{c}\frac{\partial\Psi_3}{\partial t} + \frac{\partial\Psi_2}{\partial x} - i\frac{\partial\Psi_2}{\partial x} + \frac{\partial\Psi_1}{\partial z} = 0, \tag{19}$$

$$-\frac{1}{c}\frac{\partial\Psi_4}{\partial t} + \frac{\partial\Psi_1}{\partial x} + i\frac{\partial\Psi_1}{\partial x} - \frac{\partial\Psi_2}{\partial z} = 0. \tag{20}$$

These four complex-valued equations are – which may surprise some physicists – nothing else than Maxwell's equations in a strange guise.

This becomes apparent after a short calculation, as the four components $\Psi_1 \ldots \Psi_4$ are replaced by the following complex expressions:[47]

$$\mathbf{\Psi}_1 = i\,(E_z) \qquad \mathbf{\Psi}_3 = (H_z) \tag{21}$$

$$\mathbf{\Psi}_2 = i\,(E_x + iE_y) \qquad \mathbf{\Psi}_4 = (H_x + iH_y) \tag{22}$$

When the substitutions (21) und (22) are applied to (17) und (18), they

[46] Schaefer (1937), (19)Relativist. Verallgem. d. Wellenmechanik: Diracsche Theorie, S. 455, Gl. (30).

[47] Schaefer (1937), (19)Relativist. Verallgem. d. Wellenmechanik: Diracsche Theorie, S. 456 Gl. (31)

are transformed to the following relationships:[48]

$$-i\frac{1}{c}\frac{\partial E_z}{\partial t} + \left(\frac{\partial H_x}{\partial x} + i\frac{\partial H_y}{\partial x}\right) -$$
$$-i\left(\frac{\partial H_x}{\partial y} + i\frac{\partial H_y}{\partial y}\right) + \frac{\partial H_z}{\partial z} = 0 \tag{23}$$

und

$$\left(-i\frac{1}{c}\frac{\partial E_x}{\partial t} + \frac{1}{c}\frac{\partial E_y}{\partial t}\right) +$$
$$+\left(\frac{\partial H_z}{\partial x} + i\frac{\partial H_z}{\partial y}\right) - \left(\frac{\partial H_x}{\partial z} + i\frac{\partial H_y}{\partial z}\right) = 0 \tag{24}$$

After separation of the real and imaginary components of the two complex-valued equations (23) and (24), the following four real-valued relationships, known to every physicist, become apparent:[49]

$$\frac{\partial H_x}{\partial x} + \frac{\partial H_y}{\partial y} + \frac{\partial H_z}{\partial z} = 0; \qquad \frac{1}{c}\frac{\partial E_x}{\partial t} = \left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}\right)$$

und

$$\frac{1}{c}\frac{\partial E_y}{\partial t} = \left(\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}\right); \qquad \frac{1}{c}\frac{\partial E_z}{\partial t} = \left(\frac{\partial H_z}{\partial x} - \frac{\partial H_y}{\partial z}\right)$$

After applying the same substitutions (21) and (22) to the two equations (19) and (20) using the same procedure, the then resulting two equations, together with (23) und (24) result in the known four Maxwell equations for empty space (i.e. without the presence of electrically charged bodies.) In short: The complete set of empty Maxwell equations is obtained. Those equations are, in a notation that is commonly used today:

$$\operatorname{div} \boldsymbol{E} = 0; \qquad \operatorname{div} \boldsymbol{H} = 0 \tag{25}$$
$$\frac{1}{c}\frac{\partial \boldsymbol{E}}{\partial t} = -\operatorname{rot} \boldsymbol{H}; \qquad \frac{1}{c}\frac{\partial \boldsymbol{H}}{\partial t} = \operatorname{rot} \boldsymbol{E} \tag{26}$$

[48] Schaefer (1937), (19)Relativist. Verallgem. d. Wellenmechanik: Diracsche Theorie, S. 456 Gl. (31a)

[49] Schaefer (1937), (19)Relativist. Verallgem. d. Wellenmechanik: Diracsche Theorie, S. 456 Gl. (31b)

This highly significant physical fact is **not** a novelty. It has been documented in the German physics literature (at least) since 1937 in a formerly well-known (and here already repeatedly cited) textbook on theoretical physics by Schaefer. However, a detailed footnote there expressly warns against overestimating this result.[50]

The first hint to such an analogy was already given by **Darwin only two months** after Dirac presented his famous equation.[51]

Also in today's literature this important intrinsic connection between **quantum mechanical and electromagnetic** waves is still mentioned, but extremely rarely.[52]

The ominous complexity in physics.

Imaginary numbers have even been called magic and supernatural. But actually they are simply a consequence of $(+1)(+1) = (-1)(-1) = +1$, so that $\sqrt{-1} = \sqrt{+1}$ should be true, which is impossible.

So, in order to be able to operate mathematically "logically"with roots, the root of -1 had to be assigned a number i with "special meaning".

The use of i provides an additional, **purely mathematical** dimension – **without** any **physical** meaning or significance.[53] Therefore, the expression $\sqrt{-1}$ can be assigned many **different** meanings – **without** explicitly **naming** them. The **only** required **condition** is:

The real and the imaginary part of complex-valued numbers must stand **at right angle** (in space) **to each other**. In Schrödinger's ψ it is E and H, who stand normal, but in Dirac's case it is the **spatial components** of E and H, which stand at right angle to each other.[54]

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[50] Schaefer (1937), (19) Relativistische Verallgemeinerung der Wellenmechanik: **Diracsche Theorie,** S. 456, **Fussnote** 1.

[51] **Darwin (April 1928),** (3), The electromagnetic analogy, p. 658

[52] One example found was in **Sakurai** (1967), (18), **Derivation of the Dirac equation,** S. 80, Two-component Neutrino, S. 169, Eq. (3.465) / footnote ++

[53] Siehe z.B. Taschenbuch der Mathematik von Bronsten et al, Verlag Harri Deutsch, 7. Auflage 2008: 1.5 Komplexe Zahlen, S. 35.

[54] The **Schrödinger** equation concerns **one** scalar **energy**, whereas the **Dirac** equation concerns **six** vectorial **momentums**.

Conclusion:

The Dirac equation was created by **complex-valued decomposition** of the **Schrödinger** equation.

A **corresponding** decomposition of Schrödinger's **wave function** ψ, into a real and an imaginary part, makes it possible to interpret the conjugate complex "**square of** ψ" as a **scalar energy** state. This fact then allows an explanation of the experimentally proven **atomic waves** and the still very mysterious **matter waves** of Schrödinger described by ψ:

Schrödinger's matter waves are:
longitudinal **scalar waves** of **electromagnetic energy**,
of the ever omnipresent **material medium**,
called **ether**.

Acknowledgement:

The author would like to thank **Ruggero Santilli** for the many very **inspiring** discussions and suggestions in about **twenty** years.

* * *

APPENDIX:

Seven comments by the referee.

In this Appendix, the author would like to outline the following **seven aspects** indicated by the referee **during the submission** of this paper. Their presentation in an appendix, rather than via revision of the paper itself, was suggested by the referee him/herself.

1. Santilli's early concept (1956).

The first paper written by R. M. Santilli in 1956 (see Rf. [27] and its review at the beginning of Chapter 3 of Ref. [34]), was devoted to the existence of the **ether** as a **universal substratum** for the creation and propagation of **electromagnetic** waves.

As established experimentally, **electromagnetic** waves are "**transversal** waves" (in the sense that the oscillations are perpendicular to the direction of propagation) and, according to Santilli, that feature is only possible if the **ether** has characteristics similar to a form of "**rigidity**,"hence the title of paper [27]: «Perchè lo spazio è rigido» ("Why space is rigid").

This point is important for the analysis presented in this paper because scalar waves may one day prove to be **superluminal** that, in turn, is **only** possible for **longitudinal** waves (with oscillations parallel to the direction of propagation) that, in turn, is only possible for a "rigid" ether, otherwise **scalar** waves **would be** conventional electromagnetic waves.

2. No "etheral wind".

Santilli published paper [27] for the primary intent of **dismissing** the old criticism of the ether as a universal substratum given by the "ethereal wind".

From the quantum law $E = h\nu$, the electron is an "oscillation" with $0.829 \ 10^{20}\ Hz$, but of a **point** of the **ether**, and **not** of a "**little mass**" (inside the electron).

This **eliminates** the **ethereal wind**, because the motion of an electron implies **no motion** of any **mass**. What in reality happens is a motion of the structural oscillations from one point of the ether to others. The same holds for all elementary particles and, therefore, for matter.

According to Santilli [27], **inertia** is the **resiliency** by the **ether** against changes of motion.

It appears that this second point is significant for the paper because nobody will accept the ether as a universal substratum unless the ethereal wind is dismissed.

3. World creation by oscillation.

Santilli also points out in paper [27] (as well as in subsequent works, see review [34]) the thought provoking consequence of the above view to the effect that "**space** is completely **filled** up by the **ether**", while "**matter** is completely **empty**", to such an extent that, in the event "time could be stopped" (i.e. no oscillationsions), the entire universe would disappear.

4. No privileged reference frame.

The **ether** as a universal substratum is additionally dismissed on grounds that, the existence of a universal substratum would imply the existence of a **privileged** reference **frame** with consequential violation of special relativity.

By contrast, Santilli points out in [27] and [34]: A universal substratum implies no violation whatsoever of special relativity, because one would **never** be able to ascertain **theoretically** and **experimentally**, weather a mass is **at rest** with the universal substratum – with the consequential lack of existence of a privileged reference frame.

5. The beginning end of incompleteness.

The referee also suggested the quotation of Einstein's claim in [28] of the "lack of completeness" of **quantum** mechanics according to the (**probabilistic**) Copenhagen interpretation, because the above shown paper in fact presents a form of "completion" of **quantum** mechanical **waves**.

6. "Quantum waves" and the Hamiltonian.

Another general criticism of the **ether** as a universal substratum is that it is "**external**" (in the sense of being outside) of our world (of classical "**mass-points**"). Mathematically this means that, the ether **cannot** be represented with the **Hamiltonian** in the Schrödinger equation $H(r,p)\psi(t,r) = E\psi(t,r)$ since the Hamiltonian can only represent matter.

Santilli's confirmation of Einstein's criticisms of quantum mechanics [29] [30], including the "**completion**" of quantum mechanics into the covering **hadronic** mechanics [31] [32] [33], have been conceived to **represent the ether** via the **isotopic** element T in the **Schroedinger-Santilli isoequation**

$$H(r,p) \,.\, T(\psi, ...) \,.\, \psi(t.r) = E\ \psi(t,r).$$

7. Interaction by "isotopic ether mechanics".

The last point mentioned by the referee is the indication that, the interactions characterized by the **isotopic** element T (outlined just above) carry **no potential energy** that, in turn, can only be interactions between **matter** (oscillations) and the **ether**.

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COSMOLOGICAL ORIGIN OF QUANTUM UNCERTAINTY

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Abstract

This paper concerns the derivation of quantum uncertainty relation from brane cosmological model. It is based on representation of our Universe as a four-dimensional shell (brane) with finite thickness in the additional space. This model was introduced by Gogberashvilly and Rundall-Sundrum for the construction of interactions hierarchy and for expanding Einstein's general relativity laws to higher dimensions. With that, the thickness of brane is defined by the time of initial brane spontaneous creation. It is shown here that the Heisenberg uncertainty relation is a consequence of such cosmological model because we, being bound to four-dimensional space, are not able to measure precisely the parameters of particle movement in such a brane waveguide formed in the additional dimension.

1 Introduction.

Quantum mechanics, which mathematical apparatus was created by Schrodinger and Heisenberg, is based on the uncertainty principle, according which the uncertainty of mutual measurement of physical values, cannot be made lower some level [1]. Einstein with coauthors had put in doubt the completeness of quantum mechanics [2]. Copenhagen group of physisists lead by Bohr believed that it is sufficient to consider in practice only the result of measurement and the wave function describing the quantum state of particle experiences collapse under the measurement [3]. Afterwards, it was shown experimentally that paradoxical situation described by Einstein, Podolsky and Rosen [2]

Everett had proposed approach different in respect to Copenhagen group [4]. It supposes the simultaneous objective existence of multiple Universes, each of them corresponding to its own Hilbert space. This manifold is possibly infinite. Quantum measurement transfers observer into one or another Universe. The approach close to it is approach of hidden variables developed in [5]. Within this approach, Schrodinger equation on the wave function is supplemented by equation on local hidden variable defining objectively the density of probability for a particle to be in one or another state. It determines the result of measurement making the wave function entity more realistic.

Here, we consider the three-dimensional trajectory of particle in four-dimensional brane in five-dimensional universal space as hidden parameters. Then the waveguide equation attains the visual sense describing the propagation of particle as a wave in such membrane universal waveguide. In such a waveguide, it is possible also to consider also the corpuscular propagation of particle as spiral zigzaglike propagation of this particle with the reflection from the boundaries of waveguide. With that, spin moment of particle can be regarded as the mean of spiraled particle movement quantization in the universal space in contrast to the orbital moment describing spiral movement of particle in our space that is situating on the brane surface.

2 Uncertainty relation

Let's consider for simplicity the single-dimensional zigzag like scheme for propagation of a particle in such universal membrane (brane). It uses two-dimensional model [6, 7] that is shown in Fig.1 in general and its practically straight line part shown in Fig. 2 on the short range. range.

The boundaries of such waveguide can be regarded as cosmological domain walls first theoretically considered by [8] and [9]. Later, toroidal cosmological model was introduced [10], where large circle of tor is time

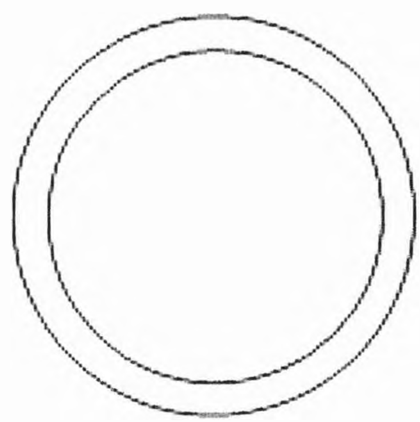

Figure 1: Two-dimensional model of universal membrane.

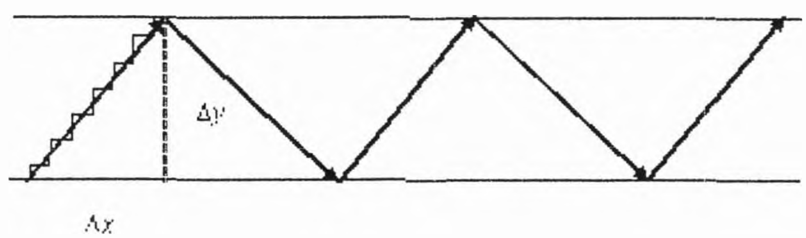

Figure 2: Waveguide model of particle propagation in universal membrane.

and small one is our three-dimensional space. So, our model here in Fig.1 corresponds to this transversal circle of this toroid model. With that, this toroid topology could be attained by Universe in the course of Bing Bang.

We have the possibility to determine the particle coordinate only when it is situated on the brane surface. Let us denote the uncertainty of coordinate as the half of distance between two successful measurements $\triangle x$ with minimally possible time between them. The minimum value of time between such measurements is realized atmaximum speed of particle replacement from one reflection to another in horizontal direction, i.e. at the movement of particle with speed of light. Particle speed in our space is defined as the rate of its replacement along its trajectory between two positions on brane (Fig. 1). Actual velocity of particle is determined by its trajectory in universal waveguide (Fig. 2). The maximal speed of particle realizes when particle moves completely in our space and minimal velocity realizes when particle reflects from upper boundary at the possibly most steep trajectory. The movement of particle can be imagined in quantum picture as the stepwise chain of transitions (quantum jumps) in horizontal and vertical directions (Fig. 2). With that, the uncertainty of velocity is determined by the rate of particle transmission only in vertical direction. It is equal to

$$\triangle v = \frac{\triangle y}{\tau}, \tag{1}$$

where $\triangle y$ is the thickness of membrane and

$$\tau = \frac{\triangle x}{c}. \tag{2}$$

is the time duration of one zigzag movement. It can be obtained from (1) and (2) that

$$\triangle x \triangle v = \frac{c \triangle y}{2} \tag{3}$$

The precision of the determination of particle's coordinate in the universal space (that is in radial direction in Fig.1 and vertical direction in Fig.2) is defined by brane thickness. The precision of all measurements is determined by minimal value of energy uncertainty. In relativistic theory, this value is equal to the energy of particle's rest mass mc^2. Let's consider the particle at rest as the particle that is not moving on brane which model is shown in Fig. 1 and the brane as quantum object that is rotating simultaneously in the clockwise and counterclockwise directions. Then, we will see that the energy of particle at rest is composed from kinetic movements of this particle in two opposite directions that is exactly equal mc^2. On the other hand, this particle's energy uncertainty is equal to energy of particle as de Broglie wave $h\omega = h\frac{2\pi c}{\lambda}$, where ω is frequency and λ is de Broglie wavelength. At the propagation in the waveguide this wavelength must be resonant to its thickness $\lambda = \triangle y$. Hence, we have

$$\triangle y = \frac{h}{mc} \tag{4}$$

That coincides completely with known relativistic formula for coordinate determination precision [11]. The substitution of (4) into (3) gives

$$\triangle x \triangle p = \frac{h}{2}. \tag{5}$$

When particles move along the brane with the velocity less than the speed of light, horizontal uncertainty $\triangle x$ increases and relation (5) transforms into the Heisenberg uncertainty principle

$$\triangle x \triangle p \geq \frac{h}{2}. \tag{6}$$

Thus, global universal membrane model (brane) yields the uncertainty principle of quantum mechanics describing, as it seemed before, only microscopic world. This description of particle's movement proceeds on the corpuscular level by the introduction of objectively existing additional dimensions in the framework of membrane universal waveguide with the thickness equal to particle's de Broglie wave.

3 Conclusion.

Thus, introduction of additional dimensions gives the possibility for quantum mechanics to be more complete explaining the uncertainty of particle parameters measurement by its corpuscular propagation in the universal membrane waveguide. It corresponds to the theory of hidden variables that, in the contrast to the theory of local hidden variables initially considered by John Bell [12, 13], is nonlocal one since points in additional dimensions have nonlocal character in respect to local points in our space-time. Eventually, Bell wrote in his book [14]: "If a hidden-variable theory is local it will not agree with quantum mechanics, and if it agrees with quantum mechanics it will not be local." Thus, non-local hidden variables used here support quantum mechanics yielding its main item - uncertainty principle.

Introduction of such additional dimensions makes, also, general relativity more physically substantiated. General relativity theory states that gravitation is a consequence of space-time curvature, but the curvature itself is just a mathematical abstraction. With the objective existence of multidimensional space-time, our four-dimensional space-time is the insertion in this multidimensional space and, accordingly to one of Friedman solutions of Einstein equation, is described by four-dimensional sphere with scalar curvature characterized by radius of this sphere. The finite thickness in additional dimensions yields quantum description of reality.

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IS SPACE ABSOLUTE?

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Abstract

The hypothesis that empty space and particles are made up of four-dimensional (4D) spheres of space whose diameter is Planck's length provides a privileged frame of reference or ether, so that the relativistic effects are due to the true Lorentz contraction of physical objects. On the other hand, the fact that the particles are also formed by 4D spheres allows us to deduce the relativistic effects from the structure of the atoms.

Keywords: Space-time discrete; Fundamental length; Special relativity; Planck length; Fundamental inertial frame; Privileged frame of reference; Lorentz-Fitzgerald contraction; Time dilation.

1 Introduction

Space is a fundamental quantity in physics, because it cannot be defined through other fundamental physical quantities. In classical physics, time is an absolute fundamental quantity. For Newton, space and time are independent and absolute entities. For Einstein, space and time are instead united in a 4D structure called space-time. According to general relativity, this space-time is continuous and relative. Concepts such as the relativity of simultaneity, length contraction, time dilation, etc., apparently make no sense and collide with human experience. On the other hand, in quantum mechanics, energy, momentum, spin, and most of the properties of matter, are discrete.

In quantum gravity models, space-time is discrete, that is, it has a fundamental length that cannot be divided into smaller ones. The discrete space hypothesis, in principle, collides with Einstein's theory of special relativity, because for an observer moving at constant speed, this fundamental length would be shorter.

Can space and time be divided into smaller and smaller units, or is there a limit? Are space and time a continuum or are they composed of indivisible discrete units? These and similar questions were raised by Greek and medieval philosophers, such as Zeno of Elea presents in the Paradox of Plurality [1] and Maimonides [2] in the Guide for the Perplexed.

2 Planck length

According to general relativity, space-time is continuous. However, there is no experimental evidence for this. We're probably convinced of continuity as a result of education. In recent years however, both mathematicians and physicists have asked if it is possible that space and time are discrete? Smolin states that space is formed from atoms of space: *"If we could probe to size scales that were small enough, would we see atoms of space, irreducible pieces of volume that cannot be broken into anything smaller?"* that he calls *"Atoms of Space and Time"* [3].

Minimum values of volume, length and area are measured in Planck units [3]. The Planck scale combines gravity (G), quantum mechanics (h) and special relativity (c) [4]. Padmanabhan shows that the Planck length provides a lower limit of length in any suitable physical [5]. "*It is impossible to construct an apparatus which will measure length scales smaller than Planck length. These effects exist even in flat space-time because of vacuum fluctuations of gravity* [6].

Planck assumed that Newton's gravitational constant, Planck's constant and the speed of light were the most important universal constants. Using a dimensional analysis, he obtained the Planck mass, length, time and energy [7, 8]. There are several theories that predict the existence of a minimum length) [9,10]. These theories are related to quantum gravity, such as string theory and double special relativity, as well as black hole physics [11-13]. "... *a fundamental (minimal) length scale naturally emerges in any quantum theory in the presence* *of gravitational effects that accounts for a limited resolution of space-time. As there is only one natural length scale we can obtain by combining gravity (G), quantum mechanics (h) and special relativity (c), this minimal length is expected to appear at the Planck scale*" [4].

Messen showed that the minimum length a, is given by the total energy of the universe E_u in a four-dimensional space, $E_u = hc / 2a$. The different excitations of space-time give rise to different particles [14]. "*... we learned already from the development of relativity and quantum mechanics that Nature can impose restrictions on our measurements because of two universal constants: the velocity c and the quantum of action h. Could Nature impose a third restriction, resulting from the existence of a universally constant quantum of length a and a universally constant quantum of time a/c?*" [15].

Haug proposes different methods of measuring the Planck length independently of the gravitational constant *G*. The Planck length is both a physical measurement and the diameter of the true fundamental particle: "*The gravitational constant is a composite (derived) constant, while the Planck length represents something physical; it is the shortest reduced Compton wavelength possible. According to recent developments in mathematical atomism, there are also strong indications that the Planck length is the diameter of the only truly fundamental particle, namely an indivisible particle that together with void is making up all matter and energy*" [16].

On the other hand, Haug, raises the hypothesis that Hesisenberg's uncertainty principle collapses on the Planck scale [17, 18]. The search for a quantum theory of gravity leads to a generalisation of the Heisenberg uncertainty principle (GUP) on the Planck scale. Adler uses Newtonian and general relativistic gravity and modifies the uncertainty principle with an additional term "*In both theories it is clear that the extra term must be proportional to the energy or momentum of the photon, so on purely dimensional grounds the order of magnitude of the extra term is uniquely determined. As a consequence there is an absolute minimum uncertainty in the position of any particle such as an electron. Not surprisingly the minimum is of order of the Planck distance. In view of the absolute minimum position uncertainty one may plausibly question whether any theory based on shorter distances, such as a space-time continuum, really makes sense*" [19]. Other authors [20, 21], also conclude that, on the Planck scale, the fluctuations are of the same order of magnitude as the distances involved.

"*We propose a GUP consistent with String Theory, Doubly Special Relativity and black hole physics, and show that this modifies all quantum mechanical Hamiltonians. When applied to an elementary particle, it implies that the space which confines it must be quantized*" [22]. The same authors solve the Klein-Gordon and Dirac equations corrected by GUP: "*We again arrive at quantization* *of box length, area and volume* and *an indication of the fundamentally grainy nature of space*" [23].

In doubly special relativity, a second parameter independent of the observer is introduced, in addition to the speed of light. It is postulated as the second invariant parameter: Planck length [24-27], mass [28, 29] or energy [30, 31].

3 Discrete space-time (DST)

One of the main objections to discrete space-time is that the existence of a discrete space-time atom is incompatible with the contraction of length and the time dilation of special relativity. However, it must be borne in mind that for lengths and times close to the Planck scale, the Pythagorean theorem is not verified. Therefore, some authors use a modified distance formula [32-35]. Specifically, Crouse and Skufca derive the relativistic phenomena of Lorentz-Fitzgerald contraction and time dilation using a modified distance formula that is appropriate for discrete spaces. They "*show that length contraction of the atom of space does not occur for any relative velocity of two reference frames. It is also shown that time dilation of the atom of time does not occur*". "*... It was shown that when applied to distances near the Planck scale, the new formula yields distances much different than those predicted by the Pythagorean theorem. But for larger length scales, the distances calculated with the new formula converge to those calculated using the Pythagorean theorem. When using the new distance formula in the otherwise typical derivations of time dilation and length contraction, one sees that the atom of space and atom of time are indeed immutable - true constants of nature and independent of the speed of any observer*" [36].

Quantum particles in discrete space-time are studied in relation to relativistic dynamics [37, 38]. Farrelly and Short studied the causal evolution of a single particle in discrete space-time [39]. There is evidence of discrete structures on the largest scales, for example superclusters and the redshift [40]. Cowan already said in 1969 that redshift can only occur with discrete values [41]. This was subsequently confirmed by Karlsson [42].

As early as 1930, Werner Heisenberg used discrete space-time to explain the electron's self-energy. For Werner Heisenberg, Henry Flint and Arthur Ruark, the discretisation of space-time is inherent in uncertainty relationships [1]. Interest in discrete space-time has increased in recent years due to the appearance of loop quantum gravity [43-45].

4 Ether or fundamental inertial frame

In the Michelson-Morley experiment to explain the constancy of the speed of light, Lorentz assumed that the arm of the interferometer contracts (Lorentz-Fitzgerald contraction) [46, 47] in the direction of the movement of the Earth, which also gives rise to time dilation [48] thus maintaining the absolute immobility of the ether [49], which is also the logical conclusion of the Michelson-Morley experiment.

From the time of Einstein's theory of special relativity, the ether theory was abandoned and Einstein's point of view was accepted: "*There is no room for ether in special relativity.*" During the 20th century it was taught that the Maxwell-Lorentz ether does not exist, there are only "fields" in a vacuum [50].

The reason for abandoning the Lorentz-FitzGerald hypothesis is illustrated in Einstein's words: "*The introduction of a 'luminiferous ether' will prove to be superfluous inasmuch as the view here to be developed will not require an 'absolutely stationary space' provided with special properties*" [51].
However, Einstein was convinced of the existence of the ether, even though there was no proof. Einstein introduced the concept of "new ether" in 1916, to refer to space-time, since it has physical properties. In a letter to Lorentz he says: "*I agree with you that the general theory of relativity is closer to the ether hypothesis than the special theory. This new ether theory, however, would not violate the principle of relativity, because the state of this $g_{\mu\upsilon}$= ether would not be that of rigid body in an independent state of motion, but every state of motion would be a function of position determined by material processes*" [52].

Again in 1920 writes: "*Recapitulating, we may say that according to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, there exists an ether. According to the general theory of relativity space without ether is unthinkable; for in such space there not only would be no propagation of light, but also no possibility of existence for standards of space and time (measuring-rods and clocks), nor therefore any space-time intervals in the physical sense. But this ether may not be thought of as endowed with the quality characteristic of ponderable media, as consisting of parts which may be tracked through time. The idea of motion may not be applied to it.*" [53].

Therefore Einstein accepts the existence of a static ether. The majority of physicists of the time (Newton, Faraday, Fizeau, Maxwell, Lorentz, Poincaré, Planck and many others) considered that ether was a real substance [50]. Dirac, Schwinger and other physicists also believe the existence of the ether is possible. Even today the idea of the ether is still valid and different studies are still being carried out [54-57].

For Isaev, 20th century physics is the physics of the ether. "*It is shown that there exists a new physical reality – the Ψ–ether. All the achievements of quantum mechanics and quantum field theory are due to the fact that both the theories include the influence of Ψ–ether on the physical processes occurring in the Universe. Physics of the XXth century was first of all the physics of Ψ–ether*" [50].

Ether is also used as a privileged frame of reference in the theory of gravitation. [58-68]. This gives rise to an alternative interpretation of special relativity, initiated by Lorentz [48] and Poincaré [69, 70].

As the result of the Michelson-Morley experiment was not completely null, but smaller than expected, Cahill and Kitto reinterpreted the experiment, taking into account the index of refraction of air. This gives rise to *"an absolute speed of the Earth of v =* 359±54 *km/s, which is in excellent agreement with the speed of v =* 365±18 *km/s determined from the dipole fitt, in 1991, to the NASA COBE satellite Cosmic Background Radiation (CBR) observations"* [71].

For Cahill, space is a quantum foam system and, in 2004, he analysed a total of seven experiments in relation to ether drift; they include the Michelson-Morley experiment and Cahill concludes that absolute motion has been detected in these experiments. "*...an analysis of date from seven experiments demonstrates that absolute motion relative to space has been observed by Michelson and Morley (1887), Miller (1925/26), Illingworth (1927), Joos (1930), Jaseja et al (1963), Torr and Kolen (1981), and by De Witte (1991)*" [72]. The speeds obtained in these experiments are in perfect agreement with the speed of the solar system obtained from the radiation of the cosmic microwave background. On the other hand, said radiation indicates that there is a privileged reference system that, in principle, is in contradiction with the theory of special relativity.

The privileged frame of reference has been used in quantum mechanics. *"In the context of modern quantum field theory we instead introduce the structured quantum vacuum, which fulfills the role that Einstein assigned to the non-material ether."* [73]. *"It is generally assumed that the physical vacuum of particle physics should be characterized by an energy momentum tensor in such a way to preserve exact Lorentz invariance. On the other hand, if the ground state were characterized by its energy-momentum vector, with zero spatial momentum and a non-zero energy, the vacuum would represent a preferred frame"* [74]. And is also used to explain the rotation curves of galaxies [75].

Finally, the characteristics of the Higgs field are reminiscent of those of the ether. Ultimately, the ether theory continues to be used today, although it is called the structured quantum field, quantum foam, fundamental inertial frame, privileged frame of reference, etc. All this clearly indicates that space-time has structure, is discrete and its length corresponds to Planck's length.

5 Gedanken experiment

5.1 Alice and Bob move away at relativistic speeds

Suppose Alice and Bob walk together at the speed of one step per second. At a given moment they decide to separate, so that their trajectories form an angle $\alpha = 90 - \varphi = 90 - \text{arc tag } 3/4 = 52.1°$. Let us analyse the situation after five steps or five seconds. For Alice (Figure 1), Bob moves away at the speed of 0.8 steps per second along the x-axis, and at the speed of 0.6 steps per second along the y-axis. Therefore after five seconds Bob's coordinates will be (4,3). However, from Bob's point of view, the situation is different, since for Bob, it is Alice who moves away (Figure 2) and therefore it is Alice who has travelled four steps in the x direction, and three in the y direction.

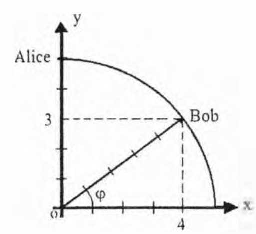

Figure 1. Alice and Bob's situation in Alice's framework

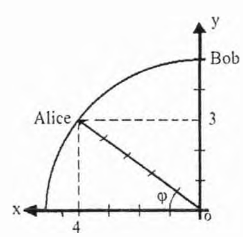

Figure 2. Alice and Bob's situation in Bob's framework.

Each observer chooses the direction of their movement as the vertical axis, so that the axes are turned at an angle of 52.1°, counter-clockwise. If we now change the speed of one step per second, by the speed of light in vacuum c, we have a symmetrical situation, equivalent to the paradox of the twins. On the y-axis we have seconds and, on the x-axis, light seconds. In Alice's frame (Figure 1), Bob moves away for five (t_A) seconds at the speed 0.8c, so Bob has moved away four light seconds ($x_0 = v\ t_A = 0.8c\ 5$), while the clock Bob will score:

$$t_B = t_A\sqrt{1-v^2/c^2} = 3 \text{ seconds} \qquad (1)$$

However, in Bob's frame (Figure 2), Alice is the one that has drifted away for five seconds at speed of 0.8c, so Alice is within four light seconds of Bob and her watch will tick three seconds. Therefore, in Alice's frame of reference, Bob's clock runs slow, while in Bob's frame of reference it is Alice's clock that runs slow. Furthermore, special relativity implies that, since Alice takes three seconds (t_B) for Bob, it turns out that Bob has travelled a contracted Lorentz distance of:

$$x = x_0\sqrt{1-v^2/c^2} = vt_A\sqrt{1-v^2/c^2} = vt_B = v_x t_y = 2.4 \text{ light seconds} \quad (2)$$

The velocity v is in the x (v_x) direction, while Bob's time (t_B), in Alice's frame, is in the y direction (t_y). Obviously on the xy plane, the above equation is not applicable and neither on the xt plane, so there is no distance contraction.
In Alice's frame, Alice moves five seconds on the vertical axis t, and Bob moves five seconds in space-time (xt plane). In Bob's frame of reference, he moves five seconds on the vertical axis t, and Alice moves the same time but in the xt plane.

The twin paradox is resolved by keeping in mind that the receding twin has to accelerate, decelerate, and turn around, so it cannot say that it is at rest in its frame of reference. "*...the accelerated twin cannot say that he is at rest because the gravitational field he experiences has no source. It is an ad hoc gravitational field introduced into the description when we say that twin A is at rest and B travels*" [76].

5.2 Alice and Bob approach at relativistic speeds

Now suppose Alice and Bob are approaching with a speed of 0.8c. Bob has a chronometer that will start when both intersect, while Alice has made an isosceles triangle using 3 mirrors, as shown in Figure 3.

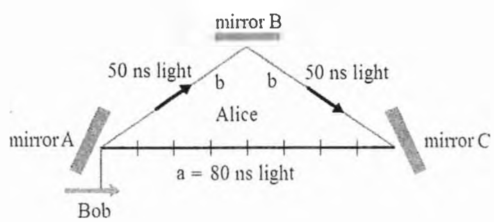

Figure 3. Start of timing according to Alice.

Alice´s frame. When Alice and Bob meet, Bob sends a photon or pulse of light to Mirror A, while starting the stopwatch. The time Bob takes to travel the distance between mirrors A and C will be:

$$t_a = \frac{a}{v} = \frac{a}{0.8c} = 100 \ ns \quad (3)$$

We choose segments b, so that the photon that hits mirror A and that is reflected in mirror B, reaches mirror C at the same time that Bob, results:

$$t_a = \frac{2b}{c} => b = 50 \ ns \quad (4)$$

this way, the photon and Bob reach mirror C at the same time, therefore, the photon will stop the stopwatch (Figure 4). Obviously, the distance between Bob's stopwatch and mirror A or C must be negligible compared to segment b or included in said segment.

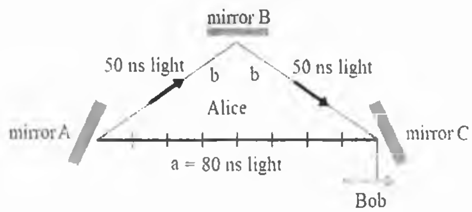

Figure 4. End of timing according to Alice. Stopwatch stopped.

Bob's frame. Like before, Bob has a chronometer that will start when both intersect (Figure 5).

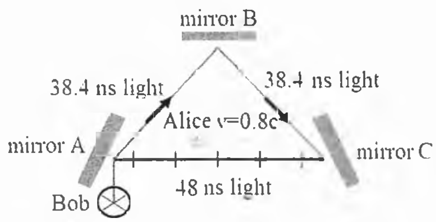

Figure 5. Start of timing according to Bob.

In this case, Alice gets closer to Bob and therefore the mirror triangle will contract in the direction of movement, according to special relativity. In this way the distance Bob has to travel is:

$$a' = a\sqrt{1 - v^2/c^2} = 48 \ \ ns \ \ luz \qquad (5)$$

and it will take a time:

$$t_b = \frac{a'}{v} = t_a\sqrt{1 - v^2/c^2} = 60 \ \ ns \qquad (6)$$

Since the height of the triangle does not contract, its value will be the same in any reference frame, then:

$$h = \sqrt{b^2 + (a/2)^2} = 30 \ \ light - ns \qquad (7)$$

Instead, the distance the photon must travel is:

$$d = 2b' = 2\sqrt{(a'/2)^2 + h^2} = 76.8 \ \ light - ns \qquad (8)$$

Therefore, the light pulse will reach mirror C after Bob has passed (Figure 6) and consequently the stopwatch will not stop.

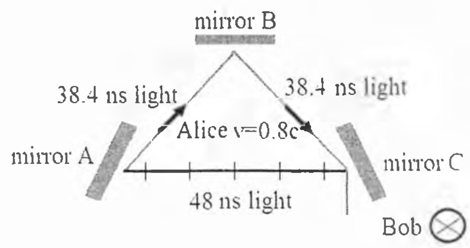

Figure 6. End of timing according to Bob. Stopwatch running.

In short, depending on the frame of reference, the stopwatch will be stopped or will continue to run. It is a thought experiment that can be studied by speeding up Alice, speeding up Bob, or both. In any case, it is a paradox, since the watch cannot be both stopped and working at the same time.

6 Lorentz contraction

For Lorentz, Poincare, Amelino-Camelia and other authors, what contracts is the object, not the space. *"..... according to FitzGerald-Lorentz length contraction, different inertial observers would attribute different values to the same physical length. The idea that the Planck length should play a truly fundamentall role in the structure of space-time appears to be in conflict with the combined implications of the Relativity Principle and Fitgerald-Lorentz length contraction"..."The Planck length could play a similar role in fundamental physics, i.e. it could reflect the properties of a background, but then the presence of such a background would allow to single out a "preferred" class of inertial frames for the description of the short-distance structure of space-time"* [24].

Therefore, it is necessary to somehow justify this contraction of the object, for which the structure of the elements that make up the atoms must be known. It is enough, for this, to focus on the hydrogen atom, since from it all the others are obtained.

6.1 Contraction of the particles

The hypothesis is that the universe is made up of four-dimensional (4D) space spheres whose diameter is Planck's length $l_p = \sqrt{G\hbar / c^3}$. Each of the spheres has two possible states, state at rest and movement of rotation. Rest spheres are empty space, and the rotational motion of the spheres gives rise to different properties of the particles. Of the four dimensions, three are observed as space (x, y, z) and the fourth (*u=ct*) spatial dimension is observed as time. Planck's four-dimensional spheres are atoms of space and time that Smolin comments [3].

In addition the 4D Planck sphere has two rotations, one in three-dimensional space and one in the fourth dimension. Rotation in the fourth dimension (ω_u) rotates the u-axis and another spatial axis around any two axes. For example, the u and y axes spinning around the x and z axes. In the rotation in space (ω_e) it is rotated around the u-axis and another spatial axis. For example, the x and z axes spinning around the u and y axes.

Each Planck 4D sphere can rotate both in 3D space and in the fourth dimension (u = ct, Figure 7), resulting in the following possible combinations [77-81]:

- zero rotations (vacuum space);
- one spatial rotation, ω_e (photons);
- one rotation in the fourth dimension, ω_u (neutrinos);
- two rotations i.e. one spatial rotation, ω_e, and one rotation in the fourth dimension, ω_u (first-generation electrons and quarks).

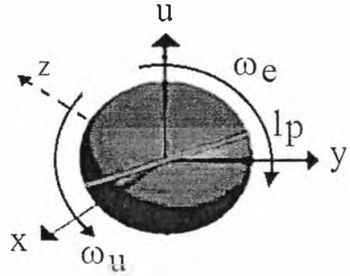

Figure 7. Rotations of a 4D Planck sphere

Static spatial spheres are not observed; it is what we call empty space. We can observe the spheres that rotate on themselves as elementary particles, such as electrons, photons and the first generation of quarks and neutrinos. The energy of rotation in the fourth dimension gives rise to the mass at rest and the period of rotation in the fourth dimension gives rise to the electric charge.

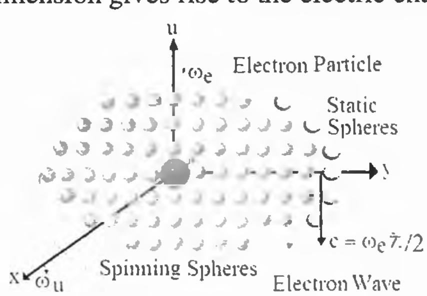

Figure 8. 2D representation of an electron

The 4D Planck spheres are linked by Planck's force, so that spinning one of them will drag it to adjacent spheres. The linear velocity of rotation (Figure 8) will increase as we move away from the rotating sphere, until the speed of light c is reached at a distance r, then

$$v = \omega_u l_p \qquad (9)$$

$$c = \omega_u r \qquad (10)$$

The resting mass of the particle is due to the energy of the rotation [77, 79-83].

$$E = mc^2 = \frac{1}{2}\hbar\omega_e = \hbar\omega_u = \frac{\hbar c}{\lambdabar} \qquad (11)$$

Where the reduced Compton wavelength $\lambdabar$, is the diameter of the particle $c = \omega_e \lambdabar / 2$. The mass can also be considered as the space in the fourth dimension of the 4D Planck sphere, projected onto the 3D sphere that we observe as a particle [81].

The equation that determines the characteristics of the particle is $c = \omega r$. An equation with two unknowns ω and r. In the same way that a skater increases his rotation by shrinking his arms, particles increase their rotation with increasing energy and at the same time decrease their radius r. Therefore, the value of the mass is not determined except for the maximum (Planck mass) and minimum (mass at rest) values [79, 81, 83].

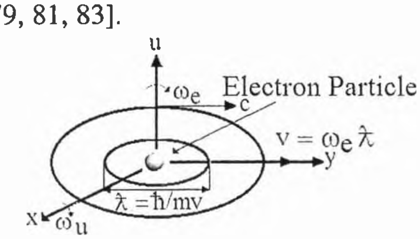

Figure 9. Rotation and displacement velocity of the electron

The rotation ω_e in the space of the Planck 4D sphere determines the speed of translation of the particle in 3D space; the greater the energy, the greater the speed. Speed corresponding to the De Broglie wavelength.

$$\lambda = h / mv \qquad (12)$$

Where $v = \omega_e \lambda / 2\pi$ is the speed of displacement in 3D space, and the wavelength λ, is the distance that the particle travels while to rotate a complete round.

The rotation ω_e is the one that generates the De Broglie wavelength. The rotation ω_u is what generates the Compton wavelength. Since both rotations are perpendicular, their moments also will be (Figure 10).

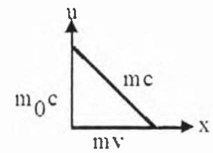

Figure 10. Particle momentums

$$mc = \sqrt{(mv)^2 + (m_0c)^2} \qquad (13)$$

From where

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}} \qquad (14)$$

At small speeds, m and m_0 coincide, but at relativistic speeds the mass m increases due to the increase in the rotation energy.

The electron is a Planck sphere in the minimum energy state (m_0). The maximum energy will be the Planck energy ($m_p\ c^2$). This gives us a maximum speed for the electron.

Haug [16, 84] has suggested that there is a maximum velocity for any particle with a rest mass, as given by the previous equation para m igual a la masa de Planck. Haug has calculated this maximum speed with 50 decimal places [18].

4D Planck spheres are always spheres regardless of the movement of the observer. As energy increases, the rotation of the particles increases and therefore the size decreases. The relativistic effects are due to the contraction of physical objects as they move through 4D space. 4D space can be considered a fundamental frame of reference or "ether" according to the alternative interpretation of the special relativity of Lorentz [48], Poincaré [69, 70] and others [58-60]. *"The "relativistic" effects, which essentially follow from the Lorentz transformation, are all due to the "true" Lorentz contraction of physical objects as they are moving through the "ether" or fundamental inertial frame"* [66].

6. 2 Contraction of atoms

Each atom is made up of a nucleus and one or more electrons rotating around the nucleus. In turn, the nucleus is made up of protons and neutrons that are called nucleons. Nucleons are made up of a triad of up and down quarks with positive and negative electric charges, respectively.

While the mass is the energy of the rotation of the fourth dimension, the electric charge is the period of that rotation. Therefore the mass and the electric charge are related by the Planck constant.

$$E = mc^2 = \frac{2\pi^2 h}{q} \qquad (15)$$

Obviously, in the previous equation, the electric charge is in seconds. Just multiply by an ampere to have the electric charge in coulombs, an arbitrary unit of electrical charge.

Rotation ω_u generates the electric charge, and rotation ω_e of the electric charge generates a magnetic field that will have two components: a spatial component and another in the temporal or fourth dimension direction. The spatial component originates the anomalous magnetic moment of the electron [79, 81] while the component in the temporal direction causes the electrons to attract each other. The union or collision of three electrons gives rise to the quark down, which will have a rotation equal to three times the rotation of the electron and therefore its charge will be 1/3 of the electric charge of the electron. In the same way, the shock of three positrons gives rise to two quarks up, which will have a rotation equal to 3/2 of the rotation of the positron and therefore its charge will be 2/3 of the electrical charge of the positron [79, 82].

The energy of the rotation of the quarks, originates the mass of the quarks. By joining three quarks, a new rotation is generated, that originates the mass of the protons and neutrons that make up the nucleus [79]. Therefore, as the energy of the object increases, the nuclei that make up the atoms contract, as a consequence of the increased rotation of the constituent quarks.

In addition to the nucleus, we have electrons. Next, let's look at the electron in the hydrogen atom. In 1913, Bohr drew the hydrogen atom with a proton in the nucleus and an electron that spins in circle orbits around the nucleus (Figure 11). In a circle orbit, the electrostatic force of attraction (F_e) is equal to the centripetal force (F_C), then:

$$K\frac{q^2}{r^2} = \frac{mv^2}{r} \qquad (16)$$

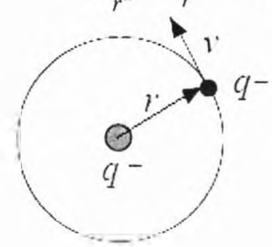

Figure 11. Bohr atomic model

If we consider that the speed of the electron in the free state is $v = \alpha c$ [83], it results in:

$$K\frac{q^2}{v} = mvr = \hbar \qquad (17)$$

Then the electron has a minimum angular momentum equal to $\hbar$. The total energy results:

$$E = \frac{1}{2}mv^2 - K\frac{q^2}{r} = \frac{p^2}{2m} - K\frac{q^2}{\hbar}p \qquad (18)$$

The system will be stable in the state of minimum energy, thus annulling the first derivate:

$$\frac{dE}{dp} = \frac{p}{m} - K\frac{q^2}{\hbar} = 0 \quad \rightarrow \quad p = K\frac{q^2}{\hbar}m \qquad (19)$$

Therefore, in the hydrogen atom the electron is in the free state, with minimal energy and with a minimum moment equal to $\hbar$, so it cannot radiate energy.

In addition, it must be taken into account that Coulomb's law is only valid for charges at rest, so the effect of speed must be taken into account. That makes the orbit that the electron describes open, so it moves around a spherical surface of radius:

$$r = \frac{\hbar}{mv} = a_0 \qquad (20)$$

Which is the Bohr atomic radius.

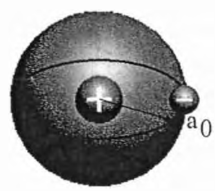

Figure 12. Electron orbital sphere

The electron moves at all times over a_0 radius sphere (figure 12) until it is observed, as the electron absorbs the energy of the observation and then modifies its angular momentum, still, the Heisenberg's uncertainty principle is always verified in a way that the quotient between the energy it has and the acquired energy as a result of the observation is the wave function. From that function it is easy to deduce the Schrodinger equation [78, 79].

Einstein was right when he said: *"I think that a particle must have a separate reality independent of the measurements. That is an electron has spin, location and so forth even when it is not being measured. I like to think that the moon is there even if I am not looking at it"* [85].

The electron, in the hydrogen atom, rotates around the nucleus with a minimum energy and a minimum angular momentum $\hbar$. In any other atom, the energy of the electron will be greater and the angular momentum will be greater than or equal to ħ. Therefore, by applying energy to the object, the electrons will increase their momentum mv, bringing them closer to the nucleus due to the principle of conservation of angular momentum. If *mv* increases r decreases ($mvr = n\hbar$).

Therefore, the movement relative to the ether affects the nucleus and the distance of the electrons from the nucleus, causing the contraction of the object. Or in FitzGerald's words: "*We know that electric forces are affected by the motion of the electrified bodies relative to the ether, and it seems a not improbable supposition that the molecular forces are affected by the motion, and that the size of a body alters consequently*" [47]. The contraction of the object is due to the decrease in the number of 4D Planck spheres in the core, it does not change the size of the spheres. It also decreases the number of 4D Planck spheres between the nucleus and the electrons.

Obviously, in the paradox of the isosceles triangle of mirrors, the contraction of the object undoes the paradox, because if the sides of the triangle are chosen properly (equation (4)), the chronometer stops in both frames of reference.

Ultimately, due to the movement relative to Planck's 4D spheres that make up empty space, the particles increase their rotation and consequently the object contracts. Planck's 4D spheres constitute a privileged frame of reference or "ether" that remains motionless. The size of these spheres depends on the Planck length and the speed of light, which are the two constants used in the doubly special theory. Planck's 4D spheres originate the space-time structure proposed by Amelino-Camelia. "*I propose a general class of space-times whose structure is governed by observer independent scales of both velocity (c) and length (Planck length), and I observe that these space-times can naturally host a modification of FitzGerald-Lorentz contraction such that lengths which in their inertial rest frame are bigger than a "minimum length" are also bigger than the minimum length in all other inertial frames*" [24].

7 Time dilation

The time dilation has been verified on many occasions: in airplanes [85, 86] and in satellites of global positioning systems [87]. Even today, experiments are carried out to increase the precision of the measurements made [88, 89] and recently by an international group of physicists by accelerating lithium ions used as a clock in motion [90].

When we apply energy to the electron, its wavelength decreases. In the same way, when applying energy to an atom, the distances of the different energy levels decrease and therefore the frequency of each transition increase.

Combining equations (11) and (14)

$$E = \frac{hc}{\lambda} = \hbar\omega = mc^2 = \frac{m_0 c^2}{\sqrt{1-v^2/c^2}} = \frac{hc}{\lambda_0\sqrt{1-v^2/c^2}} = \frac{\hbar\omega_0}{\sqrt{1-v^2/c^2}} \qquad (21)$$

Therefore, by decreasing the period of the transition, the time for the same number of transitions will decrease. Hence, the atomic clock in motion indicates a shorter time than the atomic clock at rest. The equation (21), can be put in function of the period of rotation.

$$t = t_0\sqrt{1-v^2/c^2} \qquad (22)$$

On the other hand, in the International System the second is defined as the duration of 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of the Cesium 133 atom. The two hyperfine levels of the Cesium atom get closer, it is not the space that contracts and pulls them. This approach results in shorter transitions. The size of the atoms is reduced, due to conservation of angular momentum, as a consequence of increasing the momentum *mv*, as the speed increases with respect to Planck's 4D spheres, which constitute empty space.

We need the concept of inertial system to be able to know which object moves (twin paradox). However, the particles know perfectly what particle is moving, because their energy in space ($\hbar\omega$) is greater than their energy at rest ($\hbar\omega_0$). Therefore the period t, which corresponds to the rotation ω_u does not vary with the speed. What varies is the time that the particle moves in space (Figure 13).

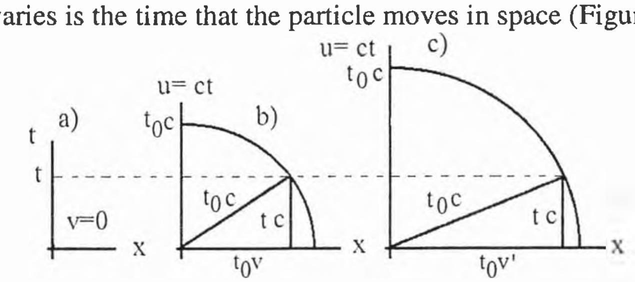

Figure 13. a) observer at rest. b) observer in motion at speed v. c) observer in motion at the speed v'> v

8 Expansion of the universe

8.1 Flat space-time

The equation that determines the characteristics of the particle is $c = \omega r$, it is the same that determines the expansion of the universe r (x, y, z) = c t. As space expands, the fourth dimension $u = c\, t$ expands.

Since the fourth dimension u is perpendicular to the other three, it is.

$$r^2(x, y, z) + u^2 = 2c^2t^2 \qquad (23)$$

Deriving twice with respect to t, it results:..

$$r\frac{dr}{dt}+u\frac{du}{dt}=2c^2t \qquad (24)$$

$$\left(\frac{dr}{dt}\right)^2+r\frac{d^2r}{dt^2}+\left(\frac{du}{dt}\right)^2+u\frac{d^2u}{dt^2}=2c^2 \qquad (25)$$

What we can put in the form:

$$\left(\frac{dr}{dt}\right)^2+\left(\frac{du}{dt}\right)^2=c^2 \qquad (26)$$

$$r\frac{d^2r}{dt^2}+u\frac{d^2u}{dt^2}=c^2 \qquad (27)$$

Equation (26) can be put:

$$v^2+v_u^2=c^2 \qquad (28)$$

Being v the speed in space and v_u the speed in the fourth dimension. That is, the vector sum of the speed in space and in the fourth dimension is constant and equal to the speed of light. Therefore, the movement in space-time is reduced to a constant movement at the speed of light c in the xt or ru plane, as seen in section 5. At rest (v = 0) we move in the fourth dimension at the speed of ligh.

Clearing the speed in the fourth dimension, it turns out:

$$v_u=\sqrt{c^2-v^2} \qquad (29)$$

Dividing by c and multiplying by t, we obtain:

$$t'=\frac{v_u}{c}t=t\sqrt{1-v^2/c^2} \qquad (30)$$

The equation above is the relativistic formula of time dilation. Furthermore, the previous formula indicates that we can consider time as two-dimensional. There is a time in space (t), which we observe as space, and there is a time in the fourth dimension (t ') that we observe and measure as time. The vector sum of both times is constant and independent of the speed of the observer.

The expansion of the universe implies that the entire universe moves at the speed of light, so that when applying energy to an object, to move it with respect to another, it changes the direction of its movement. This change in the direction of movement is what produces the contraction of the moving object and the time dilation.

8.2 Curved space-time

We assume that the universe is a 4D hypersphere, formed by Planck's 4D spheres, which expands at the speed of light, resulting:

$$r^2(x,y,z)+u^2=R^2=c^2t^2 \qquad (31)$$

Deriving twice with respect to t, it results

$$\left(\frac{dr}{dt}\right)^2 + r\frac{d^2r}{dt^2} + \left(\frac{du}{dt}\right)^2 + u\frac{d^2u}{dt^2} = c^2 \qquad (32)$$

What we can put in the form:

$$\left(\frac{dr}{dt}\right)^2 + \left(\frac{du}{dt}\right)^2 = c^2 \qquad (33)$$

$$r\frac{d^2r}{dt^2} + u\frac{d^2u}{dt^2} = 0 \qquad (34)$$

As before, we obtain, that the movement in space at speed v, is reduced to a movement in the xt or ru plane at constant speed equal to the speed of light c. In any case, what cannot be done is multiply the time ($t' = t_u$) elapsed at speed v_u by the speed in space v, since both speeds are perpendicular, except for $v << c$. This would be equivalent to calculating the distance traveled in the x direction, in the form $x = t$ and v_x, instead of $x = t\, v_x$, when an object moves at constant speed v, in the xy plane, during time t.

9 Conclusion

The cosmic microwave background indicates that there is a privileged reference system. This privileged system, according to the hypothesis of this paper, must be formed by Planck 4D spheres that remain immobile and whose size is independent of the speed of the observer. Under this hypothesis, space does not contract, the object formed by Planck's 4D spheres contracts, so that as the energy applied to the object increases, it reduces its size with increasing frequency of transition between the two levels hyperfines of the cesium atom. This results in a temporary dilation of the moving watch.

The twin paradox, in today's physics, is solved by claiming that there is no symmetry because the travelling twin has to accelerate and is therefore not an inertial system. However, acceleration causes a change in velocity in the travelling twin, and according to this study, that increased velocity causes object contraction and temporal dilation.

It seems that the old idea that something should be at absolute rest is correct.

Note Added in Proof

Since this communication was submitted, I have had knowledge of an article published by Professor Santilli in 1956. For Santilli, space must be a solid and incompressible medium. Being also the means of transmission of waves and forces. Matter is a dynamic modification of space.

"Space, that must transmit waves and forces, must be full, and matter, which must be a dynamic state of this space – because it interferes and generates forces – must be 'empty in relation to common concepts'. If we could stop all its

movements for a moment, matter would disappear completely, as it actually does, whenever corpuscular radiation interferes" [91].

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