Imaginary Relativity

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Abstract: - The main goal of this paper is to present a theory, named Imaginary Relativity, which completes Einstein's Relativity Theory. According to the recommended theory in this paper, the speed of light is not constant and absolute in an inertial frame. On the other hand, the speed of a light pulse in an inertial frame, moving with velocity u, equals to an imaginary value instead of the constant value c as it is considered in Einstein's Relativity Theory.

Key-Words: - Imaginary relativity, Lorentz transformations, Imaginary energy, Wave particle duality, Space-time

1 Introduction

Special Relativity theory is a way which helps observers in different reference frames to compare the results of their observations. This theory provides the possibility to express the laws of physics by using mathematical methods in different reference frames. The necessity for a new survey of fundamental quality of time and space is one of the results of this possibility. Using Lorentz Transformations and supposing a varying time as well as a constant speed for light, Einstein constructed equations leading to a series of wonderful results such as time expansion, length contraction, mass change due to speed change and the equivalency of mass and energy. These concepts have been experienced accurately in different ways so far and the special relativity theory has been approved in all of the experiments.

Today, there are some observations which confirm speeds over the speed of light. Scientists in NEC Company succeeded to increase the speed of a single ray higher than the speed of ordinary light [1]. In this experiment, they pass a light ray through a cesium atomic chamber prepared specifically for the experiment. The light ray reached to the end of the chamber in 62 nanoseconds earlier than it does in regular conditions. According to a theory, in processes that messages moves with a speed higher than the speed of light, there is possibility for the particles called Tachyon to exist [2]. Beside these, there are other experiments and experimental samples provided by researchers from different parts of the world that can be easily searched and studied on the web.

There is no doubt that accepting these velocities and theories are one of the strangest phenomena of modern physics, because according to the relativity theory no physical process can be occurred in the velocities upper than the speed of light. Is it really possible to have velocities upper than the speed of light? Most scientists take a defensive reasoning when they face these real events. They say that at velocities upper than the speed of light, systems behaves erratically, that is why the speed of light can be good criteria to evaluate the rightfulness of other measurements. Therefore, if we observe that the velocity of a phenomenon is higher than the speed of light, we should look for the origin of error in our experiment.

Imaginary relativity theory which is discussed in this paper intends to indicate that the speed of light can be higher than $2.988 \times 10^8\ m/s$, but as an imaginary number. On the other hand, it is supposed that in an inertial frame, the speed of light is not constant and absolute and it depends on velocity of the frame imaginarily. All relations and equations resulted from this theory is imaginary and as we will see in continuation, they have two main characteristics:

1. *The real part in imaginary relations is the same as classical value at low speed limit.*
2. *The normalized value of imaginary relations is the same as Einstein's Special Relativity relations at high speeds.*

These results can be achieved using Lorentz new transformations which will be proven in this paper. These transformations open a new sight to a new definition of relativity which is called here *Imaginary Relativity.*

2 The Imaginary Speed of Light

Consider inertial frame S' moving with velocity u and acceleration zero. In this frame, a light pulse is emitted in direction u with velocity c. What is the speed of light according to an observer located in frame S'? The answer, according to Einstein's second postulate, is c. However, the answer according to imaginary relativity theory is different.

It is assumed that velocity of frame S' affects imaginarily on the light pulse. It means that an imaginary frame is formed so that its imaginary part is u and its absolute (normalized) value is c.
According to Fig.1:

$$C = \sqrt{c^2 - u^2} \pm iu \tag{1}$$

(The positive or negative signs represent the motion of light pulse in the opposite or the same direction of the frame respectively).

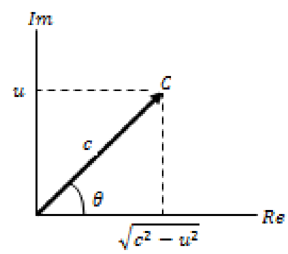

Fig.1- The imaginary speed of light in a moving inertial frame

The absolute value of C ($|C|$) always equals c. This can be considered as a required condition for having a constant value for the speed of light in an inertial frame. It should be noticed that the speed of light has changed because of the imaginary effect of the frame velocity and includes a real part ($\sqrt{c^2 - u^2}$) and an imaginary part (u).

Considering the relation between u and c in equation (1): If $u = 0$, then $C = c$. It means that in a rest frame, the speed of light is always a constant value c. If $u = c$, then $C = ic$. It means that light has no physical effect in the real world as if it has been disappeared. If $u > c$, then $C = i\sqrt{u^2 - c^2} \pm iu = iu(\sqrt{1 - c^2/u^2} \pm 1)$. In this case, such as before case, C is entirely imaginary with an unknown effect in the real world.

Using Euler formula, equation (1) can be written as follows:

$$C = ce^{i\theta} \tag{2}$$

Where

$$\theta = \tan^{-1} \frac{u/c}{\sqrt{1 - u^2/c^2}} \tag{3}$$

Variations of C versus u in Fig.2 indicate that as much as the frame velocity increases, C approaches to behave more and more imaginary. On the contrary, as much as u decreases, C approaches to behave more and more real.

Therefore equation (1) indicates that velocity of a light pulse in a moving frame is C and not c. This is against the first postulate of Einstein. On the other hand, an observer who moves in a moving frame with a constant acceleration measures the velocity of the light pulse as imaginary. It is the same theory which defines and discusses as Imaginary Relativity in this paper. According to his postulates, Einstein claimed that an observer, who moves in a moving frame with a constant acceleration, never can set an experiment to realize whether the frame is moving or not. But, according to Imaginary Relativity theory, if observer can measure *imaginary velocity* of a light pulse, then he/she can realize if he/she is in move or rest using equation (1). Unfortunately, an observer never can feel an imaginary speed in his/her world just because of being located in real world. He/she always feels the effect of both real and imaginary speeds (in other words, the normal value of equations of imaginary relativity) simultaneously. Therefore, as it can be seen, absolute or normalized value of equation (1) equal c. It is the same as it is stated by Einstein's special relativity postulates.

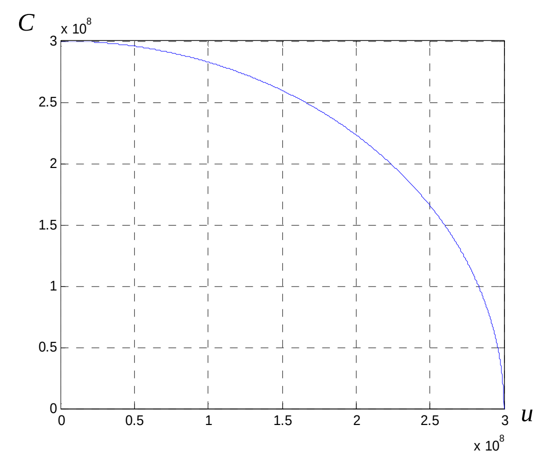

Fig.2- The speed of light in an inertial frame moving with velocity u. (MATLAB software, Version 7.1)

3 Consequences of imaginary speed of light in special relativity

In this section, one of the important consequences of Imaginary Speed of Light in Special Relativity in space and time fields will be discussed and its results will be compared with special relativity equations. In the next sections, time and space fields will be investigated by observers located in different reference frames. It should be mentioned here that C stands for a complex number in equation (1) and c stands for absolute value c ($c = 2.988 \times 10^8$ m/s).

3.1 Lorentz Transformations

Here, the aim is to see how Lorentz Transformations are changed when the speed of light is considered imaginary for a moving observer. These transformations help us to compare the measurements of space-time coordination faster for two observers who are moving relative to each other.

3.1.1 Space-time Transformations

Let us consider two observers A and B. Observer A sees an event in reference inertial frame S and determines its time-space coordination as x, y, z and t . In another inertial frame S', observer B who moves with velocity u, sees the same event with time-space coordination as $x', y', z'$and t'.The most general figure for the transformation equations of the two observers , observing the same event at the same time is as follows:

$$\begin{aligned} x' &= a_{11}x + a_{12}y + a_{13}z + a_{14}t \\ y' &= a_{21}x + a_{22}y + a_{23}z + a_{24}t \\ z' &= a_{31}x + a_{32}y + a_{33}z + a_{34} \\ t' &= a_{41}x + a_{42}y + a_{43}z + a_{44}t \end{aligned} \tag{4}$$

Now, the problem is to find the sixteen unknown coefficients in the above equations. Many books explain how the above equations can be solved [3]. Therefore, the complete solution is avoided here and just the simplified results of the solution as well as the important coefficients are considered as follow:

$$\begin{aligned} x' &= a_{11}(x - ut) \\ y' &= y \\ z' &= z \\ t' &= a_{41}x + a_{44}t \end{aligned} \tag{5}$$

Now, It is enough to find the coefficients a_{41}, a_{11} and a_{44} . To do this, it is supposed that at the time $t = 0$ a spherical electromagnetic wave leaves the origin S which coincides origin $'$. This wave is emitted in inertial frames S and S' with velocities c and C respectively. Therefore, development of the wave for each of the frames is characterized by the equation of a sphere which its radius is increased by increasing the rate of light speed versus time:

$$x^2 + y^2 + z^2 = c^2t^2 \tag{6}$$

And

$$x'^2 + y'^2 + z'^2 = C^2t'^2 \tag{7}$$

By replacing x', $y'$and z' with their values from equation (5) in equation (7):

$$a_{11}{}^2(x - ut)^2 + y^2 + z^2 = C^2(a_{41}x + a_{44}t)^2$$

And after rearrangement of the above equation:

$$\begin{aligned} (a_{11}{}^2 - C^2a_{41}{}^2)x^2 + y^2 + z^2 - 2(ua_{11}{}^2 + C^2a_{41}a_{44})xt \\ = (C^2a_{44}{}^2 - u^2a_{11}{}^2)t^2 \end{aligned}$$

Whereas the above equation is equivalent with equation (6), their equivalent coefficients should be equaled to:

$$\begin{aligned} C^2a_{44}{}^2 - u^2a_{11}{}^2 &= c^2 \\ a_{11}{}^2 - C^2a_{41}{}^2 &= 1 \\ ua_{11}{}^2 + C^2a_{41}a_{44} &= 0 \end{aligned}$$

Now, there are three equations with three unknowns. The result of solution of the above equations is as follows:

$$\begin{aligned} a_{44} &= \frac{c}{C}/\sqrt{1 - u^2/c^2} \\ a_{11} &= 1/\sqrt{1 - u^2/c^2} \\ a_{41} &= -\frac{u}{Cc}/\sqrt{1 - u^2/c^2} \end{aligned} \tag{8}$$

By substituting the above results in equation (5), new equations for Lorentz Transformation under Imaginary Relativity Theory will be formed as follow:

$$\begin{aligned} x' &= \frac{x - ut}{\sqrt{1 - u^2/c^2}} \\ y' &= y \\ z' &= z \\ t' &= \frac{\left(\frac{c}{C}\right)t - (\frac{u}{Cc})x}{\sqrt{1 - u^2/c^2}} \end{aligned} \tag{9}$$

As it can be seen, the equations which are related to place have not changed and just the equation related to time has changed. On the other hand, *length Contraction is invariant under Imaginary Relativity Theory*. But simply, it can be proved that Time Dilation is imaginary equation .So that:

$$t = \frac{Ct'}{c\sqrt{1 - u^2/c^2}} \tag{10}$$

This equation is the same known equation as Time Dilation except for the coefficient C/c . This coefficient indicates that Time Dilation is an imaginary phenomenon. To make it clear to understand, It is enough to substitute the value of C from equation (1) in equation (10)

$$t = t' \pm it'\frac{u/c}{\sqrt{1 - u^2/c^2}} \tag{11}$$

Equation (11) indicates that Time Dilation includes two values: an absolute real value which is the same measured value by observer S' and an imaginary value which expands with the coefficient $(u/c)/\sqrt{1-u^2/c^2}$. (Negative or positive sign depends on the direction of).

The normalized value of t (distance of t from the origin of the coordination) is:

$$|t| = \frac{t'}{\sqrt{1-u^2/c^2}} \qquad (12)$$

This is the same equation as Einstein's equation for Time Dilation.

3.1.2 Transformation of Velocity

For a special case, It is considered that all velocities are in the same direction $(x-x')$ of two reference inertial frames S and S'. It is supposed that frame S is earth and frame S' is a train moving with velocity u relative to earth. The speed of a passenger located in train (frame S') is v' and its place in train versus time is calculated as $x' = v't'$ .The aim is to calculate the speed of the passenger relative to earth. Using Lorentz Transformation Equations (9) and replacing x' and t' with their values:

$$x - ut = v'[\left(\frac{c}{C}\right)t - \left(\frac{u}{Cc}\right)x]$$

The above equation can be written as follows:

$$x = \frac{\left(\frac{c}{C}\right)v' + u}{1 + v'u/cC}t$$

If the velocity of the passenger relative to earth is shown with v, its place relative to earth during time t is earned from equation $x = vt$. Therefore, the above equation can be written as:

$$v = \frac{\left(\frac{c}{C}\right)v' + u}{1 + v'u/cC} \qquad (13)$$

Whereas the velocity transformation is in the direction $x - x'$, an index x is added to v and v':

$$v_x = \frac{\left(\frac{c}{C}\right)v'_x + u}{1 + v'u/cC} \qquad (14)$$

The result will be more complicated if direction of the velocity is perpendicular to the length of relative movement.

In a similar way [2], it can be proved for direction $y - y'$ that:

$$v_y = \left(\frac{C}{c}\right)\frac{v'_y\sqrt{1-u^2/c^2}}{1 + v'_x\left(\frac{u}{c^2}\right)} \qquad (15)$$

and direction $z - z'$ is

$$v_z = \left(\frac{C}{c}\right)\frac{v'_z\sqrt{1-u^2/c^2}}{1 + v'_x\left(\frac{u}{c^2}\right)} \qquad (16)$$

To get the parameters of velocity measured in frame S in terms of the parameters of velocity measured in frame S', It is enough to change the lower indices in equations (14), (15) and (16) and to replace $-u$ with u.

In appendix A, a comparison has been made between Lorentz transformation under c and Lorentz new transformation under C.

3.2 Relativistic Mechanics

At this section, the dynamic concepts of energy and momentum from the perspective of Imaginary Relativity Theory will be discussed.

3.2.1 Relativistic Momentum

Let us start discussion in this section with classical equation of momentum $P = mV$. However, before doing that it is necessary to define proper time.

Proper time τ is defined as the measured time by a fixed clock which shows the time of two events in a frame [3]. For instance, if a fixed clock in frame S records two events in the frame, then $t' = \tau$ and the equation (10) changes as follows:

$$t = \frac{C\tau}{c\sqrt{1-u^2/c^2}} \qquad (17)$$

It should be noted that proper time is always the minimum time difference measured between two events. Unfixed clocks always measure longer time difference. Therefore, if proper time τ is used instead of ordinary time t, a justified calculation for relativistic momentum can be made as follows:

$$P = m\frac{dx}{d\tau} = m\frac{dx}{dt}\frac{dt}{d\tau}$$

As it is accepted in classical mechanics, u is considered as $u = dx/dt$. Although none of the observers comes to an agreement about dx/dt, they agree about $dx/d\tau$, in which proper time $d\tau$ has been measured by a moving object. $dt/d\tau$ is obtained from equation (17). In this equation, u stands for the velocity of the moving reference frame relative to the fixed frame.

Replacing $dt/d\tau$ with its value from equation (17):

$$P = \frac{m\mathrm{u}C}{c\sqrt{1-u^2/c^2}} \qquad (18)$$

Equation (18) presents a new definition of momentum as an imaginary phenomenon which can be called *Imaginary Momentum*. It should be noticed that the new equation for low values of u/c leads to the classical equation for momentum as $\mathbf{P} = m\mathbf{u}$. To keep the appearance of the new equation like the classical one, the mass appeared in equation (18) is defined as stationary mass $m_\circ$. Therefore, Imaginary relativistic mass can be defined as follows:

$$m = \frac{Cm_\circ}{c\sqrt{1-u^2/c^2}} \qquad (19)$$

Equation (19) is *imaginary mass* and indicates how relativistic mass of an object, moving with velocity u, changes according to variations of u. It can be resulted immediately that $m = m_\circ$ (stationary mass) when $u = 0$ (object is at rest). Generally speaking, $m \to m_\circ$ when $u/c \to 0$. It indicates that Newtonian limit of relativistic mass m is $m_\circ$. Besides, statement C/c in the equation shows imaginary nature of m which can be written as follows (by replacing C with its value from equation (1)):

$$m = m_\circ + im_\circ \frac{u/c}{\sqrt{1-u^2/c^2}} \qquad (20)$$

As a matter of fact, the real part of m always equals $m_\circ$ which is a constant value. However the imaginary part of m increases with the rate of $\frac{u/c}{\sqrt{1-u^2/c^2}}$ as u increases. Like prior equations, absolute value of m ($|m|$) is the same as mass in Einstein's relativity theory:

$$|m| = \frac{m_\circ}{\sqrt{1-u^2/c^2}} \qquad (21)$$

Albert Einstein did not show much interest in equation (21). He was worried that accepting relativistic mass m invalidated the concept of mass as an inherent and invariance characteristic. Perhaps, equation (20) can heal this solicitous a little (at least because of existing $m_\circ$ in the real part), and can give us a strong perspective of mass. However, it should be stated that today, "relativistic mass" and "rest mass" are old expressions.

3.2.2 Relativistic Energy

After recommending a new definition for linear momentum (equation (18)), it is time to concentrate on force and energy. According to definition of kinetic energy (which is defined as done work on a particle):

$$W_{12} = \int_1^2 \mathrm{F}.dr = K_2 - K_1 \qquad (22)$$

Equation of second law of Newton can be corrected in order to include a new definition of linear momentum:

$$\mathbf{F} = \frac{d\mathbf{P}}{dt} = \frac{d}{dt}(m\mathbf{u}) \qquad (23)$$

In which, m is relativistic mass. If the movement starts from the rest situation ($K_1 = 0$), and velocity is on the same length as force is, $\mathbf{F}$ in equation (22) can be replaced with its value from equation (23):

$$W = K = \int \frac{d}{dt}(m\mathbf{u}) \times \mathrm{u}dt = \int_0^u ud(mu) \qquad (24)$$

(It should be noticed that $dr = \mathbf{u}dt$). By integrating to equation (24):

$$K = mu^2 - \int_0^u mudu \qquad (25)$$

Replacing m with its value from equation (20) and integrating to the second part of the equation:

$$K = u^2 m_\circ \left(1 + i\frac{u/c}{\sqrt{1-u^2/c^2}}\right) - \int_0^u um_\circ \left(1 + i\frac{u/c}{\sqrt{1-u^2/c^2}}\right) du$$

After doing algebraic and simplification operations:

$$K = \frac{1}{2} m_\circ u^2 \left[1 + i\left(\frac{\frac{u}{c} + \frac{c}{u}}{\sqrt{1-\frac{u^2}{c^2}}} - \frac{c^2}{u^2}\sin^{-1}\frac{u}{c}\right)\right] \qquad (26)$$

Equation (26) is named *Imaginary Relativistic kinetic Energy*. As it was expected, the real part of the equation is the same as equation of classical kinetic energy ($\frac{1}{2}m_\circ u^2$). It is just the imaginary part which may seem a little complicated. For low speeds, $u \ll c$, the value of imaginary part approaches to zero and K approaches to the same result as classical equation.

Physicists believe that momentum is a more fundamental concept than kinetic energy (for instance, there is no law for conservation of kinetic energy). Therefore, the equation which relates mass and energy should include momentum instead of kinetic energy. Starting with equation (18) for momentum:

$$P = m_\circ u \left(1 + i\frac{u/c}{\sqrt{1-u^2/c^2}}\right)$$

$$P^2 \mathrm{c}^2 = m_\circ{}^2 u^2 c^2 \left(1 + i\frac{u/c}{\sqrt{1-u^2/c^2}}\right)^2$$

$$P^2 c^2 = m_\circ{}^2 c^4 \left(\frac{u^2}{c^2}\right)\left(1 + i\frac{u/c}{\sqrt{1-u^2/c^2}}\right)^2 \qquad (27)$$

If it is supposed that $\gamma = 1 + i\frac{u/c}{\sqrt{1-u^2/c^2}}$, then:

$$\frac{u^2}{c^2} = 1 - \frac{1}{\gamma\bar{\gamma}} \quad (28)$$

Knowing that $\bar{\gamma}$ is complex conjugate of γ, and replacing u^2/c^2 from equation (27) with its value from equation (28):

$$P^2c^2 = m_\circ{}^2c^4(1 - \frac{1}{\gamma\bar{\gamma}})\gamma^2$$

If E and $E_\circ$ stands for total energy (mc^2) and rest energy ($m_\circ c^2$) respectively, after algebraic operations and replacing equivalent values, the above equation can be written as follows:

$$E^2 = \left(E_\circ\frac{C}{c}\right)^2 + P^2c^2 \quad (29)$$

Equation (29) is a very useful equation in dynamics, because it connects the total energy of a particle to its momentum and kinetic energy.

For a Photon which has no rest mass, equation (29) is written as follows:

$$E = Pc \quad (30)$$

It means that the total energy of photon is just because of its motion. Besides, C/c in equation (29) indicates that the value of E is imaginary. In general, $E_\circ C/c$ can be defined as energy E_C as follows:

$$E_C = E_\circ\frac{C}{c} = m_\circ c^2\frac{C}{c}$$

$$E_C = m_\circ cC \quad (31)$$

Equation (31) is called *Imaginary Energy*. Therefore, equation (29) can be written as follows:

$$E^2 = E_C{}^2 + P^2c^2 \quad (32)$$

Comparing this equation with general equation:

$$E^2 = E_\circ{}^2 + P^2c^2 \quad (33)$$

Indicates that in spite of E_C, $E_\circ$ as rest energy is independent of the velocity of object. If replacing C in equation (31) with its value from equation (1):

$$E_C = m_\circ c^2(\sqrt{1 - u^2/c^2} + i\,u/c) \quad (34)$$

According to the author of this paper, E_C has a better and more general concept than $E_\circ$. In Einstein's equations, each object has the rest energy $m_\circ c^2$ which is completely independent of its velocity. It means that if the speed of an object increases with a constant acceleration, there will be no change in the energy. The total energy should be calculated from equation (33). However, equation (34) contradicts this statement. According to this equation, if the speed of an object increases, the real value of the object's energy (E_C) decreases, but its imaginary value increases. If the object moves with the speed of light, the real value of the energy reaches to its minimum (zero) and on the contrary, the imaginary value of energy increases to its maximum (one). In this case, the equation (33) changes as follows:

$$E_C = im_\circ c^2 \quad (35)$$

That is completely imaginary. If the object is in absolute rest ($u = 0$), then:

$$E_C = m_\circ c^2 \quad (36)$$

Which is the same rest energy ($E_\circ$) appears in Einstein's equations.

It is necessary to be reminded that the normalized value of imaginary equation (34) leads to the rest energy of Einstein's special relativity equation:

$$|E_C| = m_\circ c^2 = E_\circ \quad (37)$$

The result was expectable such as prior imaginary equations. Besides, E to E_C ratio always equals:

$$\frac{E}{E_C} = \sqrt{1 - u^2/c^2} \quad (38)$$

the interesting point is that the above ratio is exactly the same as E to $E_\circ$ ratio in special relativity equations.

3.3 Relativistic Aberration and Doppler Effect

Here, Relativity aberration is discussed and during the discussion, Doppler Effect will be proved.

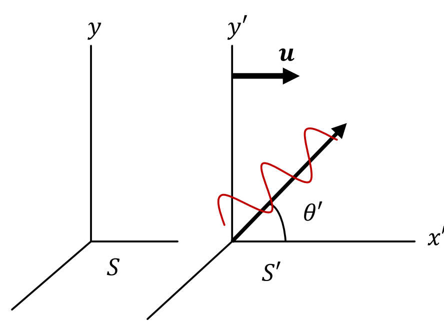

Fig.3- A plane light wave with angle θ′relative to axis x'

As it is shown in Fig.3, a plane light wave with unit amplitude is emitted from a source located on the origin of frame S'. If the wave makes angle θ' with axis x', the equation of emission for the wave will be as follows:

$$\cos 2\pi\left(\frac{x'cos\theta' + y'sin\theta'}{\lambda'} - \nu' t'\right) \quad (39)$$

This equation is a constant periodic Function with unit amplitude and shows a wave moving in direction of θ' with velocity:

$$\lambda' \nu' = C \tag{40}$$

It should be noticed that according to Imaginary Relativity, the speed of light is not c but it is C , because of movement of frame S'. λ' and ν' stands for wave length and frequency respectively.

The waves will be also plane in frame S; because Lorentz Transformation is linear ,changing one plane to another one. Therefore in frame S, emission equation will be in the same shape as follows:

$$\cos 2\pi \left(\frac{x\cos\theta + y\sin\theta}{\lambda} - \nu t\right) \tag{41}$$

λ and ν stand for wave length and frequency measured in frame respectively. θ is the angle that wave makes with axis x :

$$\lambda\nu = c \tag{42}$$

By replacing Lorentz Transformation (9) by x' and t' in equation (39):

$$\cos 2\pi \left[\frac{1}{\lambda'}\frac{(x-ut)}{\sqrt{1-u^2/c^2}}\cos\theta' + \frac{y\sin\theta'}{\lambda'} - \nu'\left(\frac{\left(\frac{c}{C}\right)t - \left(\frac{u}{Cc}\right)x}{\sqrt{1-u^2/c^2}}\right)\right] \tag{43}$$

By substituting equations (40) and (42) in equation (43) and arranging the resulted equation:

$$\cos 2\pi \left(\frac{\cos\theta' + \frac{u}{c}}{\lambda'\sqrt{1-u^2/c^2}}x + \frac{y\sin\theta'}{\lambda'}y - \frac{\nu'\left(\frac{c}{C}\right)(1+\frac{u}{c}\cos\theta')}{\sqrt{1-u^2/c^2}}\right) \tag{44}$$

This equation presents a plane wave in frame S and should be the same as equation (41) which presents the same fact. Therefore, the corresponding coefficients in the both equations (y , x and t) should be the same :

$$\frac{\cos\theta}{\lambda} = \frac{\cos\theta' + u/c}{\lambda'\sqrt{1-u^2/c^2}}$$
$$\frac{\sin\theta}{\lambda} = \frac{\sin\theta'}{\lambda'} \tag{45}$$
$$\nu = \frac{\nu'\left(\frac{c}{C}\right)(1+\frac{u}{c}\cos\theta')}{\sqrt{1-u^2/c^2}}$$

If the two sides of the second equation are divided by the two sides of the first equation in relation (45), the result will be as follow:

$$\tan\theta = \frac{\sin\theta'\sqrt{1-u^2/c^2}}{\cos\theta' + u/c} \tag{46}$$

This is the relativistic equation of light aberration. To write the reverse transformation of the above equation, it is enough to replace $-u$ by u , θ' with θ and vice versa:

$$\tan\theta' = \frac{\sin\theta\sqrt{1-u^2/c^2}}{\cos\theta - u/c} \tag{47}$$

Equations (46) and (47) make a relationship between the directions of light emission θ and θ' in inertial frames S and S'. These equations are similar to the equations of light aberration in special relativity. Therefore, it can be said that *light aberration is invariance relative to imaginary relativity*. The question which arises here is that if it can also be true about Doppler Effect.

The third equation of the equations (45) refers to another phenomenon which is known as Doppler Effect. The equation is imaginary because of C. By substituting C from equation (1) and after some algebraic operations, the third equation can be written as follows:

$$\nu = \nu'\left(1 + \frac{u}{c}\cos\theta'\right)\left(1 - i\frac{u/c}{\sqrt{1-u^2/c^2}}\right) \tag{48}$$

and its reverse:

$$\nu' = \nu\left(1 - \frac{u}{c}\cos\theta\right)\left(1 + i\frac{u/c}{\sqrt{1-u^2/c^2}}\right) \tag{49}$$

There are some special cases for equation (49) as follow:

A) For $u \ll c$, the equation of relativity changes to the classic equation

$$\nu \cong \frac{\nu'}{1-(u/c)\cos\theta} \cong \nu'\left(1 + \frac{u}{c}\cos\theta\right) \tag{50}$$

This is the same equation as the classic one.

B) For $\theta = 0$ (light source and observer moves towards each other) , equation (2.43) becomes:

$$\nu = \nu'\left(1 + \frac{u}{c}\right)\left(1 - i\frac{u/c}{\sqrt{1-u^2/c^2}}\right) \tag{51}$$

C) For $\theta = \pi$ (light source and observer moves away from each other) , equation (49) can be written as:

$$\nu = \nu'\left(1 - \frac{u}{c}\right)\left(1 + i\frac{u/c}{\sqrt{1-u^2/c^2}}\right) \tag{52}$$

Equations (51) and (52) are known as *Longitudinal Doppler Imaginary Effect*, which are in imaginary form here. A careful notice to the equations makes it clear that the real part is the same as classic form of Doppler Effect as provided in equation (50). In this equation, if θ is replaced with quantities $\theta = 0$ and $\theta = \pi$, results will be the real values of equations (51) and (52).

The values of equations (51) and (52) can be calculated as follow:

$$|\nu| = \nu' \sqrt{\frac{1 + u/c}{1 - u/c}} \quad (53)$$

$$|\nu| = \nu' \sqrt{\frac{1 - u/c}{1 + u/c}} \quad (54)$$

These equations are the same as Longitudinal Doppler equations in Special Relativity. As it can be seen again, the absolute values of equations in Imaginary Relativity are the same as related equations in special relativity.

The most interesting result is that Imaginary Relativity predicts a *Transverse Doppler Effect* (as Special Relativity does). This is entirely a relativistic effect because Transverse Doppler Effect cannot be found in classical physics. This prediction can be made using equation (49) when $\theta = \pi/2$:

$$\nu = \nu' \left(1 - \frac{u^2}{c^2}\right)\left(1 - i\frac{u/c}{\sqrt{1 - u^2/c^2}}\right) \quad (55)$$

The value of the above equation is the same as Transverse Doppler Effect in Special Relativity:

$$|\nu| = \nu' \sqrt{1 - \frac{u^2}{c^2}} \quad (56)$$

If the angle between the sight line and the length of relative movement is 90 degrees, the frequency ν will be observed which is less than the special frequency of a source (ν') passing our view.

4 Consequences of imaginary speed of light in quantum physics

In this section, quantum concepts from the perspective of imaginary relativity will be examined and it will be shown that these concepts are simpler and more convincing in confrontation new reasoning.

4.1 Wave properties of particles

In classical physics, there are fundamental differences between the laws of wave and particle motions. Projectiles' motion is based on the laws of particle dynamics and Newtonian mechanics, but wave's motion is subjected to interference and diffraction and cannot be explained with Newtonian mechanics. Each particle carries energy which is limited in a small region of space. However, wave propagates its energy out to the space in different wave fronts. Considering these clear differences, Quantum Theory is a try to justify and to make a relationship between particle and wave natures. Although it seems to be incompatible logically, it should be confessed that it is practicable using Imaginary Relativity Theory which provides us with a combination of particle and wave behaviors simultaneously.

In 1924, Louis de Broglie in a boldly hypothesis presented in his PhD dissertation stated that not only light but also *all matter* has the duality nature of particle-wave [4]. Having no experimental background, de Broglie suggested that for every object moving with momentum P , there is a related wave with the length λ according to the following equation:

$$\lambda = \frac{h}{P} \quad (57)$$

Where h is Plank constant equals to $6.626 \times 10^{-34} Js$ and λ is wave length of object or de Broglie wave length. By replacing P with mu :

$$\lambda = \frac{h}{mu} \quad (58)$$

Where m is imaginary mass. Substituting m for its value from equation (20):

$$\lambda = \frac{h}{m_\circ u\left(1 + i\frac{u/c}{\sqrt{1 - u^2/c^2}}\right)} \quad (59)$$

And after algebraic simplification of the above equation:

$$\lambda = \frac{h}{m_\circ u}\left(1 - \frac{u^2}{c^2}\right)\left(1 - i\frac{u/c}{\sqrt{1 - u^2/c^2}}\right) \quad (60)$$

Equation (60) opens a new perspective of the ratio wave length to mass and velocity. As it can be seen from prior equations, the real part of the equations indicates the classic or low-velocity region and the imaginary part presents imaginary or high-velocity region. Therefore, it is acceptable to suppose that big-mass objects at low velocities pose wave length calculated as follows:

$$\lambda = \frac{h}{m_\circ u}\left(1 - \frac{u^2}{c^2}\right) \quad (61)$$

Louis de Broglie had the same supposition, but his recommended formula was the equation (57). Whereas the statement $1 - u^2/c^2$ at low speeds nearly equals one (1), it is expected that the results of equations (61) and (58) are equal in the velocity confine.

Considering equation (1), the equation (60) can be written as follows:

$$\lambda = \frac{hC}{m_\circ uc}\sqrt{1-\frac{u^2}{c^2}} \tag{62}$$

Such as other equations and principles of Imaginary Relativity, it is expected that the normalized value of the above equation equals to Special Relativity equation. After algebraic operations and simplification:

$$|\lambda| = \frac{h}{m_\circ u}\sqrt{1-\frac{u^2}{c^2}} \tag{63}$$

And by considering equation (21):

$$|\lambda| = \frac{h}{|m|u} \tag{64}$$

Equation (64) is the same as De Broglie's formula with relativistic mass.

The question which arises here is that if it is accepted that each moving particle has a wave with the length λ. How have wave and particle been put together? On the other hand, what is the nature of what waves? In continuation, it will be shown how Imaginary Relativity Theory will help our imagination and perception to answer this question.

As a start point, imaginary relativistic mass in equation (20) will be discussed:

$$m = m_\circ + im_\circ\frac{u/c}{\sqrt{1-u^2/c^2}} \tag{65}$$

The real part of this equation has nothing to say, but there is a doubt about the imaginary part. By replacing $m_\circ/\sqrt{1-u^2/c^2}$ with the normalized value of equation (21):

$$m = m_\circ + i\frac{|m|u}{c} \tag{66}$$

By substituting $|m|$ for its value from equation (64):

$$m = m_\circ + i\frac{h}{|\lambda|c} \tag{67}$$

The above equation shows that every particle with the rest mass $m_\circ$ carries a wave with the length λ. As a matter of fact, *this equation provides the possibility to unify the duality of wave and particle relations*, the statement which seemed impossible before [4]. In order to discover behavior of particles moving with or near the speed of light, scientist made different experiments to prove the above statement which apparently seems impossible to be unified. However, all the experiments indicated that wave and particle natures do exist simultaneously instead of being separately. Equation (67) proves the above statement.

Besides, this equation is a convincing reason for existence of mass-less particles. Considering $m_\circ = 0$ in equation (67):

$$m = i\frac{h}{|\lambda|c} \tag{68}$$

or

$$|\lambda| = i\frac{h}{mc} \tag{69}$$

Comparing this equation with equation (64) demonstrates that equation (69) is the wave length of a particle moving with the speed of light (c). This particle, as it is known, is photon.

4.2 Imaginary energy

To calculate the energy of a photon, it is enough to multiply both sides of equation (68) by c^2 and then replace mc^2 with E (Relativistic Energy):

$$E = i\frac{hc}{|\lambda|} \tag{70}$$

Whereas $\frac{c}{|\lambda|}$ equals frequency of photon (ν):

$$E = ih\nu \tag{71}$$

The only difference between equation (71) and Einstein's equation ($E = h\nu$) is just in existence of i in equation (71). The question which arises here is that what imaginary energy means in general. According to opinion of the author of this paper, *imaginary energy is a kind of energy which is not distributed continuously in an environment, but it just can be delivered entirely to an object as a package*. An example makes the issue more clear. Let us consider a person who dives into water of a pool from a diving board. A part of energy of the person is changed to the waves which shake other swimmers into the water. If it was observed that diving a person into the water made another person jumped from the pool on the diving board, we had to accept that the given energy to the first diver (because of diving), had not been distributed to the expanding wave front, but it had been transferred to the jumper as a concentrated or imaginary energy [5].

The fact that energetic photoelectrons are released from the surface of metal immediately can be explained as follows: Whereas the energy of a falling photon is imaginary according to equation (71), it cannot be distributed continuously over the surface of metal. Therefore, the absorbed photon gives up its whole energy to an electron and the electron is delivered very fast. Although Einstein also used the above mentioned justification to explain photoelectric effect (by using the statement quantum energy instead of imaginary energy), his equation, $E = h\nu$ indicates a real energy and cannot justify his reasoning. In a more general case, it can be said surely that quantum equations cannot explain the experimental nature of quantum mathematically and always need to be accompanied with justifications, reasoning or even philosophical statements. However, Imaginary Relativity Theory and the imaginary part of equation (71) justify the nature of quantum's behavior.

4.2.1 Strong interaction

The pion-exchange force which tends to bind particles into a nucleus (including protons and neutrons) together is defined as strong interaction [6]. Where is this force originated from?

According to a theory, proton has the capability of producing virtual particles called pion from nothing which are absorbed by another proton. The exchange of virtual pions produces a force between inner particles of the nucleus. The resulted force makes the nucleus stable and prevents it from collapsing.

According to the law of conservation of energy, without absorbing energy from somewhere, proton cannot create a pion. Scientists justify this challenge by using Heisenberg's uncertainty principle. According to the principle, each particle can receive energy (ΔE) in time duration (Δt) if:

$$\Delta E \times \Delta t \geq h \qquad (72)$$

Where h is Plank constant. This relation indicates that the law of conservation of energy can be violated if the energy equilibrium is established after the time period Δt.

The question which arises here is that what difference is between real energy (with no possibility for violation of law of conservation of energy) and the energy produced from nothing according to the above relation. Imaginary energy justifies the difference and predicts the creation of the particles.

According to imaginary energy concept and Heisenberg's uncertainty principle, it can be proved that:

$$\Delta E_C \times \Delta t \geq h \qquad (73)$$

Whereas the particle moves with the speed of light, the above relation can be written as follows:

$$im_{\circ}c^2 \times \Delta t \geq h \qquad (74)$$

To calculate the allowable time of presence of pion or its life length, it is enough to replace h, $m_{\circ}$ and c with their values which are 6.6×10^{-27}, $1.8 \times 10^{-25}\, gm$ and $3 \times 10^{10} cm/s$ respectively. The result is $\Delta t > 4 \times 10^{-23} sec$. As a matter of fact, proton receives the imaginary energy $\Delta E = im_{\circ}c^2$ from imaginary world temporarily (as a loan) and is allowed to produce a particle (pion, at here) with the life length $4 \times 10^{-23} sec$. Now, the pion has just $\Delta t = 4 \times 10^{-23}$ seconds' time to reach another proton and to be absorbed by it. Whereas the speed of pion equals the speed of light, the particle can travel the distance $c \times \Delta t = 10^{-12} cm$ which is approximately equals the diameter of a nucleus with medium dimensions [6].

This phenomenon can be seen exactly in one of the most unusual properties of matter; *Quantum Tunneling*.

4.2.2 Quantum tunneling

If you throw a marble into a mixing bowl, one of two things can happen. If the marble has enough velocity to enable it to climb over the lip of the bowl, it will leave the bowl and go on its way. If it does not have enough energy to do so, it will be trapped. If there were no friction, it would continue to roll back and forth in the bowl [6].

If we replace marble by an electron, however, our familiar concepts can no longer guide us. Laws of quantum mechanics tell us that there is some probability that the electron can escape from the bowl. This escape cannot be something that we can picture easily. Because a quantum mechanical particle (here electron) will not remain confined in a container forever but will eventually tunnel out.

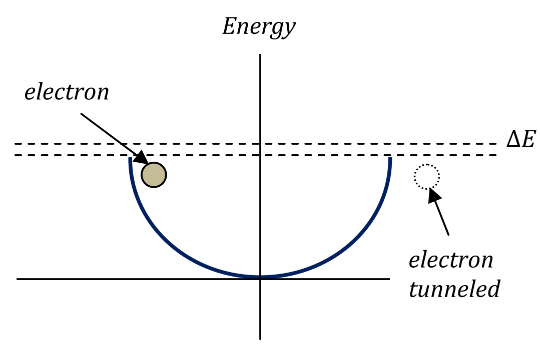

Fig.4- Energy-level diagram for the bowl and electron

We can represent this situation by what physicists call an energy-level diagram. The diagram for the bowl and electron is shown in Fig.4. The curved line, whose shape is necessarily the same as the shape of the bowl, represents the energy needed to tunneling the electron. The energy of the electron is represented by a straight horizontal line. ΔE is value of acquire additional energy sufficient to tunneling it out of the bowl [6].

In keeping with our understanding of the conservation of energy, we have to remember that it is impossible for the electron to have this extra energy. But according to imaginary uncertainty equation. (73), we proceed on the assumption that such a process can occur. If the electron has an additional imaginary energy ΔE_C

for a time Δt and if this time is long enough for the electron to travel over the lip of the bowl, then when the electron gives up the additional imaginary energy and return to its original state, it will be outside the bowl. It would appear that the electron had simply tunneled through the bowl, which is the origin of the name of the phenomenon.
Therefore, as it is demonstrated, the imaginary world is capable of giving imaginary energy (as a loan) without any preconditions. However, whereas the bank of the imaginary world is very stingy, according to the relation of uncertainty, it is allowed to loan the energy just for a very short time. Less mass the object has, much time holds the energy. Therefore, low-mass particles such as fundamental particles can hold energy for a longer time.

4.3 Compton scattering

In physics, Compton scattering or Compton Effect is decrease in energy (increase in wavelength) of an X-ray or gamma ray photon, when it interacts with matter. Because of the change in photon energy, it is an inelastic scattering process. Compton scattering usually refers to the interaction involving only the electrons of an atom. The Compton Effect was observed by Arthur Holly Compton in 1923 and further verified by his graduate student Y. H. Woo in the years following. Arthur Compton earned the 1927 Nobel Prize in Physics for the discovery.

Scattering process can be considered as an interaction between a singular photon and a free electron. It is supposed here that electron is fixed relative to the frame of experiment. Fig.5 shows the interaction.

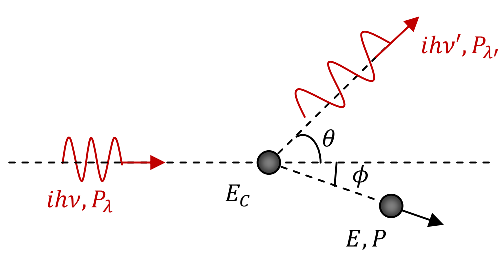

Fig.5- Geometry of interaction between a photo and an electron

Suppose a photon with energy $ih\nu$, coming from the left, collides with an electron with energy E_C (according to imaginary relativity postulate, we can't use $E_\circ$, because the speed of light in an inertial frame is C instead of c), and a new photon with energy $ih\nu'$, emerged at angle θ recoils electron with energy E and angle ϕ relative to the length of the falling photon:

$$ih\nu + E_C = ih\nu' + E \qquad (75)$$

Considering the validity of conservation of momentum for the collision:

$$(P_x)_{\text{initial}} = (P_x)_{\text{final}}$$

$$P_\lambda = P\cos\phi + P_{\lambda'}\cos\theta \qquad (76)$$

$$(P_y)_{\text{initial}} = (P_y)_{\text{final}}$$

$$0 = P\sin\phi - P_{\lambda'}\sin\theta \qquad (77)$$

where P_λ and $P_{\lambda'}$ are the momentums of falling and scattered photons respectively. P is the relativistic momentum of the recoiling electron. By deleting ϕ from equations (76) and (77):

$$P\cos\phi = P_\lambda - P_{\lambda'}\cos\theta$$

$$P\sin\phi = P_{\lambda'}\sin\theta$$

Summation of squares of the both sides of the above relations results the following equation:

$$P_\lambda{}^2 + P_{\lambda'}{}^2 - 2P_\lambda P_{\lambda'}\cos\theta = P^2 \qquad (78)$$

By considering the fact that $Pc = ih\nu$ (it is enough to replace E with the value mc^2 as well as mc with the value P in equation (71) and multiplication of the both sides of equation (78) by c^2 :

$$-h^2\nu^2 - h^2\nu'^2 + 2h^2\nu\nu'\cos\theta = P^2c^2 \qquad (79)$$

Taking $ih\nu$ and $ih\nu'$ to one side as well as E and E_C to the other side of equation (75) and squaring the both sides of the resulted equation:

$$-h^2\nu^2 - h^2\nu'^2 + 2h^2\nu\nu' = E^2 + E_C{}^2 - 2EE_C \quad (80)$$

Using equation (32) and replacing E^2 with its equivalent:

$$-h^2\nu^2 - h^2\nu'^2 + 2h^2\nu\nu' = 2E_C{}^2 + P^2c^2 - 2EE_C$$
(81)

By subtracting equation (79) from equation (80):

$$2h^2\nu\nu'(1-\cos\theta) = 2E_C{}^2 - 2EE_C$$

$$h^2\nu\nu'(1-\cos\theta) = E_C(E_C - E) = m_\circ cC(ih\nu' - ih\nu)$$

$$\frac{h}{im_\circ C}(1-\cos\theta) = c\left(\frac{\nu'-\nu}{\nu\nu'}\right) = \frac{c}{\nu} - \frac{c}{\nu'} = \lambda - \lambda'$$

And finally, by simplification of the above relation and considering $\Delta\lambda = \lambda' - \lambda$:

$$\Delta\lambda = \frac{ih}{m_\circ C}(1-\cos\theta) \qquad (82)$$

Equation (82) is the fundamental equation for Compton Effect in Imaginary Relativity Theory. Existence of i and C in the equation has made it imaginary. By replacing C with its value:

$$\Delta\lambda = \frac{h}{m_\circ c^2}(1-\cos\theta)\left(\frac{u}{c} + i\sqrt{1-u^2/c^2}\right) \quad (83)$$

where u is the speed of electron before colliding with a falling photon. Compton supposed that the scattered electron is probably valence electron which has an outermost energy level and is treated as free or loosely bound or a rest electron. Therefore, its velocity is negligible. By substituting zero for u in equation (83):

$$\Delta\lambda = \frac{ih}{m_\circ c}(1-\cos\theta) \quad (84)$$

This is the same as fundamental equation of Compton Effect in Special Relativity, but just with a small difference, i.e. i in the equation. Imaginary nature of equation (84), similar to the case which was interpreted for energy, indicates that variation of wave length of photon poses quantum nature and has been scattered partly as an electron and the remnant as a photon. It is exactly the same interpretation which Compton expressed after observing the results of his experiments.

As a matter of fact, no matter poses real free electrons. If it is supposed that the speed of electron before collision is c , then equation (83) can be written as follows:

$$\Delta\lambda = \frac{h}{m_\circ c}(1-\cos\theta) \quad (85)$$

This is a real equation. It means that a part of photon's energy is given steadily to electron and the electron can give it to another electron. This process continues and is repeated for other electrons so that finally there will be no electrons to be scattered and just a photon is scattered due to the remnant energy given to the first electron.

It is necessary to be reminded here again that the normalized value of equation (83) leads to the fundamental equation of Compton in Special Relativity:

$$|\Delta\lambda| = \frac{h}{m_\circ c}(1-\cos\theta) \quad (86)$$

This proves again the validity of the equations of Imaginary Relativity theory and the fact that the normalized values of the equations are the same as equations of Special Relativity.

4.4 Wave description of particles

In physics, a wave packet is an envelope or packet containing a number of plane waves having different wave numbers or wavelengths, chosen such that their phases and amplitudes interfere constructively over a small region of space [7].

Consider a function such as $\psi(x)$ having information about the situation of a particle in a specific time. If it is supposed that $\psi(x)$ is a complex number, the square of $\psi(x)$ tells us the probability of observing a particle in a specific place and time per length unit. In general:

$$\frac{dP}{dx} = |\psi(x)|^2 \quad (87)$$

Since the probability of finding a particle in anywhere equals one (1), the normalization condition over $\psi(x)$ can be written as follows:

$$\int_{-\infty}^{+\infty} |\psi(x)|^2\, dx = 1 \quad (88)$$

If the wave number k is a continuous variable, the wave can be shown as a combination of terms e^{ikx}. The distribution of wave numbers is given by function $g(k)$. According to integral transformation of Fourier, function $\psi(x)$can be written in terms of $g(k)$ as follows:

$$\psi(x) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{+\infty} g(k)e^{ikx}\, dk \quad (89)$$

Function $g(k)$ can be calculated based on (x) :

$$g(k) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{+\infty} \psi(x)e^{-ikx}\, dx \quad (90)$$

Let us suppose that the probability of finding a particle is the same within the confines of $-L < x < L$. The first thing to do is to make the distribution function of wave number $(\psi(x))$ for a square wave packet. Whereas the Probability of finding a particle is the same within the confines of $-L < x < L$, $\psi(x)$ is a constant function. The best choice for $\psi(x)$ is equation (67), because for a constant velocity lower than the speed of light ($u \ll c$), mass is constant within the space confines. By replacing k in equation (67) from the below relation:

$$k = \frac{2\pi}{\lambda} \quad (91)$$

We will have:

$$m = \psi(x) = m_\circ + i\frac{h|k|}{2\pi c} \quad (92)$$

To simplify equations, $h/2\pi$ is shown by $\hbar$ in quantum physics. Therefore:

$$\psi(x) = m_\circ + i\frac{\hbar|k|}{c} \quad (93)$$

Now, k can be calculated from the above equation so that the normalization condition (equation 88) is satisfied:

$$\int_{-L}^{+L} |m_\circ + i\frac{\hbar|k|}{c}|^2\, dx = 1 \quad (94)$$

And after solving of integral:

$$\left(m_\circ{}^2 + \frac{\hbar^2 k^2}{c^2}\right) 2L = 1$$

$$k = \frac{c}{\hbar}\sqrt{\frac{1}{2L} - m_\circ{}^2} \quad (95)$$

Equation (94) determines the value of k which makes function $\psi(x)$ normalized by replacing k from equation (95) within the confines $L < x < -L$, in equation (93):

$$\psi(x) = m_\circ + i\sqrt{\frac{1}{2L} - m_\circ{}^2} \quad (96)$$

And for $x < -L$ or $x > L$:

$$\psi(x) = 0 \quad (97)$$

It should be noted that according to equation (94), the area under the curve is 1 and its absolute value is calculated from equation (96) as follows:

$$|\psi(x)| = \sqrt{1/2L} \quad (98)$$

Now, the function $g(k)$ can be obtained from equation (90). Please note that $\psi(x)$ is constant relative to integral's variable:

$$g(k) = \frac{1}{\sqrt{2\pi}}\int_{-L}^{+L}\left(m_\circ + i\sqrt{1/2L - m_\circ{}^2}\right)e^{-ikx}\, dx$$

$$= \frac{(m_\circ + i\sqrt{1/2L - m_\circ{}^2})}{\sqrt{2\pi}}\int_{-L}^{+L} e^{-ikx}\, dx$$

After calculation of the integral and simplification:

$$g(k) = \frac{1}{\sqrt{\pi}}\left(\sqrt{2}m_\circ + i\sqrt{1/L - 2m_\circ{}^2}\right)\frac{\sin(kL)}{k} \quad (99)$$

$g(k)$ is a sinc and imaginary function. Distribution of wave numbers (here, wave packet) is a function of $\psi(x)$. To find the probability of the distribution in terms of, the square of absolute value of $g(k)$ should be calculated:

$$|g(k)|^2 = \frac{1}{\pi L}\frac{\sin(kL)^2}{k^2} \quad (100)$$

Wave number is within the confines $-\pi/L < k < \pi/L$ and the area under the curve is unit (1) in the space k.

5 Space-time

n physics, space-time is any mathematical model that combines space and time into a single continuum. Einstein used a three-dimensional geometric figure termed the light cone to represent the usual four-space metric or Minkowski metric in a two-dimensional plane, based on the conic section diagrams. This geometric picture is formed from a figure with two axes, the ordinate is time, t and the abscissa is formed from the three dimensions of space as one axis X =x, y, z .The speed of light forms the sides of the two cones apex to apex with the t axis in the vertical direction.The purpose of this picture is to define the relationship between events in four space .For events connected by signals of $u<c$, where c is the velocity of light, events occur within the top of the light cone (forward time) or bottom (past time) .These are termed time-like signal. Event connections outside the light cone surface, $u=c$, are connected by $u>c$ and are called space-like signals and are not addressed in standard physics [8].

In a Euclidean space, the separation between two points is measured by the distance between the two points. A distance is purely spatial, and is always positive. In space-time, the separation between two events is measured by the *interval* between the two events, which takes into account not only the spatial separation between the events, but also their temporal separation. The interval between two events is defined as

$$\Delta s^2 = \Delta X^2 - c^2\Delta t^2 \quad (101)$$

where $\Delta X^2 = \Delta x^2 + \Delta y^2 + \Delta z^2$, and Δt and ΔX denote differences of the time and space coordinates, respectively, between the events. This equation is invariant under the Lorentz transformation, based on the constant of speed of light by Einstein's postulate. In the other hand, for a case that frame S' moves with constant velocity u relative to S, we can write

$$\Delta s^2 = \Delta X^2 - c^2\Delta t^2 = \Delta X'^2 - c^2\Delta t'^2 \quad (102)$$

But we know that speed of light isn't constant relative to S and S' frames under Imaginary Relativity, and therefore we must replace follow equations instead equation (102)

$$\Delta X^2 - c^2\Delta t^2 = \Delta X'^2 - C^2\Delta t'^2 \quad (103)$$

or

$$\Delta X_C{}^2 - cC^*\Delta t^2 = \Delta X_C{}'^2 - cC\Delta t'^2 \quad (104)$$

Where C^* is the complex conjugate of C and $\Delta X_C{}^2$defined as

$$\Delta X_C{}^2 = \frac{c}{C}\Delta x^2 + \Delta y^2 + \Delta z^2 \quad (105)$$

Equation (104) is invariant under Lorentz imaginary transformation (9), waive of C transform to C^*, and so in this space distance Δs^2 is invariant and given as

$$\Delta s_C{}^2 = \Delta X_C{}^2 - cC\Delta t^2 \qquad (106)$$

Since C is complex, above equation presented at least a complex six-dimensional Minkowski space with a purely geometrical model formulated in terms of space and time coordinates. This complex metrical space includes the three real dimensions of space and the usual dimension of time; it also includes one imaginary dimensions of space and one imaginary dimension of time. In the six space, the real components comprise the elements of the space defined by Einstein and Minkowski.

The standard Minkowski metrical space is constructed so that all spatial components are real. But, the square of the temporal component differs by a $-c^2$, which is formulated from ict_{Re}, yielding a component $-c^2t_{Re}^2$. In Minkowski complex space each spatial component has an ix_{Im} component, yielding the square component $-x_{Im}^2$. The corresponding temporal component is $+c^2t_{Im}^2$. This is the basis upon which the eight space allows apparent zero spatial and temporal separation.

Rauscher and Newman [8] expressed the complex eight-space metric using along lines of the detailed formalism of Hansen and Newman [9] expressed in general relativistic terms and extended usual four-dimensional Minkowski space into a four complex dimensional space-time. This new manifold (or space-time structure) is analytically expressed in the complexified eight space. They wrote in general for real and imaginary space and time components in the special relativistic formalism

$$\Delta s^2 = \Delta X_{Re}^2 + \Delta X_{Im}^2 - c^2(\Delta t_{Re}^2 + \Delta t_{Im}^2) \qquad (107)$$

We can rewrite equation (106) as the format of (107)

$$\Delta s_C{}^2 = \frac{c}{C}(\Delta X_{Re}^2 + \Delta X_{Im}^2) - cC(\Delta t_{Re}^2 + \Delta t_{Im}^2) \qquad (108)$$

The light cone metric this space may imply superluminal signal propagation between subject and event in the real four space, but the event-receiver connection will not appear superluminal in some eight-space representations. We can consider that our ordinary four-dimensional Minkowski space is derived as a four-dimensional cut through the complex eight space [10].

Recall that the normalized value of equation (108) leads to the Minkowski space equation (101).Then

$$|\Delta s_C{}^2| = \Delta s^2 \qquad (109)$$

6 Conclusion

In this paper, the author provided his recommended theory and described some of its results and subsequences. However, there are still many other possibilities to develop the theory. The author intended to open a section in the paper describing quantum mechanics and fields, but their complicated mathematics and not being sure about the resulted equations, convinced the author , far from any kinds of hypocritically modesty, to let the related scientists and experts extract the correct equations and judge about the theory.

The author agrees that perception of imaginary terms in the equations of Imaginary Relativity Theory seems a little difficult. However, he believes that difficulties and hardships have been always existed about the concepts of physics and its surrounding realities. For example, why is it not possible yet to understand the nature of fundamental particles especially electron in quantum mechanics? How can the duality of wave-particle be imagined? As it will be explained, there is no exception for the concept of imaginary relativity.

At first, the author asks a question. What is the weight of a pencil in my hand and how can it be weighed? It is obvious that all of you say: "put it on a balance and weigh it ". Suppose that the author does so and the balance shows 5 grams. However, what does it really mean? What does the number 5 exactly show? It is just a value which is measured by tester tools and felt by our senses. It may be the resultant of some acting forces and other factors. What will be the reaction if the author says that the weight of the pencil is 4+3i? The absolute value of this complex number is $\sqrt{4^2 + 3^2} = 5$.

The author would like to claim that the imaginary world which was introduced in this paper, probably affects all the laws of physics directly so that the effect of a force or a factor in the real and imaginary worlds can be always calculated and felt simultaneously. The effect is the normalized value of the real and imaginary worlds. The equations of Imaginary Relativity Theory which were presented in the paper, testify the author's claim and have, as it was seen in the paper, two main important characteristics:

1. *The real term in the imaginary equations is the classical value (according to Newtonian Physics) at low speeds confine.*
2. *The normalized (absolute) values of the imaginary equations are the same as Einstein's special relativity equations at high speeds.*

The author does not know where the imaginary world is located or what its nature is. However, the evident show that it is very close to us; so close that it seems we are plunged in it but unconscious about it, like fishes into an ocean. When a body shares much of the imaginary world (its imaginary part is much bigger than its real part), then its behavior became strange from our perspective. It behaves sometimes such as a wave and sometimes such as a particle. It seems to be sometimes present and sometimes absent in the same place as if it has tunneled and disappeared. Even sometimes, it seems clever; capable of guessing what is going on in the mind of scientists and aware of its twin in the other side of the world. As it was stated, all can share of the imaginary world because it can loan energy. However, the loan is a very-short-time one for big and low-speed bodies. Only quantum particles can share of the loan. To get a better understanding of the concept of imaginary relativity, the equations of imaginary relativity and special relativity have been compared in appendix B.

To make the words shorter, the judgment of the validity of the mentioned statements and equations is left to the scientists of physics and mathematics. A theory can be valuable experimentally if it is based on the prior theories and has confirmed mathematical equations. Validity of any natural law is established by experiment, and a theory is only as good as the experiments used to confirm it.

The author does not know how it is possible to prove the imaginary terms in the provided equations experimentally. Verification of the imaginary equations at this time may seem as much difficult as the verification of special relativity ones in about one hundred years ago. Albert Einstein, once stated that he knew there was not any experience to prove the accuracy of his equations, but it was clear for him that he was right. Today, in spite of technological developments in making modern laboratory equipment, it can be surely said that no experiment had been able to violate Einstein's equations. The same may happen for the theory of imaginary relativity in the future.

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APPENDIX A

Table.1- Comparison between Lorentz transformations under c and Lorentz new transformations under C

Lorentz Transformation of Space-Time	
transformations under c	transformations under C
$x' = \dfrac{x-ut}{\sqrt{1-u^2/c^2}}$	$x' = \dfrac{x-ut}{\sqrt{1-u^2/c^2}}$
$y' = y$	$y' = y$
$z' = z$	$z' = z$
$t' = \dfrac{t-\left(\frac{u}{c^2}\right)x}{\sqrt{1-u^2/c^2}}$	$t' = \dfrac{\left(\frac{c}{C}\right)t-(\frac{u}{Cc})x}{\sqrt{1-u^2/c^2}}$
Transformation of Velocity	
transformations under c	transformations under C
$u_x = \dfrac{v'_x+u}{1+v'_x u/c^2}$	$u_x = \dfrac{(\frac{c}{C})v'_x+u}{1+v'_x u/Cc}$
$v_y = \dfrac{v'_y\sqrt{1-u^2/c^2}}{1+v'_x u/c^2}$	$v_y = (\frac{C}{c})\dfrac{v'_y\sqrt{1-u^2/c^2}}{1+v'_x u/c^2}$
$v_z = \dfrac{v'_z\sqrt{1-u^2/c^2}}{1+v'_x u/c^2}$	$v_z = (\frac{C}{c})\dfrac{v'_z\sqrt{1-u^2/c^2}}{1+v'_x u/c^2}$

APPENDIX B

Table.2- Comparison between equations of classical (Newtonian) limit, Special Relativity and Imaginary Relativity

Caption	Classical limit	Special Relativity	Imaginary Relativity
Speed of light	c	c	$C = \sqrt{c^2 - u^2} \pm iu$
Time dilation	Δt	$\Delta t = \frac{\Delta t_\circ}{\sqrt{1 - u^2/c^2}}$	$\Delta t = \Delta t_\circ (1 + i\frac{u/c}{\sqrt{1 - u^2/c^2}})$
Length contraction	L	$L = L_\circ \sqrt{1 - u^2/c^2}$	$L = L_\circ \sqrt{1 - u^2/c^2}$
Composition of velocities	$v = v' + u$	$v = \frac{v' + u}{1 + v'u/c^2}$	$v = \frac{v'(c/C) + u}{1 + v'u/cC}$
Longitudinal Doppler effect	$\nu = \nu' \left(1 + \frac{u}{c} cos\,\theta\right)$	$\nu = \frac{\nu' \left(1 + \frac{u}{c}\cos\theta'\right)}{\sqrt{1 - u^2/c^2}}$	$\nu = \nu' \left(1 + \frac{u}{c}\cos\theta'\right)\left(1 - i\frac{u/c}{\sqrt{1 - u^2/c^2}}\right)$
Transverse Doppler effect	$\nu = \nu'$	$\nu = \nu' \sqrt{1 - u^2/c^2}$	$\nu = \nu' \left(1 - \frac{u^2}{c^2}\right)\left(1 - i\frac{u/c}{\sqrt{1 - u^2/c^2}}\right)$
Mass	$m = m_\circ$	$m = \frac{m_\circ}{\sqrt{1 - u^2/c^2}}$	$m = m_\circ (1 + i\frac{u/c}{\sqrt{1 - u^2/c^2}})$
Kinetic energy	$K = \frac{1}{2} m_\circ u^2$	$K = m_\circ c^2 \left(\frac{1}{\sqrt{1 - u^2/c^2}} - 1\right)$	$K = \frac{1}{2} m_\circ u^2 \left[1 + i\left(\frac{u/c + c/u}{\sqrt{1 - u^2/c^2}} - \frac{c^2}{u^2}\sin^{-1}\frac{u}{c}\right)\right]$
Force	$F = m_\circ a$	$F = \frac{m_\circ a}{(1 - u^2/c^2)^{3/2}}$	$F = \frac{m_\circ a}{(1 - u^2/c^2)^{3/2}}$
Momentum	$P = m_\circ u$	$P = \frac{m_\circ u}{\sqrt{1 - u^2/c^2}}$	$P = m_\circ u \left(1 + i\frac{u/c}{\sqrt{1 - u^2/c^2}}\right)$
Energy-Mass	*undefined*	$E = mc^2$	$E = mcC$
Energy-Momentum	*undefined*	$E^2 = E_\circ{}^2 + (pc)^2$	$E^2 = (E_\circ C/c)^2 + P^2 c^2$
de Broglie wavelength	*undefined*	$\lambda = \frac{h}{m_\circ u}\sqrt{1 - u^2/c^2}$	$\lambda = \frac{h}{m_\circ u}\left(1 - \frac{u^2}{c^2}\right)(1 - i\frac{u/c}{\sqrt{1 - u^2/c^2}})$
Wave-Particle duality	*undefined*	*undefined*	$m = m_\circ + i\frac{h}{\lvert\lambda\rvert c}$
Photoelectric effect	*undefined*	$E = h\nu$	$E = ih\nu$
Heisenberg's uncertainty	*undefined*	$\Delta E \times \Delta t > h$	$\Delta E_C \times \Delta t > h$
Compton scattering	*undefined*	$\Delta\lambda = \frac{h}{m_\circ c}(1 - \cos\theta)$	$\Delta\lambda = \frac{h}{m_\circ c^2}(1 - \cos\theta)(\frac{u}{c} + i\sqrt{1 - u^2/c^2})$
Packet wave	*undefined*	$\psi(x) = \sqrt{1/2L}$	$\psi(x) = m_\circ + i\sqrt{1/2L - m_\circ{}^2}$
distribution of wavenumbers	*undefined*	$g(k) = \frac{1}{\sqrt{\pi L}}\frac{\sin(kl)}{k}$	$g(k) = \frac{1}{\sqrt{\pi}}\left(\sqrt{2}m_\circ + i\sqrt{1/L - 2m_\circ{}^2}\right)\frac{\sin(kL)}{k}$
Space-time	$\Delta s^2 = \Delta x^2 + \Delta y^2 + \Delta z^2$	$\Delta s^2 = \Delta x^2 + \Delta y^2 + \Delta z^2 - c^2\Delta t^2$	$\Delta s^2 = \frac{c}{C}\Delta x^2 + \Delta y^2 + \Delta z^2 - cC\Delta t^2$