Space And Time Separation, Time Travel, Superluminal Motion And Big Bang Cosmology

Luigi Maxmilian Caligiuri $^{1,2}$, Amrit Sorli $^1$

$^1$Foundation of Physics Research Center - FoPRC, Italy
$^2$University of Calabria, Italy

Abstract

Einstein’s Special Theory of Relativity (STR), based on Lorentz transformations, considers time as the fourth physical dimension, and raises the possibility of time travel, analogous to traveling in space. Nevertheless, alternative versions of STR are possible in which transformation in time and space different from Lorentz are allowed. We argue that time cannot be considered as the fourth component of four-dimensional physical space-time but only as a mathematical parameter quantifying duration of material changes i.e. duration of motion happening in space. Time is not a physical dimension in which motion happens but simply the duration of that motion in 3 dimensional space. This leads to a distinction between physical, mathematical and psychological times. This view on space and time categorically excludes time travel. Likewise, superluminal propagations are also possible without violating causal requirement and which also contributes to the inability to travel into the past. This proposed model has important implications for the unification between quantum mechanics and relativity, and on quantum entanglement, quantum teleporting, psychological time and cosmology.

Keywords: Big Bang, Determinism, Psychological Time, Quantum Teleporting, Quantum Vacuum, Space, Space-Time, Superluminal Signals, Time, Time Travel.
1. Introduction

Cosmology strongly depends on fundamental physics. The most part of actual theories about the birth and the evolution of the universe, including the Big Bang one, are based on the consideration of Minkowski four–dimensional space-time as the fundamental arena of the Universe whose validity depends on the assumption of the space and time mix predicted by Special Theory of Relativity (STR). In this picture, as known, the variable \( ct \) plays a fundamental role like that of space variables \( x, y, z \) with the “only” difference of the pseudo – Euclidean metric associated to the time “direction”, and the Universe is considered as a four – dimensional continuum in which space and time are interconnected. This interconnection is established through the Lorentz space–time transformations on which the “traditional” version STR is based. The idea of time being 4th dimension of space - time was prevailing in physics of 20th century although there is no experimental evidence that by clocks we measure some concrete physical dimension in which motion happens. In fact, our recent research has shown it is possible to realize alternative and well – posed versions of STR, only by considering homogeneity of empty space and time, without assuming the invariance of light velocity in vacuum (Caligiuri & Sorli, 2013).

The latter principle has in fact a “special” electrodynamics origin being associated to a property of light arising from Maxwell equations and it is not required by the internal consistence of STR. Nevertheless, as known to Einstein itself (Einstein, 1920), this invariant velocity cannot be measured without adopting a convenient procedure concerning the synchronization of distant clocks (Manouri & Sexl, 1977) that is not necessarily related to true properties of physical states (Nelson et al., 1993) but is only conventional. In order to explain this conventional nature of the postulate of invariance of light velocity, that also represents one of the weakest point of his theory, Einstein wrote, in 1916, considering the middle point of a segment \( AB \) whose extremes have been “simultaneously” stroked by two lightning: “That light requires the same time to traverse the path \( A \rightarrow M \) as for the path \( B \rightarrow M \) is in reality neither a supposition nor a hypothesis about the physical nature of light, but a stipulation which I can make of my own free will in order to arrive at a definition of simultaneity ” (Einstein, 1920).

This conceptual scenario can be better explained considering the following situation. Let’s consider an inertial system \( S \) in which a flashlight starts from a point \( A \) at time \( t_1 \) and reaches a point \( B \) at time \( t_2 \) then it is reflected back to \( A \) where it arrives at time \( t_3 \).

The critical point is how to synchronize a clock placed near \( B \) with a clock placed in \( A \). Despite its apparent simplicity this problem is the basis of STR and its possible solution has deep consequences on all the theoretical framework of modern physics. In the traditional STR, it is implicitly assumed that the one – way velocity of light is invariant, i.e. the light velocity in going from \( A \) to \( B \) has the same value of that in going from \( B \) to \( A \), implying \( t_2 - t_1 = t_3 - t_2 \) or equivalently

\[
t_2 = t_1 + \frac{1}{2}(t_3 - t_1)
\] (1)
This apparently obvious equation is far from foregone. Now, although this is an essential requirement in order the STR to hold, it has no necessary epistemological necessity. It can be shown (Reichenbach, 1958), in fact, that the most general requirement wanted in order to construct a coherent STR is given by the equation

\[ t_2 = t_1 + \alpha (t_3 - t_1) \]

where \( \alpha \) is the “synchronization” parameter, introduced by Reichenbach (Reichenbach, 1958) and \( 0 < \alpha < 1 \). The commonly accepted version of STR then corresponds to the particular choice \( \alpha = 1/2 \) and has been chosen simply because it leads to simpler mathematical relations within the theory itself (Reichenbach, 1958). Later, Max Jammer (Jammer, 1979), discussing the Reichenbach parameter, strongly pointed out that “One of the fundamental ideas underlying the conceptual edifice of relativity, as repeatedly stressed by Hans Reichenbach and Adolf Grunbaum” is the conventionality ingredience of intrasystemic distant simultaneity”. This thesis, also known as “conventionality thesis”, states that the value of \( \alpha \) must not to be necessarily equal to \( 1/2 \) but could be any real number such as \( 0 < \alpha < 1 \), without contrasting with any of the experimental previsions of Relativity (Jammer 1979, Bondi 1962).

Nevertheless, the choice of \( \alpha \) has deep consequences on the internal structure of the Theory of Relativity, since different values of \( \alpha \) correspond to different values of one – way velocity of light, this resulting in a non invariant one – way velocity of light. If we then indicate with \( c_1 \) the light velocity on a given one – way distance \( d = AB \) the two – way light velocity (on the distance \( AB + BA \)), say \( c_2 \), can be easily measured by one clock only, without posing synchronization problems. We can then obtain the relationship between \( \alpha \), \( c_1 \) and \( c_2 \) using Eq. 2

\[ \alpha = \frac{t_3 - t_1}{t_2 - t_1} = \frac{L/c_1}{2L/c_2} = \frac{1}{2} \frac{c_2}{c_1} \]

Hence the freedom in choosing \( \alpha \) is equivalent to the possibility to adopt different values of one – way velocity of light that cannot be considered invariant. This also means that any clocks synchronization procedure, being based on the value of one - way velocity of light, is also related to the choice of \( \alpha \) and the principle of the constancy of light velocity is only a useful human convention, able to simplify some mathematical relationship and not a fact of Nature.

The conventional character of clocks synchronization method and its particular choice gives rise to all the possible different space and time transformations between two inertial frames \( S_0(x_0,y_0,z_0,t_0) \) and \( S(x,y,z,t) \) in motion with relative velocity \( \vec{v} = \nu \vec{u}_{x,y,z} \), including two particularly interesting subsets (Caligiuri & Sorli, 2013). The first one contains Lorentz – like transformations (LLT) characterized by an invariant velocity \( \Lambda = c \) (even greater than \( c \)) namely:

\[
\begin{align*}
x' &= \frac{x - vt}{W} \\
y' &= y \\
z' &= z \\
t' &= \frac{t - \Lambda vt}{W}
\end{align*}
\]
where $W = \sqrt{1 - \Lambda v^2}$ and $\Lambda$ represents a velocity invariant in all the equivalent inertial frames defined by Eq. 4, whose value cannot be obtained within the theory itself but only considering more fundamental principles (Caligiuri & Sorli, 2013). The second subset is represented by the so-called “inertial transformations” (IT) given by (Selleri, 1995)

$$
\begin{align*}
    x' &= \frac{x - \beta ct}{R} \\
    y' &= y \\
    z' &= z \\
    t' &= Rt
\end{align*}
$$

(5)

where $\beta = v/c$, $R = \sqrt{1 - \beta^2}$ and $c$ is the speed of light measured in $S_0$.

As it has been shown (Caligiuri & Sorli 2013, Selleri 1996, Caligiuri & Sorli 2014a) the IT represent the most “natural” time and space transformation, arising from universal principles of homogeneity of space and time only, able to reproduce all the main experimental evidences of “standard” STR (like, for example, Michelson – Morley experiment and so on) but without the paradoxes and difficulties of STR itself like, for example, the lack of the explanation of the Sagnac effect.

Nevertheless the IT given by Eq. 5 have several deep physical consequences (Caligiuri & Sorli 2013, Selleri 1995, Selleri 1996) as, first of all, the introduction of a “preferred” inertial frame $S_0$, that is the system in which the first synchronization of clocks is made according to the “classical” Einstein’s procedure, and the definition of the “absolute” synchronization, by which two events that are simultaneous (taking place at different spatial locations) in the inertial frame $S$ are considered to be like that also in every other inertial systems $S'$ ($S$ and $S'$ being two inertial frames moving with respect to the preferred system $S_0$).

The existence of such preferred frame implies the anisotropy of the one–way velocity of light in all the inertial frames $S$ different than $S_0$ in which it is given by

$$
c'(\theta) = c/(1 + \beta \cos \theta)
$$

(6)

where $c$ is the speed of light in the system $S_0$ and $\theta$ is the light polar angle in the frame $S$.

As we have shown (Caligiuri & Sorli, 2014a) the development of a STR based on IT has very deep consequences with regard to the true meaning of the most fundamental physical quantities as space, time, energy and mass.

In particular, the absence of the space variable $x$ in the time transformation of Eq. 5 implies a novel and totally different understanding of physical time with respect the commonly accepted one. In fact, in the latter view, the relation between the fourth component of space-time and time in special relativity, namely

$$
x_4 = i ct
$$

(7)

is strictly related to Minkowski metric

$$
(\Delta s)^2 = c^2 (\Delta t)^2 - (\Delta x)^2 - (\Delta y)^2 - (\Delta z)^2
$$

(8)

where $(\Delta s)^2$ represents the squared interval between two events. The possibility to assume the validity of Eq. 7 substantially depends on the invariance of $(\Delta s)^2$ among all
the different inertial frames $S$ and $S'$

$$c^2t'^2 - x'^2 - y'^2 - z'^2 = c^2t^2 - x^2 - y^2 - z^2$$  \(9\)

If we insert Eq. 5 into Eq. 9 we immediately verify that

$$(\Delta s')^2 \neq (\Delta s)^2$$  \(10\)

showing that the squared interval of the metric is not invariant under the space–time transformations given by Eq. 5.

This means the interpretation of the physical time as directly related to the fourth coordinate of a space-time as a whole, expressed by Eq. 7, is not “a priori” justified by any universal postulates on which, on the contrary, IT and the related STR formulations are based (Caligiuri & Sorli, 2013).

These results confirm that time, as defined by Eq. 7, is only a mathematical quantity, which has no necessary physical existence. Real physical time we measure by clocks is duration of material changes happening in 3D space. Time and space can be then considered, in the most general case, as two separated physical realities (Caligiuri & Sorli, 2013).

Experimental data also confirm that time we measure by clocks is only duration of change of a physical system happening in a 3D universal space, whose relative velocity is described and quantified by the time equation of the inertial transformations

$$t' = t\sqrt{1 - v^2/c^2}$$  \(Caligiuri & Sorli, 2013, Fiscaletti & Sorli, 2013\).

In our model, duration has its own structure giving the numerical order of motion or change of a system. Let’s say, for example, that a photon is moving from point A to the point B in the space. Distance AB can be considered as a sum of $N$ Planck distances $d_{P,i}$. To the each Planck distance $d_{P,i}$ that photon passes corresponds exactly one Planck time $t_{P,i}$, so the total duration (time) of the phenomenon is

$$t = t_{P,1} + t_{P,2} + \ldots + t_{P,N} = \sum_{i=1}^{N} t_{P,i}$$  \(11\)

The duration of changes has its own numerical order where change $n+1$ happens after the change $n$ doesn’t anymore exist and so on. Each change $i$ corresponds exactly to one Plank time $t_p$. Photon moves in a 3D space which originates from elementary Planck structure which itself is timeless in the sense that time is not its 4th physical dimension. In the commonly accepted version of STR, the relative velocity of physical change is described as a consequence of dilatation of time viewed as a 4th dimension of space. We have shown that this assumption is not generally true when we correctly consider space and time transformations different from the Lorentz’s ones. In this case what is relative is not time itself but the velocity of changes, which do not run in time as a physical dimension because time is simply a mathematical parameter quantifying this velocity.

It’s now very important to stress that, in the proposed model, time is not deprived of existence but its has a mathematical existence only, since it shows that there is a clearly ontological and operative distinction between the “physical” time $t$ and the “coordinate” time $x_i$ that makes generally no possible the identification of time as a “spatial” coordinate of a four – dimensional space–time as a whole.
The use of IT, apart from being possible, it is even necessary in order to solve some of the most important theoretical difficulties and paradoxes of the “standard” STR. Among these we can remember the explanation of the Sagnac effect, the description of relative motion on rotating platforms, the stellar aberration and the twin paradox (with respect to this famous paradox, we shortly observe that, in our model, the twin brother in a fast spaceship grows slower because velocity of change in fast spaceship is slower than on the earth. Twin brothers do not get older “in time, they get older only in space, the clocks measuring the velocity of their getting older. Clocks do not run in time, but the run of clocks is time).

These aspects have also been considered in several previous studies (Selleri 1995, Selleri 1994, Barone 2004), so we will not analyse these in detail in this paper. In this paper we will show how this novel understanding of physical time has very deep consequences, as we’ll show in this paper, on the interpretation of the relationship between past, present and future, as well as on the existence of super – luminal – signals (SLS) and on the meaning of space itself. In particular, the proposed view on space and time categorically excludes the theoretically predicted time travels. Within this picture superluminal propagations are also possible without violating the causal principle so further confirming the impossibility of travelling into the past. Finally, some very important consequences on psychological time, on the relationship between Classical Physics (CP), General Relativity (GR) and Quantum Mechanics (QM), on Quantum Teleporting, as well as on Cosmology will be discussed.

2. The “block – universe” and the “predetermined” future

The traditional formulation of STR, based on the Lorentz transformations (LT) and Minkowski space–time, also gives another paradoxical consequence, namely the existence of a pre - determined future for every inertial observer, leading to the so-called concept of “block – Universe”. According to this view there is no objective distinction between past, present and future but only a subjective one. From an objective point of view this Universe then appears as a “monolithic” entity whose homogeneous reality ranges from past to future and in which there are a multiplicity of “nows” intersecting at different angles.

This paradoxical view can be analyzed in a simple way. Let’s consider a Minkowski diagram (for simplicity in one dimension) in which the x axis is space and the y axis is time. At time \( t = 0 \) an observer at rest \( W_0 \) is placed at the origin of an inertial system \( S \) as shown in fig. 1. The x axis has equation \( t = 0 \) and then, to the observer \( W_0 \), all the events placed at different positions on the x axis appear to him simultaneous and real, the x axis also represents the universe line of \( W_0 \) at \( t = 0 \). A generic different inertial system \( S' \), moving with velocity \( v \) with respect to \( S \), will have coordinate \( (x',t') \) and its coordinate axis will be represented in the same Minkowski diagram by rotated lines, due to the linearity of LT. In particular in \( S' \) the \( x' \) axis has equation \( t' = 0 \) while in \( S \) its equation can be found by considering the LT between \( t \) and \( t' \)

\[
ct' = \frac{ct - xv/c}{\sqrt{1 - v^2/c^2}}
\]

and using \( t' = 0 \) to obtain
that represents in $S$ a line with slope $v/c$ rotated by an angle $\alpha = \arctan(v/c) < \pi/4$ since $v < c$.

\[ ct = (v/c)x \] 

(13)

Fig. 1. The “reality” lines of two inertial observers in relative motion represented in a Minkowski diagram.

The line given by Eq. 13 then represents, as viewed by $S$, the universe line of an observer $W_0'$ placed at rest at $t'=0$ at the origin of $S'$. Due to the perfect symmetry of LT also the observer $W_0'$ considers all the events on $x'$, the line given by Eq. 13, simultaneous and totally real, nevertheless, as evident from Fig. 1, the sets of events experienced as real and simultaneous by the two observers are clearly different. In the formulation of STR based on LT both the observers are right and there is no set that can be considered more real than the other. But the “real” world of $W_0'$ at $t=t'=0$ is inclined with respect to “real” world of $W_0$ at $t=t'=0$ by an amount depending on the relative velocity $v$. Then the observer $W_0'$ will consider as real and present some events belonging to the future of $W_0$ that are not yet real for $W_0$. Someone could object that all the events on the inclined $x'$ axis, corresponding to the future of $W_0$ for $x>0$, are placed “somewhere else” with respect the position of $W_0$ at rest in $x=0$.

The objection is totally unfunded because the same above reasoning can be applied if we consider in $S$ different observers $W_1,W_2,...,W_n$, respectively placed at $x_1,x_2,...,x_n$ all equipped with clocks synchronized by the Einstein classical procedure. These observers are all equivalent among each other and to $W_0$, giving the same description of reality. In this way an event viewed by $W_1'$ (and by $W_0'$ as well) occurring at $t'=0$ in $S'$ corresponds to an accessible future event of $W_1$. Then in general the line of “reality” of $W_0'$ goes across the future of some observers, at rest in $S$, placed on the positive $x$ axis (if $v>0$) or on the negative one (if $v<0$). This means that a given
observer, for example $W_0$, can say to me $W_0$ when passing near my position at $t = t' = 0$, an information about the future of a friend of mine placed, for example, at $x_n$ in $S$, this resulting in a pre-determination of his future. The above reasoning can be extend to any time instant different than $t = 0$ simply by noting that for every point of the $(x,ct)$ plane there pass infinite lines, each of them corresponding to a different inertial observer, characterized by a different slope (smaller than $\pi/4$) depending on the relative velocity $v$.

Obviously the conclusion doesn’t change if we generalize to the four-dimensional Minkowski space–time. In this picture of block Universe, as consequence of STR and LT, the past, the present and the future are then strongly pre–determined, and the free would be considered only as an illusion.

This paradox cannot be solved within the commonly accepted picture of STR based on LT but only considering a different approach using space and time transformation different than LT.

The unavoidable pre–determinism of the future implied by the block Universe is in fact substantially originated by the particular definition of simultaneity adopted in STR. As we have shown (Caligiuri & Sorli 2013, Selleri 1995, Selleri 1996) the clocks synchronization procedure is only conventional and can be properly chosen in order to build a coherent STR without paradoxes.

In fact, given two inertial systems $S$ and $S'$ moving with velocity $v$ and $v'$ with respect to the “preferred” inertial frame $S_0$, the most general time transformation can be obtained by considering the IT:

$$t = \sqrt{1 - \frac{v^2}{c^2} t_0}$$

$$t' = \sqrt{1 - \frac{v'^2}{c^2} t_0}$$

where $t$ and $t'$ respectively are the time measured in $S$ and $S'$ while $t_0$ is the time measured in $S_0$.

Eliminating $t_0$ between the Eq. 14 and Eq. 15 and multiplying by $c$ we have

$$ct' = \frac{\sqrt{1 - \frac{v'^2}{c^2}} ct}{\sqrt{1 - \frac{v^2}{c^2}}}$$

where $x'$ is the line of universe of $S'$, having equation $ct' = 0$, and $x$ the line of universe of $S'$ whose equation is $ct = 0$. Now if we put $ct = 0$ in Eq. 16 we have $ct' = 0$ meaning that all the observer experience the same line of the universe and none of them have access to the future of the other but only to the their common present.

3. **The existence of superluminal signals doesn’t imply violation of the causal principle and doesn’t allow travelling into the past**

As already shown (Caligiuri & Sorli, 2013), the use of different space and time transformations than LT gives different coherent formulation of STR, characterized by a not constant and / or not isotropic velocity of light in vacuum in the different inertial frames, suggesting a novel rationale for the formulation of a theory of superluminal signals (SLS). Experimental evidences of the existence of SLS have been found in many physical phenomena as, for example, in the astrophysical redshift (Zensus &
Pearson 1980, Arp 1997), tunnelling of photons (Nimitz & Enders, 1993), microwave pulses (Mugnai et al., 2000), X – shape waves (Saari & Reivelt, 1997) although a theoretical treatment of these signals has not been achieved until now.

The first case refers to the evidence of superluminal jets from the core of several quasars and, more recently, of superluminal expansions in some celestial bodies (called “micro – quasars”) in our galaxy, furthermore other jets, called “blue nodules”, has been associated to the galaxy M87 (whose distance from us has been estimated without using redshift) at a speed of about $5 - 6c$.

The second phenomenon refers to the experiment realized at Colonia during 1992 in which tunnelling photons moved at a group velocity higher than $c$ within a given barrier. In the microwave experiment it has been shown that microwaves was able to move, through open air, at a velocity of about $2c$ when the detector had laterally moved with respect to a source of 90 cm long and it has been associated to the decay of evanescent waves over a length of few wavelengths. The fourth experiment refers to the so-called “Bessel pulses”, characterized by an X-shape theoretically prevised and experimentally found. They move with a superluminal velocity equal to $c/\cos \alpha$ where $\alpha$ is opening angle of the Bessel cone.

Among the above experimental evidences, one of the most interesting ones is represented by the generation of superluminal X – shape waves. The theoretical explanation of the experiment performed by Saari et al (Recami, 1986) is as follows: let’s suppose the case of an ideal superluminal source $S$ of negligible size, moving at velocity $V$ in the vacuum and emitting electromagnetic spherical waves $W$ (each propagating at velocity $c$). These waves will be internally tangent to an enveloping cone $C$, having its axis along the line (for example the x axis) of source motion and vertex at $S$ (as it happens in the case of acoustics shock waves). The waves $W$ negatively interfere inside $C$ and positively on its surface only. A plane detector perpendicular to the x axis records the amplitude and direction of the waves $W$ as function (with cylindrical symmetry) of space and time. If we now replace the detector with a plane antenna emitting, instead of recording, the same space –time wave structure of waves $W$, we can generate an conical electromagnetic wave $C$, propagating along the x axis at a superluminal velocity $V$ (obviously without any sources at $S$ and with each waves $W$ travelling at velocity $c$) (Recami 1986, Shaaravi & Besieris 2000).

According to the commonly accepted formulation of STR, the most popular, recurring and unfounded objection to the existence of SLS is that they would violate the causality principle, making it possible to travel into the past and alter the reality of the present, so generating a crucial causal paradoxes (like the famous “grandfather” paradox). The occurrence of the causal paradox within the STR can be explained as follows considering the exchange of SLS between two inertial observers A and B in relative motion with velocity $v < c$ as represented in Fig. 2.
Figure 2 shows the Minkowski diagram of the two moving observers in which the axes \((x, ct)\) represent the inertial frame \(S\) and the axes \((x', ct')\) the inertial frame \(S'\) (which appear rotated due to LT). The observer A at a certain time sends, from a point \(A_1\), a SLS signal to B being at the position \(B_1\); after the time interval \(\Delta t\), B is at point \(B_2\) and replies with a SLS that reaches A in when it is in \(A_2\).

Since there is no restriction on the value of signal velocity (if we admit the existence of SLS) the only need is the slope of \(A_1B_1\) to be lower than the \(x'\) axis’s one and the slope of \(B_2A_2\) to be greater than the \(x\) axis’s one so that both the signals appear to propagate in the future of their respective senders. From Fig. 2 we can see that, if we “properly” choose the SLS velocities, the reply of B can reach A before it sends the question signal to B so violating the causal principle since the effect (B’s reply) would precede its cause (A’s question). The paradox can be solved within the standard formulation of STR based only refusing the SLS existence, in disagreement with the above-cited experimental evidences.

The overcoming of this paradox is, on the other hand, very simple in the STR based on IT. In this case, in fact, the space – time diagram appears as in Fig. 3.
Now the $x'$ axis, defined by $ct' = 0$, coincides with $x$ axis defined by $ct = 0$ because of Eq. 15. As in the previous case $A_1$ sends a SLS to $B_1$ that replies, after the time $\Delta t$, with another SLS from the location $B_2$ that reached $A_2$. Also the needs for the two signals $A_1B_1$ and $B_2A_2$ are that both of them must have a slope greater than their respective x axes. But now $x = x'$ because the present – line of both the systems is the same and since $B_2$ always sends its SLS signal after $B_1$, then it will always reach $A_2$ after $A_1$ so avoiding any kind of causal paradox.

Therefore the adoption of an alternative but perfectly coherent version of STR, based only on “universal” principles and using IT, in which time cannot be thought as the fourth physical component of a space - time, since we cannot anymore assume the general validity of $x_4 = ict$, but only as the duration of a physical change, is able to explain the existence of SLS without run into paradoxes. The interpretation of true physical time as duration of changes, happening in 3D space, is also able to give a simple physical reason to justify the Hawking chronology protection conjecture which purpose, as known, is to prevent time travels into past, supposing the impossibility of stable closed time-like curves in General Relativity (GR)(Xin – Li, 1996).

These curves can be considered as purely mathematical entities having no necessary existence in the physical Universe. A given theoretical model could allow closed time-like curves as mathematical objects, but this does not mean that one can truly travel in physical time. Existence of closed time-like curves in General Relativity
then does not automatically guarantee travels in time.

The proposed model theoretically excludes the possibility for massive bodies and elementary particles to travel in time, simply because time itself should not be considered as a physical “component” of the universal arena but only as a mathematical measure of the duration of the physical changes happening in space. One can travel in space only and time is duration of its travel. Such an approach excludes all contradictions that are allowed by hypothetical travels in time (Sorli et al., 2011). Past, present and future do not exist in a physical universe; they exist only as a linear psychological time through which humans experience material change happening in a 3D space (Sorli et al., 2011).

From this point of view also interpretation of positron as an electron which moves backward in time (Feynman, 1949) appears non adequate whereas particles and their respective antiparticles have origin in quantum vacuum (QV) where time represent the duration of their motion and existence between appearance and annihilation (Caligiuri & Sorli, 2013). The physical inconsistence of the interpretation of the antiparticle as a particle traveling into past is easily proved by considering the experimental set-up used by Anderson when he discovered the positron (Alvarez, 1975) and observing the trajectories of particles going through a thick sheet of lead in a cloud chamber. These trajectories indicated the presence of some particles that, after passing the sheet, loose energy when moving in a well specified direction as shown in Fig. 4.

![Fig. 4. The trajectory of the positron in the Anderson experiment](image)

If the observed trajectory had belonged to a particle moving from the future (above the sheet) to the past (below the sheet) it would have to decrease its curvature, acquiring energy after the interaction with the sheet. But, as obvious, the probability of increasing the particle’s energy after an interaction with a thick sheet is practically zero, while the phenomenon is always observed thus contradicting statistical and thermodynamics laws if it were a real physical effect. Thus the positron must be a real antiparticle moving towards the future.

The commonly accepted space-time model of Relativity also does not satisfy the “bijection test” of set number theory, appearing as a mathematical model that could have no general correspondence to the physical universe (Caligiuri & Sorli, 2013) as shown by the possibility to assume space and time transformations different than the LT within a coherent alternative formulation of STR.
4. Physical time, mathematical time and travels in psychological time

Physical time we measure by clocks is duration of changes in space and through “duration” one cannot travel. It is possible to travel only through inner psychological time “past-present-future” which is a “mind travel” only and does not mean real travel in physical world. Psychological time is generated by the neuronal activity of human brain and is a fundamental mind-frame of common human “temporal experience” (Sorli et al., 2013).

![Temporal experience](image)

Fig. 5. Temporal experience

For today common observer, inner psychological time is the mind-frame through which he experiences physical world. That’s why he experiences motion runs in time as a fundamental physical reality. Conscious observer is aware of inner psychological time and he experiences motion happening in a space where only existent time is duration of motion itself. Discovery of psychological time allows “timeless experience” where one discovers that motion happens in timeless universal space where there is no present, no future and no past (Sorli et al., 2013).

![Timeless experience](image)

Fig. 6. Timeless experience
5. Superluminal motion and quantum entanglement

As we have seen in the previous discussion, the use of IT eliminates the causal paradox that, in the “standard” STR, is associated to SLS propagation. In quantum mechanics the theoretical possibility to transmit physical information at superluminal velocity (virtually infinite) is often associated to the phenomenon of quantum teleporting based on quantum entanglement. As known from QM, if \( \psi_1, \psi_1' \) and \( \psi_2, \psi_2' \) are two couples of possible wavefunctions for two quantum systems \( S_1 \) and \( S_2 \) then the products \( \psi_1 \cdot \psi_2 \) or \( \psi_1' \cdot \psi_2' \) are possible wavefunctions for the system \( (S_1, S_2) \) composed by both \( S_1 \) and \( S_2 \) as well as every linear combination of these products.

In QM if a physical system truly exists then it must necessary have its own wavefunction then if both \( S_1 \) and \( S_2 \) are real then the composed system \( (S_1, S_2) \) must have a wavefunction in the form of a product of the two wavefunction of the two single system. Then if the wavefunction of a composed system \( (S_1, S_2) \) couldn’t be written as such product then we should not assign a real existence to the individual system \( S_1 \) or \( S_2 \): in this case we say the two wavefunctions to be entangled. The quantum teleporting use the entangled quantum wavefunctions as follows.

Let’s suppose that A and B make physical measures on a statistical ensemble of \( N \) entangled couples of physical systems \( (S_1, S_2) \) and that A receives all the particles in the state \( S_1 \) while B receives all the particles in the state \( S_2 \). We can also suppose the particles are labelled in the order of reception. Let’s suppose now that, from a different source, A receives a sequence of particles \( S_0 \) all characterized by the same wavefunction \( \psi_0 \) and relates each of them with the each of particles \( S_1 \) in the order of arriving, up to \( N \).

Furthermore, A makes measurements of certain physical observables on the couples \( (S_0, S_1) \) so composed, selecting and numbering all the cases giving a precise value and discharging the others. Then he sends a “classical” message (via light signal for example) to B telling him the number of the coupled characterized by the precise value above. B selects the particles \( S_2 \) whose numbers correspond to the numbers recorded by A. By doing this B will find the particles \( S_2 \) in the state \( \psi_0 \) that described the particles \( S_0 \).

Now if, as we have said, the quantum state of a particle stated its reality in QM, we can conclude that the measures of A on the couple \( (S_0, S_1) \) destroys the reality of \( S_0 \) described by \( \psi_0 \) creating a new state different from that associated to \( \psi_0 \), in the same time this reality will be instantaneous “teleported”, during the measurements made by B, to the reality (state) of particles \( S_2 \) selected by B. At a first view this could be interpreted as superluminal propagation like that described in the discussion above. But there are many important conceptual and operative differences between the two cases.
In the first case (superluminal motion allowed by alternative STR versions based on IT) we allow, without any causality violation, the superluminal motion, at a generic velocity $v > c$ of a particle, a massive macroscopic body or a signal (as in the case of X shape or microwaves experiments cited above) without referring to any quantum mechanism. In the second case (quantum teleporting) what is teleported is the information about quantum state.

This teleporting, as we have seen, critically depends on two conditions: a) the presence of entangled quantum states; b) the exchange of information, by means of a “classical” signal, between the two observers. The former condition implicitly assumes the precise knowledge of the quantum state of the system to be prepared in an entangle state. Nevertheless, in QM, we have dealings with the fundamental problem of the no unlimited observability. As a result, states and observables are no more in a one to one correspondence as a consequence the process of measurement, needed to known the physical status of the system, that becomes a fundamental element in the determination of the phenomnic properties of a physical object.

Thus the act of measuring changes the system itself, potentially destroying the entangled state. Furthermore the prepared entangled system must be preserved from decoherence, i.e the tendency of a given quantum state to loose its “identity” when interacting with its non – quantum environment (as for, example, particles collisions, temperature increasing and so on). These interactions destroy the “purity” of the entangled state since they act as a measurement (like the interaction between the “classical” macroscopic observer and the microscopic quantum system). This phenomenon is particularly important in the macroscopic system like massive bodies in which, in general, the very high numbers of interactions completely destroys quantum state giving the classical physics behavior. This inevitably compromises the possibility to use quantum entanglement to teleporting massive (macroscopic) objects.

But when assuming the commonly accepted version of STR, we encounter another unsolvable difficulty represented by the need to “communicate” information about the quantum state between the two observers A and B (see point b of the discussion above) whose velocity cannot exceed $c$. In this way the transmission of the information about quantum state and then its reality cannot be realized at superluminal velocity in quantum teleporting.

In this sense, the superluminal motion discussed in this paper allowed by the alternative version of STR, based on IT, appears as different kind of physical phenomenon and doesn’t show these criticises (since it refers to signals or massive bodies of any size and it is not based on quantum mechanisms). However, it could be very interesting both from a theoretical and experimental point of view, to study the application to the alternative version of STR, obtained by IT, to the quantum teleporting in order to verify the possibility to overcame its limitation due to the communication of the quantum state information at the maximum velocity $c$. 
6. **Einstein’s NOW and travels in time**

Einstein called timeless experience as NOW: “… there is something essential about the NOW which is just outside the realm of science. People like us, who believe in physics, know that the distinction between the past, present and future is only a stubbornly persistent illusion” (Sorli, 2013).

Our understanding regarding Einstein’s NOW follows from the interpretation of time as a measure of the physical change that happens in 3D universal space originating from QV where time exists as duration of motion (Caligiuri & Sorli 2013, Caligiuri & Sorli 2014a). In QV there is always the NOW through which it is possible to travel, time being the duration of this travel.

![Einstein's NOW](image)

**Fig. 7. Einstein’s NOW**

The “traditional” imagine of eternity is temporal, the new one is timeless: eternity is not infinitely back into the past and infinitely ahead into future, eternity is Einstein’s NOW (Sorli, 2013). In our model time is not a dimension of space any more. Time in our model represents only a mathematical parameter of changes that runs in NOW. Past, present and future have only a mathematical character.

7. **The understanding of time as a purely mathematical entity allows the conceptual unification of time concept among Classical Physics, Relativity and Quantum Mechanics**

It is undoubted that time is one of the most important concepts in physics, nevertheless, until now, there is no unique interpretation of this entity throughout CP, GR and QM. This is also one of the deepest reasons for the missing unification between GR and QM. In CP the most general description of physical system is given in terms of set of classical physical observables (Withaker, 1970), for a matter – point this set is the quadruple \((\vec{x}, m)\) where \(\vec{x}\) is the position of the point in a given system of reference and \(m\) is its mass. The state of motion of this matter – point is defined by giving at different times \(t\) the values of \(\vec{x}\) and \(\vec{p} = m\vec{x}\). Thus any state of motion of the matter – point can be uniquely represented by a point in a six – dimensional classical phase –
space \((\vec{x}, \vec{p})\) describing a well-defined trajectory \((\vec{x}(t), \vec{p}(t) = m\dot{\vec{x}}(t))\) where time plays a role of a mathematical parameter.

A complex physical object can be then considered as the “union” of a number \(n\) of such points whose phase – space \((\vec{x}_i, \vec{p}_i)\) is \(6n\) - dimensional that, in the limit \(n \to \infty\), represents a continuum body or a field. The case of \(n\) very large (of the order of Avogadro number \(N_A = 6.02 \cdot 10^{23}\)) but not infinite gives the point of view Maxwell – Boltzmann statistical mechanics, including thermodynamics. Substantially different is the point of view of Theory of Relativity (both Special and General) time is the fourth physical component of the spacetime, considered as a whole entity representing the universal arena of physical phenomena. In this sense the spacetime itself appears as “frozen” because it cannot evolve respect to time but in time, time being part of itself. In this picture they not exist external clocks, independent of spacetime. In QM, whose observables are just Hermitian operators in a complex Hilbert space, things are completely different: in fact it requires an “external” universal clock beating the time exactly at the same rate for all the observers, since quantum systems are described by complex wavefunctions giving the probability of the measurement results whose value changes with time (Dirac, 1958).

The conceptions of time in GR and QM appear in this way irreconcilable. As we have seen by the above concise discussion, CP and QM both fundamentally consider time as a mathematical parameter external to system itself and that is measured by clocks. In this sense the interpretation of time as a purely mathematical parameter quantifying the duration of change of a physical system, proposed in this paper and in our previous ones, could give valuable and interesting insights in view of the elaboration of a suitable unified theory of GR and QM.

8. Cosmological considerations

The interpretation of time as a purely mathematical quantity, disconnected from space, describing the duration of a change in a physical system and not representing the 4th component of a continuum four - dimensional space-time has deep consequence on the main cosmological theories and, first of all, on the Big Bang (BB) and Inflationary model (IM). The adoption of a fourth dimensional space-time is in fact fundamental for the BB theory to work. In a pure 3D space, in fact, a possible BB would produce a Universe very different from the strongly homogenous one predicted by the BB model (Bonali, 2000). From a theoretically point of view all the possible formulations of BB require a four dimensional space-time, since they are based on General Relativity in turn founded on the Minkowski space time of the STR.

In fact the BB theory is substantially founded on three presumed experimental evidences: the Hubble laws of Universe expansion, the Cosmic Background Radiation (CBR) and the relative abundance of light elements. In order to obey the Hubble law cosmologists have introduced the very known picture of an inflating balloon that appears a non – sense model since the balloon’s surface only has two dimensions in comparison with our 3D Universe. According to J. A. Wheeler (Wheeler, 1990) in order to make this picture coherent with the observed features of our Universe we must then introduce, following the GR formalism, a fourth dimension “at hand” and consider the
Universe as a three-dimensions sphere viewed as a three-dimensions spherical surface of a hypersphere in a fourth-dimensional Universe.

This model of Universe is based on elliptic geometry, whose three-dimensional sphere is “immersed” in a four – dimensional Euclidean space. There also exist alternative models of Universe based on hyperbolic or Euclidean geometries but all of these need the presence of a fourth physical dimension to work. All these models use the distance – redshift relation for galaxies and the GR to describe the expansion or contraction of the Universe within the BB theory, under the assumption that universal curvature evolves with time. The redshift – distance relation can be then obtained in terms of acceleration or deceleration of the galaxies, multiplying by the scale factor $R(t)$, associated to time dependent curvature and related to Hubble parameter through the equation $H = (dR/dt)/R$, the 3-space metric of equation, under the assumption of a isotropic and homogeneous 3-space

$$dl^2 = \frac{dr^2}{1-kr^2} + r^2(\sin^2 \theta d\phi^2)$$

where $dl$ is the infinitesimal length element of the space, $(r, \theta, \phi)$ are the polar coordinates of the reference system and $k = 0, \pm 1$ determines the metric of space (flat for $k = 0$, spherical for $k = 1$, hyperbolic for $k = -1$). This gives, after adding the term for the time coordinate (Ohanian & Ruffini, 2013)

$$ds^2 = cdt^2 - R(t)^2 dl^2$$

that represents the “generalized” version of Minkowski metric in a non inertial frame describing expansion / contraction.

The conceptual stability of the BB model is then based on the validity of the LT on which the Minkowski metric is based. But as we have seen this validity cannot be general assumed and a different formulation of STR, based on IT, is not only possible, but also necessary in order to avoid the fundamental paradoxes implied by the currently accepted formulation of STR.

Moreover a lot of experimental evidences strongly suggest the adoption of IT, instead of LT, in the construction of STR as, for example, the data collected by VLBI (Very Long Baseline Interferometry) and GPS system characterized by a discrepancy between the time measured on the Earth surface and that measured by the GPS clocks (Hatch 2004, Rydin 2003) or the related so – called “midnight - midday problem” concerning the difference in the clock speed at midnight and midday in a given place of the Earth surface (Rydin, 2003).

A further difficulty for the accepted BB model arises from the bulk of data about the so-called “anomalous redshift” (Arp, 1997) concerning a very high number of galaxies that, as it has been shown are not at the “right” redshift distances estimated by the commonly accepted cosmological models based on GR and BB. Another very important question, related to the relationship between space and time in GR, regards the emission of particles of very high energy from the black holes and the theoretical
missing of a universal energy conservation law in GR because of the impossibility to define a potential energy function as shown by Rindler (Rindler, 2001).

This latter very fundamental but generally underestimated question is related to the theoretical inability of GR to explain, even in a very simple case as that of a free falling body in a gravitational field, the energy transfer between the field itself and the falling body. The increase of the mass – energy of the falling body of rest mass \( m \) is given by

\[
\Delta E_k = m_0 c^2 \left( \frac{1}{\sqrt{1-v^2/c^2}} - 1 \right)
\]

(19)

and must be described by introducing external assumptions as suggested, for example, by Tolman (Tolman, 1987). In order to explain the origin of the kinetic energy increase and the emission data from black holes, Brandes (Brandes, 2005) have assumed a variation of rest mass as a function of the energy of a particle that, however, calls into question the true meaning of inertial mass.

He furthermore supposed the existence of a preferred frame and the independence between space and time. As shortly recalled above in this paper, the model recently proposed by us (Caligiuri & Sorli 2013, Caligiuri & Sorli 2014a) is able to simply and coherently solve this question in a very general and fundamental way by the introduction of a novel concept of a 3D physical space in terms of universal properties only whose underlying structure, constituting the space itself, is given by QV of QED nature.

In this model rest mass and relativistic energy naturally emerge as energy density variations of QV referred to a preferred inertial frame (Caligiuri & Sorli 2014a).

Within this model, the crucial role is played by energy density, viewed as the most fundamental entity also originating mass.

In a fixed volume of physical space, a given isolate system has a total energy we can express as

\[
E_{QV} + E_{em} + E_M = D
\]

(20)

where \( E_{QV} \) is the quantum vacuum energy, \( E_{em} \) is the electromagnetic energy in the form of radiation, \( E_M \) is the relativistic energy in the form of matter and \( D \) is a constant.

This can be rewritten in a more general form, independent on the volume, in terms of density, also assuming that energy tends to a uniform distribution

\[
\rho_{QV} + \rho_{em} + \rho_M = d
\]

(21)

where \( \rho_{QV} \) is the quantum vacuum energy density, \( \rho_{em} \) the electromagnetic energy density, \( \rho_M \) is the relativistic energy density in the volume \( V \) and \( d \) is a constant energy density.

According to the Planck metric, quantum vacuum energy density, in the absence of matter and radiating electromagnetic fields, can be written as

\[
\rho_{QV} = \frac{m_p c^2}{l_p^3}
\]

(22)

where \( m_p \) is the Planck mass and \( l_p \) the Planck length. The value of \( \rho_{QV} \) can be
considered as the maximum possible value of quantum vacuum energy density, representing the volumetric energy density averaged on all the frequency possible modes within the visible size of the universe.

The quantum vacuum energy density is usually considered as the source of the so-called dark energy and, consequently, of the cosmological constant in General Relativity. Dark energy, in turns, is supposed to represent the bridge between Quantum Mechanics and General Relativity and its role is crucial for the elaboration of an eventual Theory of Everything. Nevertheless, the above correspondence between \( \rho_{QV} \) and dark energy poses some questions.

The most noticeable one is represented by the numerical value given by Eq. 22 we can obtain substituting in Eq. 22 the known expressions for \( m_p \) and \( l_p \) namely

\[
\rho_{QV} = \sqrt{\frac{c^4}{\hbar^2 G^4}} \approx 10^{97} \text{kg} \cdot \text{m}^{-3}
\]  

(23)

in disagreement with the value deriving from the currently available experimental evidences

\[
\rho_{DE} \approx 10^{-26} \text{kg} \cdot \text{m}^{-3}
\]  

(24)

this poses the so – called “cosmological constant problem”.

In order to solve this question Santos (Santos, 2011) has recently proposed the consideration of quantum vacuum fluctuations through the introduction of an energy density operator \( \hat{\rho}(\vec{r},t) \) of the quantum field. This operator square has a non zero expectation value when applied to quantum vacuum

\[
\langle \text{vac} | \hat{\rho}^2 | \text{vac} \rangle \neq 0
\]  

(25)

due to the fluctuations of quantum vacuum itself, possibly associated, according to the what suggested by Zeldovich (Zeldovic, 1967) to dark energy density \( \rho_{DE} \) in turns related to the gravitational energy of quantum vacuum as due to the presence of a particle of mass \( m \) such as

\[
\rho_{DE} \cdot c^2 \sim G m^6 c^4 / h^4 = G m^2 / \lambda^4, \quad \lambda \equiv h / mc
\]  

(26)

In addition, the interpretation of mass as the results of an electromagnetic quantum vacuum energy density has been also proposed by Rueda and Hairsch [39] in whom model the inertial mass \( m_i \) of a given particle is given by

\[
m_i = m_g = V_0 / c^2 \int \eta(\omega) \omega^3 / 2 \pi^2 c^3 d\omega
\]  

(27)

where \( V_0 \) is the proper volume of the object, \( \omega \) is the characteristic frequency of the e.m mode and \( \eta(\omega) \) is a sort of coupling function representing the relative strength of the interaction between the zero – point field and the massive object. In this picture a mass \( m \) expels from the space volume \( V_0 \) associated with it a quantity of energy equal to its rest energy \( E_0 = mc^2 \).

The above pictures both agree with our model but the latter has the advantage that it is obtained only considering universal invariance of 3D space without any further assumptions, especially as regard as the particular type of energy density of quantum vacuum involved. According to the above results we can then consider that every
particle is made out of electromagnetic energy of quantum vacuum and so it consists of diminishing energy density of an ideal quantum vacuum.

For massless particle, the diminishing of energy density corresponding to the “creation” of a particle of energy $E = \hbar \omega$ is

$$\rho'_{QV,E} = \left( m_pc^2 - \hbar \omega \right) / l_p^3 \quad (28)$$

where $\rho'_{QV,E}$ is the quantum vacuum energy density after the “expulsion” of the massless particle. For a massive particle of rest mass $m$ we have

$$\rho'_{QV,m} = \rho_{QV} - mV/c^2 \quad (29)$$

where $V$ is the proper volume of the considered body and the energy density variation is considered to be concentrated in the body center of mass.

According to Eq. 28 and Eq. 29, particles are made out of quantum vacuum energy “stuff”, substantially made of electromagnetic field modes.

From Eq. 29 it immediately follows that mass can be expressed as a result of the difference of energy density of an “electromagnetic” quantum vacuum

$$m = \left( \rho_{QV,m} - \rho'_{QV} \right) V/c^2 \quad (30)$$

or, equivalently

$$m = \Delta E_{QV} / c^2 \quad (31)$$

having defined $\Delta E_{QV} = \left( \rho_{QV,m} - \rho'_{QV} \right) V$, and that energy of which particles are made out, comes from quantum vacuum.

In this picture, as we have shown (Caligiuri & Sorli 2013, Caligiuri & Sorli 2014a), time is separated by space as physical dimension and plays the fundamental mathematical role of quantifying the duration of changes in physical systems. It also gives a general theoretical explanation of the Tolman’s and Brandes’s hypothesis within a wider model of QV and physical space.

The separation between space and time and the use of IT gives decisive consequences on the metric structure of physical space derived by LT, suggesting that Minkowski metric and, consequently, all the theoretical models based on it could have no general validity. In particular even the concept of space curvature, as currently formulated, should be deeply revised, as already pointed out by Roscoe (Roscoe, 1995). In his model, in fact, the concept of curved space is needless for the description of the gravitational phenomena and the resulting theory cannot be distinguished from GR in any local test.

The questions about the ontological and epistemological role of curvature imply the search of alternative physical mechanisms able to originate gravity. One of the most interesting suggestions is the theory proposed by Milne (Milne, 1952) several years ago, later reconsidered by Wegener (Wegener, 2004) in which gravity emerges as local deviations from global symmetry of the Universe.

NASA results confirm, with 0.4% margin of error, that universal space is “flat” (NASA, 2013). This means observable universal space is described in terms of Euclidean geometry and not in terms of Riemann’s one. Between NASA results and
curved space in GR seems to be a discrepancy. Recently, a novel physical mechanism able to explain the origin of gravity has been proposed by us (Caligiuri & Sorli, 2014b). It doesn’t make use of the concept of space curvature as starting point but considers the pushing effect of the quantum vacuum energy density variations; curvature of space in GR represents a mathematical model of actual variable energy density of quantum vacuum. This model, in which time is disconnected from space according to IT, is able to explain the main features of gravity as well as many yet obscures physical phenomena like, for example, the physical origin of dark energy; it introduces cosmological model of the universe in a permanent thermodynamic equilibrium which runs in Einstein’s NOW. In this universe one can travel in NOW only and time is duration of its motion.

9. Conclusions

Some recent researches, including our latest ones, have confirmed the possibility to develop perfectly coherent alternative versions of STR, considering the fundamental principle of homogeneity of space and time and the relativity Principle without assuming the postulate of invariance of light velocity in vacuum. These alternatives generally admit space and time transforms different than the Lorentz’s ones. Among these a special role is played by the IT that allow to reproduce all the main experimental features of the “standard” STR without giving rise its paradoxes and faultiness as the lack of explanation of the Sagnac effect. The IT, including LT as a particular case, implies very deep consequences as regard as the true meaning of physical time. This is due to the absence, in the time transform, of spatial terms causing, as we have shown, the metric interval \( (\Delta s)^2 \) not to be invariant among all the possible inertial frames, resulting in \( x_4 \neq ict \), namely time cannot be generally considered as the fourth physical component of a four dimensional Minkowski space – time.

In today physics “timeless approach” wants to abolish time as a physical reality while classical approach wants to interpret time as a 4th physical dimension of space. We have proposed a novel understanding of time as duration of changes of a physical system in 3d space. In our model the duration of a change in a physical system doesn’t happen in time because time is the duration itself, occurring in a 3D space originating from a QED quantum vacuum ruled by a Planck metric. In this picture only duration then represents a fundamental physical entity.

Time we measure with clocks is instead a numerical order of material change, i.e. motion while duration is a sum of numerically ordered changes of an observed physical phenomenon. This view doesn’t abolish time that remains a fundamental quantity of physics, but assigns to time only a mathematical existence. In CP, QM, Relativity and Cosmology the symbol \( t \) has then always the same unifying meaning only: the duration of the observed physical phenomena. This view on time categorically excludes travel in time. One can travel in universal space only and time is duration of its motion.

Traveling in time in physics is a product of imagination based on model of closed time curves of General Relativity. Gödel itself already pointed out the contradictions coming out of hypothetical travel in time needs revision of our understanding of space and time. He was not fully understood by his contemporaries who understood Gödel’s closed time lines as a proof for existence of time if considered
as a physical reality in which motion happens. The conceptual and operative separation between space and time allows the overcoming of all well–known paradoxes afflicting the commonly accepted formulation of Relativity. In particular we have shown how the proposed approach is able to solve the crucial paradox of the predetermination of future and the causal paradox currently associated with the existence of SLS in the “standard” formulation of STR.

It also excludes the interpretation of antiparticles as particles moving backward in time. Furthermore this new interpretation of time emerging from the formulation of STR based on IT deeply compromises the theoretical stability of the most popular cosmological models based on the assumption of a four - dimensional space-time as the fundamental arena of the Universe, seriously calling into question the conceptual background of BB model and Inflation Theory as already suggested by several experimental evidences, often ignored by mainstream physics. Incidentally we can note, in this connection, that the presumed experimental confirmation of universal inflation attributed to the recent BICEP2 group (BICEP, 2014) is anything that exhaustive or indisputable.

The doubtful general validity of the four–dimensional structure of universal arena also implies a reformulation of the concept of space and its properties in order to primarily explain the physical origin of gravity from micro to macro scales as suggested in our recent proposal of a novel model of gravity originating from the variable energy density of a QED based quantum vacuum (Caligiuri & Sorli 2014b, Caligiuri 2014) and capable to give valuable and interesting insights in view of the elaboration of a suitable unified theory of GR and QM.
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