On the Meaning of Relativity in Contemporary Physics

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Abstract

The paper examines the evolution of the concept of relativity from origins, in the 17th century, to this day. Doubtless the concept of relativity has undergone a substantial change that misrepresents the concept that instead expresses in its essence the fact that laws and equations of physics do not depend on the inertial reference frame and on the inertial observer. The principle of relativity hence is valid only for inertial reference frames and observers who move with constant relative motion. For all inertial observers the same laws of physics and the same equations are valid, it doesn't mean nevertheless for them also the same mathematical solutions are valid when these solutions depend on inertial velocity of a second reference frame with respect to the reference frame supposed at rest.

1. Introduction

The concept of relativity has lost over centuries its initial meaning and today it is really hard to establish what this word means. In fact frequently it is possible to read in media the statement "all is relative" that in actuality means nothing. It proves only the great confusion that is in present physics and Contemporary Physics, described in numerous papers and in the Manifesto Project, strives to criticize a few present convictions, in order to reach a clear and unequivocal definition of physical concepts.
The concept of relativity was explained in clearest way by Galileo Galilei in his famous work[1] "Dialogo sopra i due massimi sistemi del mondo" (1632) but afterwards that concept was changed so that it has assumed at present a meaning that is fully in conflict with the initial meaning. Already previously the philosopher Giordano Bruno (1548-1600) gave an important contribution, more properly philosophical, to the definition of relativity in the famous work "La cena de le ceneri" (1584). Galileo explained in unequivocal way what it needs to intend for relativity through the well-known experiment regarding a boat at rest along the pier and afterwards the same boat in uniform motion with respect to the pier. With this experiment Galileo clarified firstly the definition of inertial reference frame and then the concept of relativity in the unique correct way in which that concept is valid. Galileo doesn't have an absolute idea of inertia but he explains perfectly two reference frames are inertial if they move with an uniform relative velocity.
Like this supposing that one of the two reference frames is at rest, the second reference frame is inertial with respect to the first if and only if it moves with uniform velocity with respect to the first, i.e. without accelerations. The concept of inertia in Galileo isn't connected with a concept of absolute reference frame.

2. Galilean relativity and inertial systems

In his famous work Galileo considers a simple experiment: before a still boat along the pier and in that case the reference frame of the boat can be supposed a reference frame at rest. Afterwards Galileo supposes that the boat moves with uniform velocity u with respect to the pier. In that case the boat can be considered an inertial moving reference frame with respect to the pier that represents the reference frame at rest (fig.1).

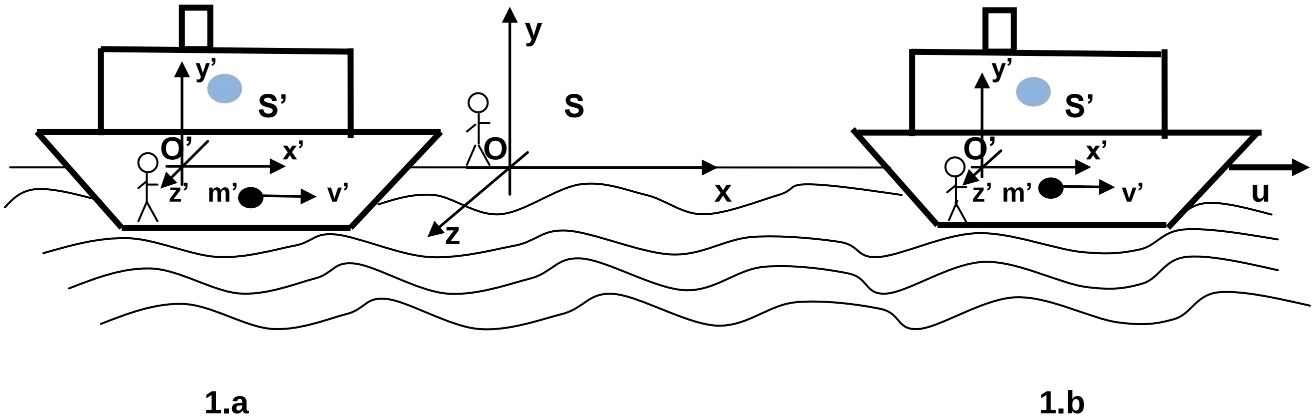

Fig.1 In fig.1.a the boat is still along the pier. In fig.1.b the boat moves with constant and linear velocity u with respect to the pier, v' is the velocity of a mass m' inside the boat in the two described physical situations.

Like this Galileo defines the inertial reference frame considering nothing of absolute. Then he observes what happens inside the boat in the two cases: still boat and moving boat. Galileo observes in the two cases all happens similarly inside the boat: that is the motion of boat doesn't changes physics of what happens inside and the observer O', who is inside the boat, verifies physical phenomena happen similarly in the two cases: still boat and boat in inertial motion. This experimental result represents the first physical definition of the

Principle of Relativity:

" Physical laws and consequently mathematical equations that describe them are the same whether when the boat is still or when it is in inertial motion with respect to a reference frame supposed at rest".

Hence for instance Newton's law of dynamics F'=m'a' has to be written exactly similarly if an ordinary body with mass m' is subject to a force F' whether when the boat is still or when it is in inertial motion.
In order to represent correctly laws of physics and relative mathematical equations, it is convenient to use, for representing the boat, a reference frame S'[O'.x'.y',z',t'] that allows to write a mathematical model of physical law. In that case in fact Newton's law can be written in S'

$$F' = m'a' = m' \frac{dv'}{dt'} \qquad (1)$$

where t' is time of the boat and of the reference frame S' and consequently of the observer O', v' is the velocity of body with mass m' that is inside the boat and it is subject to force F'. For ordinary bodies of mechanics mass m' is inertial. Besides it is evident that in the Galilean relativity time t' of the boat (reference frame S') is the same in the two cases, i.e. when the boat is still and when the boat moves with inertial motion and also the Newton's law is the same in the two cases. This is the first aspect of relativity.
The second aspect of relativity regards the consideration of a second observer O that is placed instead along the pier. The question is then: what the observer O observes in the two cases of still boat and of boat with inertial motion.
It is manifest that for this second observer it needs to define a new reference frame S[O,x,y,z,t] because it is clear that if for the observer O' space coordinates, inside the boat and of S', don't change in the two cases, for the observer O there is an evident change of space coordinates because of motion of the boat.
From a mathematical viewpoint it is convenient to use Cartesian reference frames and to represent the situation of fig.1 like in fig.2.

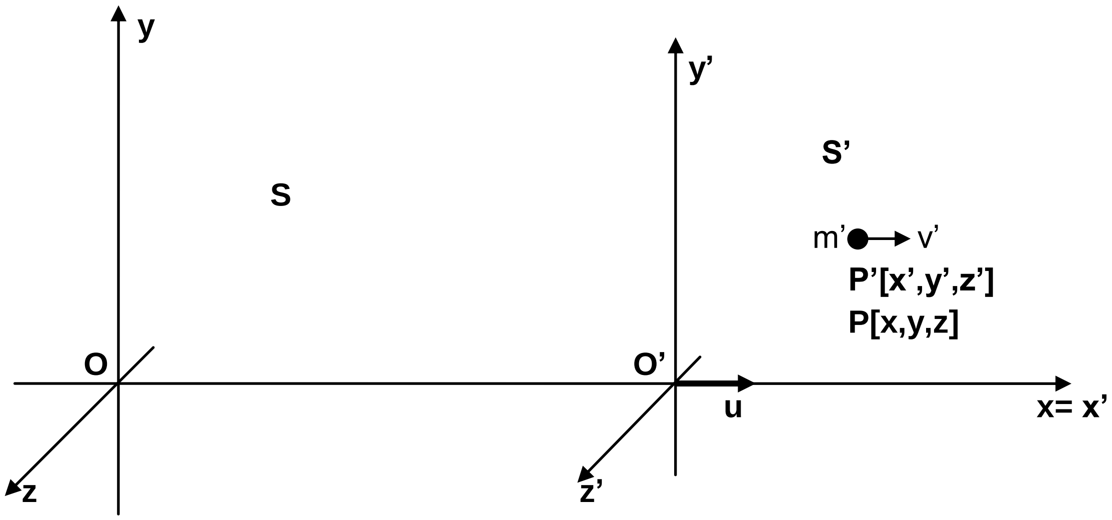

Fig.2 Representation of the reference frames S and S' with Cartesian axes.

If for instance Newton's law of dynamics in the reference frame S' is described by the equation F'=m'dv'/dt' , then the same law in the reference frame at rest S is described, for the Principle of Relativity, by the analogous equation

$$F = ma = m \frac{dv}{dt} \qquad (2)$$

where F, m and v are the force applied to mass m, mass and velocity of the body with respect to the reference frame at rest S.

Supposing that at initial time t'=t=0 the two reference frames coincide (S'=S), the kinematic situation described in fig.2 is defined by the following "Galilean transformations" relative to the passage from the reference frame at rest S to the moving reference frame S'

$$\begin{aligned} x' &= x - ut \\ y' &= y \\ z' &= z \\ t' &= t \end{aligned} \qquad (3)$$

From (3) we deduce, being u=constant,

$$v' = \frac{dx'}{dt'} = \frac{dx}{dt} - u = v - u \qquad (4)$$

$$a' = \frac{dv'}{dt'} = \frac{dv}{dt} = a \qquad (5)$$

Because the two reference frames are inertial and because motion of S' with respect to S is uniform (u=constant) and it doesn't introduce accelerations, it must be necessarily

$$F' = F \qquad (6)$$

Comparing (2) with (1) we obtain for ordinary bodies

$$m' = m \qquad (7)$$

The (7) proves inertial mass of ordinary bodies doesn't change with velocity.
The Galilean relativity hence is defined by the Principle of Relativity, by transformation equations (3) for inertial reference frames and by the relation (7) that proves the invariance of inertial mass of ordinary bodies of mechanics.
Galileo defined relativity fundamentally for mechanics and for optics that were branches of physics known at the time.
It is manifest that relativity involves an invariance of physical laws and of mathematical equations, that describe the physical phenomenon, for inertial reference frames, and hence they are independent of the observer. It needs nevertheless to point out that a few physical quantities that depend on the velocity u, like for instance the space coordinate x in (3), the frequency of the Doppler effect, as we will see afterwards, and other quantities depend on the state of motion of observer just because of transformation equations (3) and it is perfectly compatible with the Principle of Relativity.

3. Newtonian Relativity and absolute space-time

Newton has been the scientist who has discovered two of the most important equations of physics: the law of dynamics and the gravitational law.
With regard to relativity Newton accepted and confirmed practically the Galilean relativity with an important difference that had a controversial meaning in the history of physics.
In fact Newton had full awareness of the new experimental scientific method, introduced and perfected by Galileo, but he needed to define the two absolute concepts of space and of time with these words[2]:

" Absolute, true, mathematical time, for its own sake and by its nature without relation to something of outside, flows in uniform way............ .
Absolute space, by its nature without relation to something of outside, remains always equal and immobile .... "

From a philosophical viewpoint these two definitions can have also a meaning but from the physical viewpoint they had a negative outcome because they generated in physics the concept of absolute reference frame that still today is cause of many controversies for physics.
In fact with regard to the question of the physical nature of light Newton was convicted light has corpuscular nature and it is composed of a beam of mass particles. Many experimental facts, above all in geometric optics, confirm this assumption but other experimental facts, like diffraction and interference, don't have a clear explanation in that theory. On this account the wave hypothesis of light (Huygens) had much support by physicists. Because all waves propagate through a medium, physicists reached the conclusion also light propagates through a medium. This medium was associated with the Aristotelian ether that as per the Newtonian concepts of absolute space and absolute time became the absolute reference frame of physics, with respect to which light propagates always with the same velocity c.
We observe this absolute reference frame isn't in conflict with the Galilean relativity because all equations of the Galilean relativity (from (3) to (7)) continue to be valid, including the (4) that defines an additive composition of velocities, whether at scalar level or at vector level.
In the Newtonian physics and afterwards in all classic physics, till 1881, relativity was still defined by the Galilean relativity with only one difference. In fact for Galileo the last equation of (3) had only the meaning that times of the two reference frames S and S' are equal, in post-Galilean classic physics the relation $t'=t$ defined the existence of an absolute time, introduced by Newton.
Besides in consequence of the introduction of the absolute reference frame, coinciding with ether, physicists convinced themself light propagates always with the known velocity c with respect to ether and the velocity of light with respect to any other reference frame S is obtained from the vector composition of c with the velocity of S with respect to ether.
This conviction will be cause of many disputes as we know and will see afterwards.

4. The Michelson-Morley experiment and ether

The question of the physical nature of light and of its propagation interested always physicists. It was common conviction in the 19th century that light propagates with the known velocity $c \approx 300000$km/s with respect to the absolute reference frame represented by ether that was considered the medium of propagation of light and of electromagnetic waves. No experiment nevertheless could have proved the real existence of ether and of the absolute reference frame. In this context A. Michelson, at first alone (1881) and then together with E. Morley (1887), projected an experiment for proving the existence of ether that in actuality could be still only a hypothesis. It is well-known that with a famous letter J. Maxwell encouraged the experiment because Maxwell was a supporter of ether that seemed to be the only possible explanation for the propagation of light.
Unfortunately Maxwell died (1879) before the effective execution of the first experiment and consequently we cannot know its reaction towards the result of that first and of subsequent experiments that had always negative outcome with regard to the existence of ether: the hypothesis of ether and of the absolute reference frame didn't have an effective confirmation in the physical reality by experimental verifications.
A graphic representation of the famous experiment is showed in fig.3

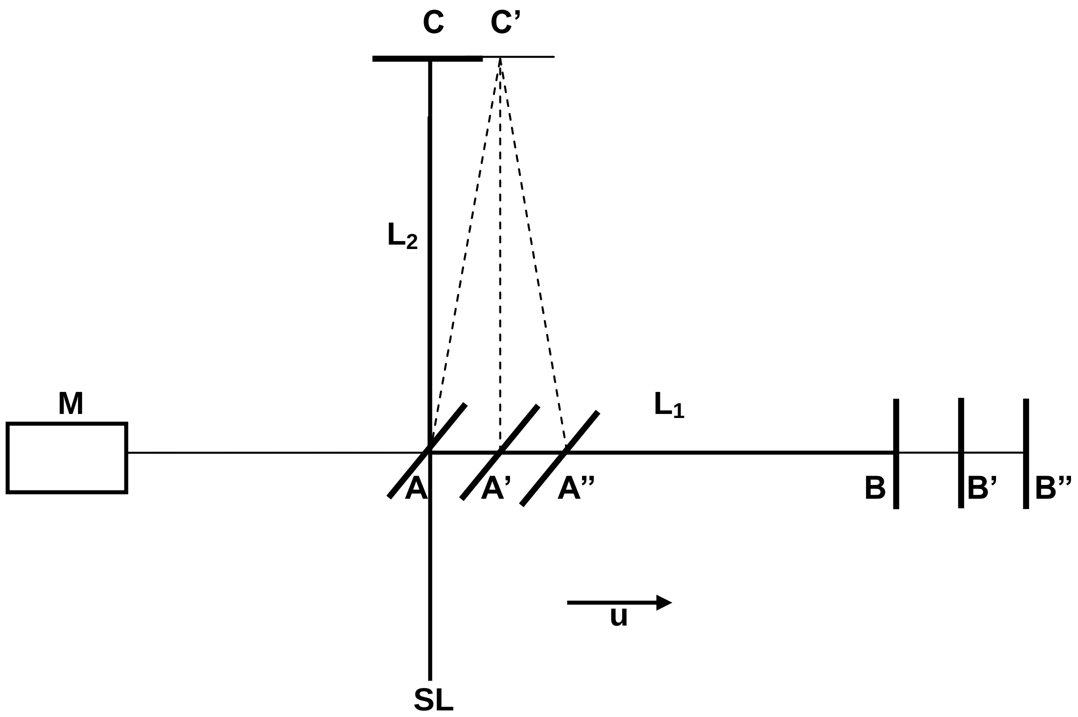

Fig.3 Interferometer used by Michelson and Morley. SL is a source of light, M is a microscope that records the interference, B and C are reflecting mirrors, A is a half-reflecting mirror, u is the speed of Earth.

The Michelson-Morley experiment can be performed whether with two equal arms of the interferometer L_1 and L_2 (L_1=L_2) or with different lengths ($L_1 \neq L_2$). Anyway if ether exists and the velocity of light propagates always with velocity c with respect to ether, going-return times of light in the two arms are:

a. longitudinal arm L_1

$$T'_{L1} = \frac{2L_1 c}{c^2 - u^2} \qquad (8)$$

b. transverse arm L_2

$$T'_{L2} = \frac{2L_2}{\sqrt{c^2 - u^2}} \qquad (9)$$

Different values of T'_{L1} and T'_{L2} prove the microscope M points out interference of the two rays of light coming from the longitudinal arm and from the transverse arm.
Rotating the interferometer of 90°, the result is

c. longitudinal arm L_2

$$T''_{L2} = \frac{2L_2 c}{c^2 - u^2} \qquad (10)$$

d. transverse arm L_1

$$T''_{L1} = \frac{2L_1}{\sqrt{c^2 - u^2}} \qquad (11)$$

The microscope points out again an interference of the two rays of light, but in the event that the two arms have different length also a shift of interference fringes would have to happen after the rotation. Similarly also in the event of equal arms, rotating interferometer with different angles there would have to be a shift of fringes. Outcomes of the experiment, also repeated in order to remove possible errors in the equipment of measurement, gave always negative result: i.e. there isn't shift of interference fringes. This result has only one physical consequence: ether doesn't exist.
Many physicists, who still today persist in believing ether exists, think Sagnac's experiment proves the existence of ether because that experiment has pointed out a shift of interference fringes in disagreement with the Michelson-Morley experiment. It is manifest that a correct analysis of the Sagnac experiment proves this experiment has no significance in this context because in this experiment the interferometer is placed on a rotating platform: in that case the rotary motion, imposed to the interferometer, generates a centrifugal force that changes completely the nature of the Michelson-Morley experiment, in which this centrifugal force doesn't exist. It is manifest that the different experimental result doesn't prove the existence of ether but simply the existence of a centrifugal force that in an inertial motion doesn't exist.

5. Post-classical relativity and Lorentz's Transformations

Classical physicists believed certainly in the existence of ether and they refused to accept the result of yhe MM experiment that was planned just for proving that existence respecting all requirements of the experimental scientific method.
In order to save ether and consequently the absolute reference frame they searched for finding solutions ad hoc for explaining the negative result of the experiment and for saving like this the concept of ether.
G.F. FitzGerald first supposed a length contraction of a moving body in the direction of motion. This hypothesis was considered by H. Lorentz who to length contraction added the concept of local time. These two concepts were introduced in order to save however ether even if in a modified version with respect to classical ether.
Hence Lorentz reached the conclusion that Galileo's Transformations of space-time (3) could have to be replaced with a new group of transformations. For reaching this aim also other physicists and mathematicians gave their contribution, as H. Poincarè, J. Larmor, W. Woigt and others.
The following Lorentz Transformations were the result of this work:

$$\begin{aligned} x' &= \gamma\,(x - ut) \\ y' &= y \\ z' &= z \\ t' &= \gamma\left(t - \frac{ux}{c^2}\right) \end{aligned} \qquad (12)$$

in which

$$\gamma = \frac{1}{\sqrt{1 - \dfrac{u^2}{c^2}}} \qquad (13)$$

is the Lorentz factor with $\gamma>1$.
It is possible to observe Lorentz's Transformations (12) are different from Galileo's Transformations above all for the presence of Lorentz's factor γ and for the time coordinate.
Like this post-classical physicists believed to save the concept of ether, renouncing Galileo's Transformations and introducing new concepts like length contraction and time variation. It is also true that post-classical physicists didn't understand completely all consequences of their work because they believed like this to have saved, beyond the concept of ether, also the theorem of addition of velocities of classical physics, including the velocity of light.
A. Einstein clarified inconsistencies in work of post-classical physicists when he published in 1905 his paper "On Electrodynamics of Moving Bodies".

6. A. Einstein's Special Relativity

We want here to present a few aspects regarding A. Einstein's scientific work[3], and to point out a few contradictions that are present in his work and that could be already present in work of post-classical physicists even if Einstein believed of removing those contradictions.

Einstein's main contradiction consists in the fact that he affirmed the concept of ether could be superfluous but then he accepted and demonstrated the same Lorentz transformations that post-classical physicists formulated just for saving the concept of ether. Unlike post-classical physicists who started from length contraction and from time change for proving Lorentz's Transformations, Einstein started instead from two postulates: the Principle of Relativity, that in actuality isn't a postulate but a principle of nature in concordance with Galileo, and the postulate of the Constancy of the Velocity of Light.

Post-classical physicists didn't understand Lorentz's Transformations invalidated the classical theorem of addition of velocities, but it was understood by Einstein.

Einstein instead didn't understand the second postulate could invalidate just the Principle of Relativity and he thought the second postulate could represent instead the premise for a new meaning of relativity.

Starting from the two postulates Einstein reached the same Lorentz Transformations, he demonstrated again length contraction and time dilation. Unlike post-classical physicists Einstein demonstrated also a new theorem of addition of velocities, different from the Galilean theorem. Later always in the same work he demonstrated also increase of mass with velocity distinguishing a longitudinal mass from a transverse mass, and then the new formula of the Doppler effect that nevertheless is valid only for moving observer and source at rest.

A further evident contradiction consists in the fact that length contraction and time dilation aren't in concordance with the new Einsteinian theorem of addition of velocities.

In fact length contraction and time dilation are given by the following relations

$$L = \frac{L'}{\gamma} \qquad (14)$$

$$T = \gamma T' \qquad (15)$$

while the Einsteinian theorem of addition of velocities is given by

$$v = \frac{v' + u}{1 + \frac{uv'}{c^2}} \qquad (16)$$

From (16) we deduce that if the velocity v' coincides with the velocity of light v'=c , it is

$$v = c \qquad (17)$$

Hence the theorem of non-Galilean addition of velocities demonstrates the velocity of a same shaft of light is the same, and equal to c, at the same time with respect to all reference frames.
From (14) and (15) we derive instead that if a shaft of light travels a distance L' in the moving reference frame S' in time T' with the velocity c=L'/T', then that distance and that time undergo respectively a contraction L=L'/γ and a dilation T=γT' with respect to the reference frame at rest S, for which in S we have

$$v = \frac{L}{T} = \frac{L'}{\gamma\,\gamma\,T'} = \frac{c}{\gamma^2} \neq c \qquad (18)$$

The (18) proves the length contraction and the time dilation are not in concordance with the theorem of Einsteinian addition of velocities (16). This result is certainly a further important point of contradiction for the theory of Special Relativity.
Special Relativity theorizes then an increase of mass of any object with the velocity but this conclusion is in evident conflict with the Principle of Energy Conservation because there are like this unknown terms of energy, that are not negligible at velocities near to the velocity of light, where whether mass or kinetic energy of the object would become infinite with a double simultaneous singularity that has no physical meaning.
Also for the Doppler effect there is an evident problem in SR because Einstein demonstrated that effect only in the event of source at rest and moving observer.
Besides it is true that Einstein's famous equation[4], $E=mc^2$, has experimental confirmations; it needs nevertheless to point out it has been demonstrated by Einstein in a second work (always in1905) in the order of an approximate demonstration, valid only for $u \ll c$, that neglects energy terms that are important at high velocities and hence it limits the physico-mathematical validity of that proof only for small velocities. Besides that equation in SR is valid for any mass while we have proved that equation is valid only for elementary particles that have an electrodynamic mass.
It follows from these considerations that many physical facts, theoretical and experimental, raise many doubts on the validity of Special Relativity.

7. The Newtonian gravitation and General Relativity

General Relativity represents a generalization of Special Relativity from inertial systems to accelerated systems. For the principle of equivalence the gravitational field is equalized with an accelerated system for which the study of accelerated systems involves in GR also the study of gravitational field that in this theory has a relativistic origin.
In Contemporary Physics, Physics of Gravitational Fields allows to find an alternative solution whether with respect to the action at distance of the Newtonian gravitation or with respect to the Einsteinian curvature of spacetime.
In the Newtonian physics the gravitational action at distance between two masses M and m is given by the relation

$$F = \frac{GMm}{r^2} \tag{19}$$

where G is the constant of universal gravitation and r is the distance between barycentres of the two masses. In the event of orbital gravitational systems, like the solar system, one of the two masses represents the central mass (for example the Sun in the solar system) and the other mass represents the orbiting mass (for example the Earth).
In the Einsteinian physics[5] the gravitational action isn't produced by a force but by a curvature of spacetime, due to the action of the central mass. The spacetime curvature is defined by a tensor model of the quadratic infinitesimal element:

$$ds^2 = \Sigma_{ij}\ g_{ij}\, dx_i\, dx_j \qquad i= 1, 2, 3, 4\ ;\quad j= 1, 2, 3, 4 \tag{20}$$

where parameters g_{ij} are components of a tensor with 16 elements, called fundamental tensor:

$$\begin{pmatrix} g_{11} & g_{12} & g_{13} & g_{14} \\ g_{21} & g_{22} & g_{23} & g_{24} \\ g_{31} & g_{32} & g_{33} & g_{34} \\ g_{41} & g_{42} & g_{43} & g_{44} \end{pmatrix} \tag{21}$$

characterized by the symmetry relation $g_{ij} = g_{ji} \quad i \neq j$ (22)
It is manifest that whether the Newtonian model or the Einsteinian model present problems and they are considered obsolete in the order of Contemporary Physics.
The Newtonian model is inappropriate because of the theorization of a mysterious action at distance whose Newton himself wasn't satisfied.
The Einsteinian model is inappropriate because of the fact that for determined values of tensor components g_{ij}, the quadratic infinitesimal element ds^2 assumes negative values determining like this evident physico-mathematical problems because a negative quadratic quantity involves necessarily the existence of imaginary complex values of the element ds that aren't compatible with the real physical universe.
Einstein thought of solving the problem with the introduction of mathematical re-normalizations that instead aggravated further the question opening the way to other numerous re-normalizations that are present in post-modern physics. The most extravagant re-normalization, introduced by Einstein, regards the replacement of $\sqrt{g}$ with $\sqrt{-g}$ in which g is the determinant of the fundamental tensor. It is manifest that if $g<0$ then $\sqrt{g}$ is unreal imaginary and hence it has no physical meaning.
Einstein thought to solve the problem introducing the first mathematical re-normalization in the history of physics with that replacement that nevertheless has no physico-mathematical justification.

8. The Theory of Reference Frames

The Theory of Reference Frames[6][7][8] was formulated in 1978 with the paper "Sintesi Critica della Toeria della Relatività" (Critical Sinthesis of the Relativity Theory), in consequence of a work of critical research by author[7]. This critical work continued afterwards at first with the article "Relativistic Effects of the Theory of Reference Frames"[9] (2007) and later with the article "Physico-Mathematical Fundamentals of the Theory of Reference Frames"[10] (2013).

The **Theory of Reference Frames** (TR) is based on two basic principles:

1. **Principle of the Non-Absolute Preferred Reference Frame**
2. **Principle of Relativity**

The Principle of the Non-Absolute Preferred Reference Frame, called also **Principle of the Natural Reference Frame** claims

"in every physical situation a Non-Absolute Preferred Reference Frame exists and it coincides with physical space-time (3+1)D in which physical phenomenon under consideration happens with the same equal modalities whether when the reference frame is supposed at rest or when it moves with uniform velocity with respect to the reference frame supposed at rest".

This principle points out a physical fact that whether post-classical physicists or modern and post-modern physicista refuse, that is the existence in every physical situation of a non-absolute preferred reference frame, that post-classical physicists refuse because they persist in supporting an absolute reference frame, that for a few coincide with classical ether while for others it coincides with a modified ether. Modern and post-modern physicists refuse instead this non-absolute preferred reference frame because they persist in supporting the equivalence of all reference frames and consequently the absence of a preferred reference frame: two extreme scientific opinions that have in common the replacement of Galilean Transformations with Lorentz's Transformations.
We observe in the Michelson-Morley experiment for instance the non-absolute preferred reference frame coincides with the reference frame of interferometer that in every single stage of measure is at rest with respect to Earth's reference frame. The correct choice of reference frames proves ether doesn't exist, in fact in the experiment there isn't shift of fringes of interference after any rotation of interferometer. It isn't due to the fact that the velocity is always the same with respect to all reference frames as Special Relativity postulates, but because in all situations of the experiment light moves, along the two immobile arms, always with the same velocity with respect to the reference frame of the interferometer that represents in the experiment the non-absolute preferred reference frame. We observe the interferometer represents also the natural reference frame of the physical phenomenon that has been considered in the M.M. experiment.
The Principle of Relativity claims

“ Physical laws and mathematical equations that describe natural phenomena are the same in all reference frames that are inertial among them “.

This definition of the Principle of Relativity is equal whether to Galileo’s definition or to Einstein’s. We have demonstrated in TR the Galilean relativity is valid in all fields of physics (mechanics, optics, electromagnetism, etc...) except for particle physics, in which because of a particular property of mass of elementary particles, it needs to consider an important relation between time and mass of particles.
In the Einsteinian relativity instead the principle of relativity is modified deeply in its meaning by the “postulate of constancy of the velocity of light” that changes the basic meaning of the principle of relativity.
As per these two fundamental principles, in the Theory of Reference Frames transformation equations of space-time are different from Lorentz’s transformations.
Let us consider in fact a reference frame S[O,x,y,z,t], supposed at rest, and a second reference frame S’[x’,y’,z’,t’] in motion with any velocity **u** with respect to S (fig.2), general equations of transformation of space and of time from S to S’ are given in TR by

$$\mathbf{P'}[S'] = \mathbf{P}[S] - \int_o^t \mathbf{u}\,dt$$

$$dt' = \frac{m'}{m}\,dt \qquad (23)$$

in which **P’** and **P** represent the same point of space with respect to the two reference frames S’ and S. The point **P’** and mass m’ are inside the natural reference frame S’.
The first relation of (23) can be specified through space coordinates

$$x' = x - \int_o^t u_x\,dt$$

$$y' = y - \int_o^t u_y\,dt$$

$$z' = z - \int_o^t u_z\,dt \qquad (24)$$

$$dt' = \frac{m'}{m}\,dt$$

Supposing $u_y=u_z=0$, the velocity $u=u_x$ has the direction of the axis x, as in fig.2, and (24) become

$$x' = x - \int_{o}^{t} u dt$$

$$y' = y$$

$$z' = z \qquad (25)$$

$$dt' = \frac{m'}{m} dt$$

If the velocity u is constant, and consequently the two reference frames S and S' are inertial, we have

$$x' = x - u\, t$$

$$y' = y$$

$$z' = z \qquad (26)$$

$$dt' = \frac{m'}{m} dt$$

We observe the (26) coincide with the Galilean Transformations with regard to space coordinates while the time transformation is different.
Anyway in (26) the Lorentz factor γ isn't present.
Let us observe then in space-time transformations of TR a new fact is evident that instead is absent whether in the Galilean Transformations or in the Einsteinian Transformations: that is the presence of mass in the last relation of (26).
If mass m of material object doesn't change with the velocity, as it happens for inertial mass of mechanical classical bodies, it is $m'=m$ and consequently

$$x' = x - u\, t$$

$$y' = y \qquad (27)$$

$$z' = z$$

$$t' = t \quad \text{(inertial time)}$$

Equations of space-time transformation, represented by (27), coincide with Galilean equations of space-time transformation and the relation of time $t'=t$ represents the inertial time unlike the Newtonian absolute time.
It is manifest that space-time transformations of the Theory of Reference Frames, in all shapes represented by equations (23), (24), (25), (26), (27) don't predict a length contraction and a time dilation.

Besides for inertial systems the theorem of Galilean vector composition of velocities is given by the relation, that derives from the first equation of (27),

$$\mathbf{v'} = \mathbf{v} - \mathbf{u} \qquad (28)$$

The TR demonstrates then in Particle Physics mass of particles changes with the velocity, for instance in the event of electrons and protons.
For these particles it is possible to define a mass at rest m' and a moving mass m.
Mass of these particles isn't the inertial mass of mechanical systems but it needs to consider a different concept of mass that in TR is called "electrodynamic mass". In fact it is inconceivable to think for instance an iron sphere and an electron have the same type of mass.
Particle Physics assumes the existence of a conversion mass-energy that derives from many experimental facts like decay of free neutron, annihilation particle-antiparticle, production of pairs particle-antiparticle, etc.... . On this account it is altogether rightful to associate every particle at rest, that has an electrodynamic mass m', with an equivalent energy E' given by

$$E' = m'c^2 \qquad (29)$$

This law of equivalence is similar to Einstein's law but there two different aspects:

a. for Einstein the law (29) is valid for all objects that have mass while in TR it is valid only in Particle physics for particles that have an electrodynamic mass (for instance electrons and protons)
b. Einstein demonstrated the law (29) is valid only in first approximation for velocities $u \ll c$ while inTR the law of conversion is valid for all velocities.

If this particle is accelerated to the velocity u, it is known that under a few physical conditions, it emits electromagnetic energy E_r at the expense of electrodynamic mass at rest m', for which for the Conservation Principle of Energy, it must be

$$E' = E + E_r \qquad (30)$$

in which E is the equivalent energy of particle at the velocity u.
Because emission of energy happens at the expense of electrodynamic mass m' of particle, it follows that at the velocity u the particle has an electrodynamic mass $m < m'$.
The equivalent energy of particle at the velocity u is therefore

$$E = mc^2 \qquad (31)$$

If instead of a particle with electrodynamic mass, we consider an ordinary physical body with inertial mass, this doesn't emit energy and the effect of acceleration from velocity zero to velocity u is the acquisition of a kinetic energy

$$E_c = \frac{m'u^2}{2} \qquad (32)$$

In the established equivalence we can assume energy emitted from electrodynamic particle coincides just with kinetic energy that would be acquired by the equivalent ordinary body that doesn't emit, for which from (30) we have

$$m'c^2 = mc^2 + \frac{m'u^2}{2} \qquad (33)$$

and therefore

$$m = m'\left(1 - \frac{u^2}{2c^2}\right) \qquad (34)$$

The (34) represents the **"law of variation of electrodynamic mass"** of an elementary particle with the velocity.
The analysis of (34) shows that unlike SR, in TR electrodynamic mass decreases with the velocity while in SR mass increases with the velocity.
Besides in TR the concept of relativistic mass is independent of direction while in SR there is a distinction between longitudinal mass and transverse mass and consequently there is a different relativistic mass for every direction. At last the variation of electrodynamic mass in TR happens only for electrodynamic particles while in SR the change of mass happens for all physical bodies that have mass.
Another important difference between Special Relativity and the Theory of Reference Frames is represented by the Doppler effect.
Special Relativity is able to explain the Doppler effect when observer is moving and source is at rest while it isn't able to explain this effect when observer is at rest and source is moving. In fact in the work of 1905, Einstein considered only the case of moving observer obtaining the following result of the Doppler effect

$$f_m = f_s \frac{1 - \frac{v}{c}\cos\varphi}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (35)$$

in which f_s is the frequency of source at rest and f_m is the frequency measured by the moving observer with velocity v with respect to source (fig.4).
In the event that the line source-observer has the same direction of the velocity v ($\varphi=0$), the longitudinal Doppler effect in SR is given by

$$f_m = f_s \sqrt{\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}} \qquad (36)$$

Attempts done then by Einstein and by others, in the order of Special Relativity, for demonstrating the Doppler effect with moving source and observer at rest didn't have acceptable results.
The Theory of Referene Frames proves in reality there is no difference between the two physical sistuations and the Doppler effect is given always by the same formula, independently of whom is moving, observer or source [9][10] .

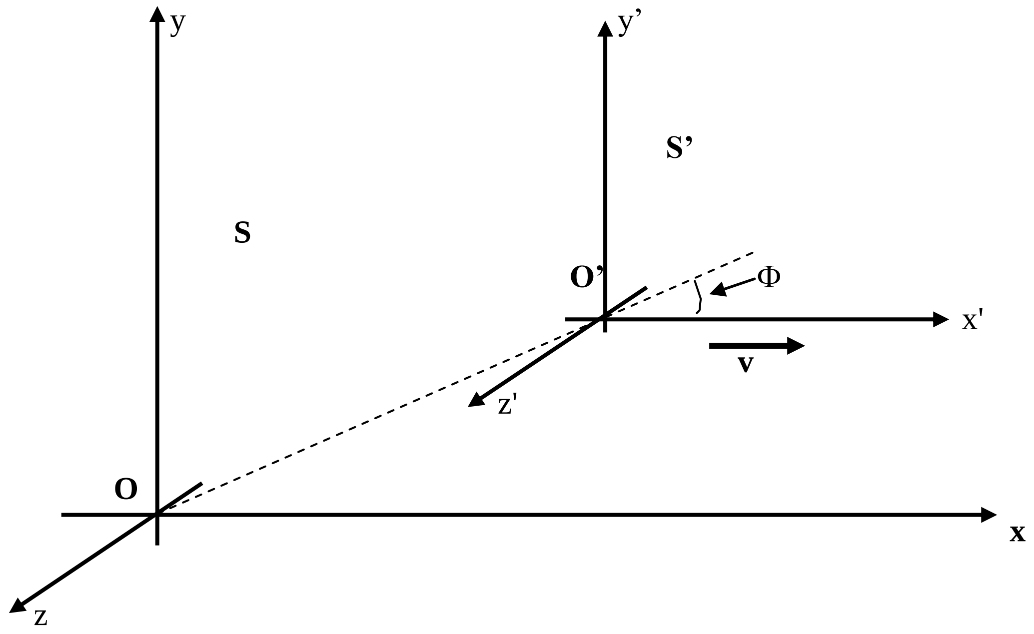

Fig.4 S[O,x,y,z] is the reference frame at rest and S'[x',y',z',t'] is the moving reference frame with velocity v. Observer and source of radiation can be whether in O or in O'.

Considering the fig.4, the formula of the Doppler effect for frequency in TR is given by

$$f_m = f_s \sqrt{1 + \frac{v^2}{c^2} - 2\frac{v}{c}\cos\varphi} \qquad (37)$$

and for wavelength by

$$\lambda_m = \frac{\lambda_s}{\sqrt{1 + \frac{v^2}{c^2} - 2\frac{v}{c}\cos\Phi}} \qquad (38)$$

For φ=0, the longitudinal Doppler effect with departure in the two cases (moving observer or moving source) for frequency is given by

$$f_m = f_s\left(1 - \frac{v}{c}\right) \qquad (39)$$

For wavelength the longitudinal Doppler effect in the two cases is given by

$$\lambda_m = \frac{\lambda_s}{1 - \frac{v}{c}} \tag{40}$$

With respect to wavelength in TR the longitudinal Doppler effect in departure presents terms of the second order and of higher order in v/c.

For $\varphi=\pi$, the longitudinal Doppler effect for frequency, with approach in the two cases (moving observer or moving source) is

$$f_m = f_s\left(1 + \frac{v}{c}\right) \tag{41}$$

For wavelength the longitudinal Doppler effect in the two cases is given by

$$\lambda_m = \frac{\lambda_s}{1 + \frac{v}{c}} \tag{42}$$

Withy respect to wavelength the longitudinal Doppler effect in approach presents still terms of the second order and of higher order in v/c.

Besides the Doppler effect in departure produces decrease of frequency and consequently redshift while the Doppler effect in approach produces increase of frequency and blueshift.

For $\varphi=90°$, the transverse Doppler effect in frequency, in TR is

$$f_m = f_s\sqrt{1 + \frac{v^2}{c^2}} \tag{43}$$

and in wavelength

$$\lambda_m = \frac{\lambda_s}{\sqrt{1 + \frac{v^2}{c^2}}} \tag{44}$$

We deduce from (43) and (44) the transverse Doppler effect produces always blueshift because $f_m > f_s$ and $\lambda_m < \lambda_s$.

9. Physics of Gravitational Fields

Physics of Gravitational Fields[11][12] is the theory that in Contemporary Physics gives a solution to gravitational question. This question is physical and hence it isn't appropriate to give to this question a relativistic meaning as it happens in General Relativity: it confirms in modern physics relativity has assumed a different function with respect to its initial object. In Physics of Gravitational Fields the action between two masses is still described by Newton's law (19) in which nevertheless the Newtonian action at distance is replaced with the concept of field that Newton didn't know because this concept was introduced in physics about after a century, above all by physicists who studied questions concerning electric phenomena.
Physics of Gravitational Fields considers three gravitational situations:

1. gravitational field of first type concerning mass fall into a central field
2. gravitational field of second type regarding an orbital mass
3. gravitational field of third type regarding an interaction between two any masses

In the first type central mass is provided with a rotary motion, in the second type both masses are rotary, the third type doesn't require rotary masses.

- In the gravitational field of first type a mass M generates in the surrounding space (theoretically infinite) a gravitational potential U depending on the amount of mass and on the distance r of the considered point of surrounding space from the barycentre of mass, according to the equation

$$U(r) = -\frac{GM}{r} \qquad (45)$$

in which G is the constant of universal gravitation $G=6.67 \times 10^{-11}\ Nm^2/kg^2$.
When in the potential field U of mass M is placed a mass m, the experience proves an attractive force is produced by mass M on m and this force is given by

$$\mathbf{F_g}(r) = -\frac{GMm}{r^2}\,\mathbf{i_r} \qquad (46)$$

in which $\mathbf{i_r}$ is the unitary vector along the direction r.
This force has vector nature, i.e. it has a direction besides intensity, and the intensity of this force coincides just with the Newtonian force (19).
The fundamental difference with respect to the Newtonian theory consists in the fact that in Physics of Gravitational Fields there is no need to suppose a force at distance because the force acts on mass m because of the pre-existing potential U and of the pre-existing gravitational field $\mathbf{E_g}$ in space that surrounds the mass M. This gravitational field is a vector given by

$$\mathbf{E_g} = \frac{\mathbf{F_g}}{m} = -\frac{G\,M}{r^2}\,\mathbf{i_r} \qquad (47)$$

In this way the gravitational field $\mathbf{E_g}$ represents the force that the field practises on an unitary mass m.
Generally gravitational field of first type generates fall of bodies that happens in concordance with the (46) and Newton's dynamic law.

- The gravitational field of second type, under determined physical conditions, produces the orbital motion of an orbiting mass around the central mass that generates the field.
It is manifest that if physical conditions don't exist the field of second type degenerates into a field of first type with the fall of orbiting mass towards the central mass. The physical condition so that a gravitational field of second type with orbital motion happens is that the centripetal force F_{cp}, coinciding with the gravitational force F_g=F_{cp}, , is exactly balanced by the centrifugal force F_{cg}, due to the orbital motion.
Because

$$F_g = \frac{GMm}{r^2} \quad \text{and} \quad F_{cg} = \frac{mv^2}{r} \qquad (48)$$

from the equality of the two forces we derive the tangential orbital velocity with circular orbit and ray r

$$v = \sqrt{\frac{GM}{r}} \qquad (49)$$

In actuality in a planetary system orbits of planets aren't circular but elliptical because of the Principle of Action and Reaction, for which also planets perform an action (reaction) towards the central pole of the star producing a complex motion of the star and above all an inclination of its rotary axis with respect to the plane of the ecliptic, that in its turn produces an inclination of rotary axes of single planets: these inclinations are the cause of the precession[14].
Precession phenomenon consists in a space shift of particular points (perihelion and aphelion) and of particular lines (line of the apsides and line of equinoxes) with respect to static elliptical orbits.
Generally in meanstream physics precession of a planet is explained considering two actions: the perturbing action of other planets and the relativistic correction due to the spacetime curvature[5].
We have given, in the order of the Theory of Reference Frames, a new systematic interpretation of phenomenon that doesn't present inconsistencies that are present in other interpretations.
It is manifest that this new interpretation is valid for the Sun system and for any orbital system. We cite here what we wrote in the reference [14]:

“ We start from the consideration that the Sun has a rotary axis that isn’t exactly perpendicular to the plane of the ecliptic (that is the plane in which orbit of planets happens), but it is inclined of about 7°15’ because of interactions of planets on the Sun. At the same time as a consequence of this inclination, also the rotary axis of every planet of the solar system isn’t perpendicular to the plane of the ecliptic but it is inclined of an angle that changes for every planet.
This inclination of the solar axis and of planet axes is the physical cause of precession motions in the order of Physics of Gravitational Fields.
It is suitable to do the following considerations:

a. if the Sun could be fixed in the centre of the solar system then planet orbits would be perfectly circular and the Sun would be in the centre of all concentric orbits

b, the Sun isn’t fixed because of the Principle of Action and Reaction and of gravitational field generated also by planets. The Sun undergoes an attractive force by every planet that generates a small motion of the Sun and elliptical planet orbits in which the Sun is in one of two foci

c. the axis of rotation of the Sun isn’t perpendicular to the plane of the ecliptic because of interactions produced by planets and it has a motion of conic rotation

d. the axis of rotation of every planet isn’t perpendicular to the plane of the ecliptic because of the inclination of the solar axis and itself has a motion of conic rotation. “

Keplero’s three classical laws are:

1. Planets describe elliptical orbits around the Sun that is placed in one of the two focuses

2. Areas covered by the radius vector O-F are proportional to times that are necessary for covering them. That is equal areas are covered in equal times.

3. Squares of revolution periods T are proportional to cubes of greatest semi-axes R=PA of elliptical orbits: $T^2=kR^3$.

In fig.5 the precession of an orbiting planet O around a star S is represented.

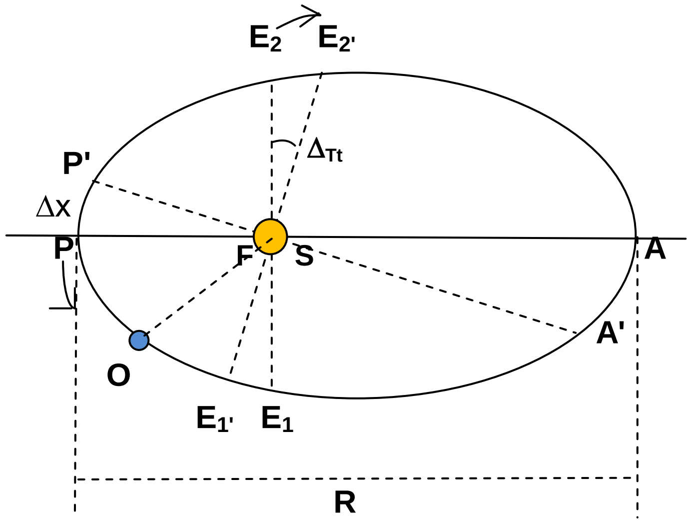

Fig.5 Representation of the precession of a planet **O.** **PA** is the line Perihelion-Aphelion at the initial time of observation. **A'P'** is the same line after a sidereal year. The shift of the aphelion A into A' and of the perihelion P into P' represents just the precession of the planet. In figure Δx is the precession of the planet

The study of precession in the order of Physics of Gravitational Fields and the systematic nature of precession phenomena induces to think it needs to add to Keplero's three laws a fourth law, that considers the precession phenomenon.

Our considerations on precession motions of planets of the solar system involve Keplero's three known laws are valid only for stationary elliptical orbits, that is for orbits in the absence of precession. It follows that it is necessary to add a fourth law that considers precession movements of effective elliptical orbits.

If Δx and Δy are precessions of two planets into the solar system, calculated with respect Earth's year, and if α and β are inclinations of their axes of rotation with respect to the perpendicular to the orbital plane of the ecliptic, the fourth law says[14]

" The ratio of precessions of the two planets is equal to the ratio of respective inclinations

$$\frac{\Delta x}{\Delta y} = \frac{\alpha}{\beta} \quad \text{"} \tag{50}$$

Because the ratio $\Delta x/\alpha = \Delta y/\beta = K_p$ is constant and equal to

$$\frac{\Delta x}{\alpha} = 535 \times 10^{-6} \tag{51}$$

the fourth law can be formulated also in the following way:

“ The precession of a planet is proportional to the inclination of its axis of rotation with respect to the perpendicular to the plane of the ecliptic through a constant of proportionality K_p=535x10^{-6}. ”

10. Conclusions

On the question of propagation of light and electromagnetic waves all seemed clear at the end of the 19th century: propagation happens through a medium, called ether, that represents the absolute reference frame of the universe. Light and electromagnetic waves propagate with the known velocity c≈300000km/s with to respect to the absolute reference frame of ether, that is fixed in the absolute space. With respect to any other reference frame the velocity of light and electromagnetic waves is given by the Galilean addition of velocities.
This scientific construction had only one problem: ether never was observed with experimental method and neither the velocity of the Earth with respect to ether was known. The Michelson-Morley experiment, supported with a famous letter by Maxwell himself to Michelson, had just this object: to register in experimental way ether and to measure the velocity of the Earth with respect to it. As we know the experiment had negative result and it represented a heavy problem for convictions of classical physicists. In order to save anyway ether post-classical physicists began to introduce hypotheses ad hoc: at first length contraction (FitzGerald) of bodies that move with respect to ether, then local time (Lorentz) in place of absolute time. The result of these hypotheses ad hoc was that post-classical physicists were obliged to replace Galileo’s Transformations of space-time with Lorentz’s Transformations of spacetime. Like this they thought to have saved ether, even if in a modified shape with respect to classical ether. Post-classical physicts thought also to have saved like this the Galilean addition of relativistic velocities.
Albert Einstein in his main work “On Electrodynamics of Moving Bodies” (1905), known also as Special Relativity, clarified the true meaning of Lorentz’s new transformations. Einstein maked use of a different methodology: in fact while post-classical physicists used an empirical methodology and they adopted each time tactics ad hoc in order to explain and to justify the result of MM experiment anyway in the order of an ether theory, on the contrary Einstein maked use of a mathematical axiomatic methodology, renouncing any hipothesis of ether and adding the Postulate of Constancy of the Velocity of Light to the Principle of Relativity. Like this through a series of subsequent steps, starting from an arbitrary definition of synchronization of ideal and unreal clocks, making use of rays of light, he reached mathematically Lorentz’s same transformations through mathematical connections that often show a revealing arbitrariness like hypotheses ad hoc of postclassiccal physicists.
Einstein nevertheless analysed systematically Lorentz’s Transformations, unlike post-classical physicists, and besides to confirm length contraction and time dilation independently of ether in the order of an interconnected spacetime, he demonstrated new results, associated with those transformations, like the variation of longitudinal and transverse mass with the velocity and a new theorem of addition of velocities.

The Theory of Reference Frames has demonstrated the hub of the controversy between post-classical theory and modern theory isn't represented by the different viewpoint on the existence of ether, but by the basic fact that both theories reach different theoretical results, despite they make use of the same mathematical model, represented by Lorentz's Transformations.
Consequently it is manifest that if a critical analysis proves Lorentz's transformations don't represent the physical reality, as it is achieved in the Theory of Reference Frames, it follows that whether the post-classical theory of ether or the modern theory of spacetime in Special Relativity don't represent the physical reality.
It doesn't mean the return to the absolute reference frame of classical physics, based on absolute space, absolute time and immobile ether, but the introduction of a new concept: the non-absolute preferred reference frame, called also natural reference frame.
The non-absolute reference frame allows to give the right interpretation for the Michelson-Morley experiment with the recognition that the M.M. interferometer represents in the experiment just the natural reference frame. Because both arms of the interferometer are fixed it is manifest the velocity of light is the same with respect to the two arms but it doesn't involve the velocity of the two rays of light is the same with respect to any other reference frame that is in motion with respect to the interferometer. This fact excludes the necessity of modifying Galileo's Transformations for questions concerning mechanics, optics and electromagnetism. Different considerations are valid in Particle Physics where massive elementary particles have an electrodynamic mass, given by the (34), that is different from inertial mass, and it involves different physical considerations, as we have seen in the paragraph 8 of this paper.

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