Short History of Relativity

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Abstract

A brief history of Relativity from the origins to these days is presented.

1. The origin of Relativity

The scientific meaning of Relativity was born in 1632 when Galileo Galilei published his main work " Dialogue Concerning the Two Chief World Systems ". He explained there the Principle of Relativity with these simple words[1]:

> **" *Shut yourself with a few friends in the gratest room that is below decks of some large ship and here...........when the skip is still, observe with diligence what happens inside the room....... Later get the skip moving with any constant, straight and non-floating speed, you will recognize no change........ and you will not understand if the skip is moving or is still.........................* " .**

That great room below deck of Galileo's ship was really the first scientific laboratory of history. As per these words that represent the act of birth of the Principle of Relativity, Galileo went beyond the Principle of Inertia which had fixed a simple equivalence of state between rest and uniform motion, and he defined a complete equivalence of physical laws (at that time only a few laws of mechanics were known) with respect to all inertial reference frames. Galileo was a great experimental physicist but at the same time he understood, in innovative way for those times, the importance of the mathematical tool (that he called "mathematical progress") and therefore he demonstrated a group of kinematic transformations of space which allowed just the independence of inertial reference frame, for mathematical laws which describe physical phenomena, in concordance with the experimental evidence verified in his laboratory.
Various decades later Isaac Newton completed Galileo's work and reached the definitive formalization of the group of kinematic transformations for inertial reference frames. Supposing that the uniform inertial motion u happens along the axis x≡x' of the two inertial reference frames, transformations are

$$\begin{aligned} x' &= x - ut \\ y' &= y \\ z' &= z \\ t' &= t \end{aligned} \qquad (1)$$

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in which (x',y',z') are the space coordinates of the reference frame with inertial motion (for instance the ship with uniform motion with respect to the still quay) and (x,y,z) are the space coordinates of the reference frame supposed at rest (quay).
Even if Newton accepted fully Galileo's Principle of Relativity he introduced a freshness with respect to Galileo. In fact according to Galileo the last relation of (1), relative to time, meant only that times of the two reference frames, the resting reference frame and the moving reference frame, were equal.
According to Newton instead time and space were absolute. Like this he explained himself in his main work[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 .... "***

Moreover he affirmed still:

> ***" The true God is living, intelligent and potent....... . He is eternal and infinite, almighty, omniscient, lasts since eternity untill kingdom come and from infinity is present in the infinite....... . He lasts forever and is present everywhere, and existing forever and everywhere, he represents time and space...... ."***

With these words Newton deduced the concepts of space and time directly from God' s idea and identified them with God' s attributes. Although Newton wasn' t a metaphysician but was a fully aware scientist of the new experimental science, he needed to give a metaphysical meaning to kinematic concepts of space and time creating like this the concept of absolute reference frame. For Newton the last relation of (1) represented the absolute time.
Even though in front of underlined differences, the Galilean-Newtonian synthesis was the relativistic basic theory for physical phenomena for about two centuries.

2. The question of light and electromagnetic waves

Newton believed light was composed of corpuscles which move with equal speed with respect to the absolute reference frame. Newton' s corpuscular theory of light was accepted by many scientists even though it had some problem in describing a few optical phenomena, like interference.
Simultaneously nevertheless an alternative theory had been formulated by Huygens and Fresnel: the wave theory, that associated the phenomenon of light propagation with the phenomenon of sound propagation; this theory was able to explain the interference in satisfactory way. Sound propagation involved a transmissive medium represented by air, similarly also the wave theory of light involved a transmissive medium which was identified

in ether, the fifth Aristotelian element that filled the whole universe and was in a state of absolute immobility.
The debat among supporters of the two theories was long and even though the two thories were deeply different with regard to the physical nature of light, however they had an important point in common: light propagated always with the same speed with respect to the absolute reference frame.
Later in the second middle of the nineteenth century, Maxwell formulated an electromagnetic theory of the propagation of light in which this was considered like the propagation of electromagnetic waves. He completed the equations of electromagnetism, in particular adding Maxwell' s term in Ampere' s equation (that became therefore the Ampere-Maxwell equation). In this theory Maxwell accepted and demonstrated the wave nature of both electromagnetic radiation and light. Maxwell and others after him, like for instance O. Heaviside, manage at last to synthesize electromagnetic phenomena in an only group of four equations in vector shape:

$$\mathrm{div}\,\mathbf{E} = \frac{\rho}{\varepsilon_o}$$

$$\mathrm{rot}\,\mathbf{E} = -\frac{\delta\,\mathbf{B}}{\delta\,t} \qquad (2)$$

$$\mathrm{rot}\,\mathbf{B} = \mu_o\,\mathbf{J} + \frac{1}{c^2}\,\frac{\delta\,\mathbf{E}}{\delta\,t}$$

$$\mathbf{E_L} = \mathbf{u}\wedge\mathbf{B}$$

As a matter of fact the (2) represent Maxwell' s "rationalized equations" in which in the order of the Theory of Reference Frames the equation relating to Lorentz' s field, the fourth of (2), has replaced the initial relationship div**B**=0 that actually isn' t a true equation but a simple identity. Only the group of rationalized equations (2) is able really to describe all electromagnetic phenomena which happen in any physical state.
Shortly nevertheless Maxwell' s equations raised a few problems whose two specially had relevant importance: the existence of ether and the Principle of Relativity.
In the first place in Maxwell' s equations there isn' t any theoretical proof of the existence of ether; they are valid also in the absence of ether because only electric and magnetic constants (permittivity and permeability) relating to medium (vacuum, air, water, etc.) where propagation happens, are present in equations. In second place it seemed that the equations didn' t respect the Principle of Relativity enunciated by Galileo because just in Ampere-Maxwell' s equation the speed of both electromagnetic waves and light was present. It is known that speed is non-invariant for inertial systems. All that induced physicists to think an experimental verification about the way of propagation of light and electromagnetic waves was necessary.

Michelson at first alone (encouraged by Maxwell himself with a letter some year before dying) and then together with Morley conceived and performed the well-known experiment which had to prove just the existence of ether and to allow the calculus of the speed of the earth with respect to ether. Against all expectations experiments had negative result, i.e. absence of interference in the interferometer which had been prepared. The result of experiments produced innumerable discussions that generated a deep crisis in the heart of physics.

3. The extreme attempt of saving the absolute reference frame

A few scientists, Fitzgerald, Poincarè and above all Lorentz, attempted a different explanation on the negative result of the Michelson-Morley experiment in order to save the absolute reference frame and consequently ether. Fitzgerald first supposed a contraction of ether and space, that had to explain the experimental result. This hypothesis however was inadequate and was confuted by a subsequent modified experiment like other changes to the concept of ether proved inadequate because of subsequent experiments. Later Poincarè and Lorentz introduced the new concept of local time which not only was a different time for every reference frame but also a variable time for every point inside the same reference frame. As per both hypotheses the space contraction and the local time Lorentz and Poincarè demonstrate with succeeding approximations and corrections the final group of kinematic transformations of space and time for inertial reference frames, in presence of ether, which were called definitively "Lorentz' s Transformations" and had to replace Galileo' s Transformations.
These transformations were obtained with Poincarè' s important contribute, besides Lorentz, and supposing that the relative motion of the two reference frames happens with velocity u along the axis x≡x', they are

$$\begin{aligned} x' &= \beta\,(x - ut) \\ y' &= y \\ z' &= z \\ t' &= \beta\left(t - \frac{ux}{c^2}\right) \end{aligned} \qquad (3)$$

in which

$$\beta = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}} \qquad (4)$$

is Lorentz' s factor ($\beta \neq 1$ for $u \neq 0$ and $\beta > 1$ for $u < c$).
In authors' s mind these equations (3) represented the new kinematic transformations of space and time, in place of Galileo-Newton' s transformations (1), with respect to inertial reference frames in relative motion.

4. Special Relativity

Einstein' s scientific work was inside this theoretical scenario of physics in the beginning of the twentieth century:

a. The bond imposed by the result of Michelson-Morley' s experiment that proved absence of interference and therefore absence of ether.

b. The well-established conviction of large part of physicists in Newton' s absolute reference frame from which Fitzgerald-Poincarè-Lorentz' s scientific works were derived in order to save the ether and consequently the absolute reference frame.

c. The electromagnetic theory completed by Maxwell raised the question concerning the constancy of the speed of both light and electromagnetic waves because this theory seemed to be in conflict with the principle of Relativity.

Einstein resolved the question like this:

a'. He accepted the result of Michelson-Morley' s experiment denying definitively the existence of both the ether and the absolute reference frame in that famous preamble[3] of his work " On Electrodynamics of Moving Bodies" (1905):

"............ an absolutely resting space not will be introduced...................."

b'. He apologized to the great scientist I. Newon with the following words:

"Newton, forgive me; you found the only way that at your time was still possible for a men with highest thinking and constructive capacity. Concepts that you created are still today guides of our physical thought although now we know they have to be replaced with other remoter concepts from our direct experience".

c'. He confirmed the validity of the Principle of Relativity also for electromagnetism and optics adding to this principle the postulate on the constancy of the speed of light that had just the purpose to resolve the question of the conflict of Maxwell' s equations with the Principle of Relativity.

As per these considerations Einstein calculated the new kinematic transformations of space and time and in surprising way he achieved still Lorentz' s Transformations (3), which instead had been calculated in order to preserve concepts of absolute reference frame and ether.
In substance Einstein resolved an alleged logical conflict (between the Principle of Relativity and Maxwell' s equations) with a postulate generating like this numerous contradictions.
The subsequent history, to this day, concerns the debate among supporters of the absolute reference frame (Newtonian-Lorentzian physicists) and supporters of the Theory

of Special Relativity (Einsteinian relativist physicists). Beyond the question on the existence of ether and of the absolute reference frame, the only interesting thing we can say is that both supporters neglect the important question that they make use of the same mathematical model, just Lorentz's Transformations, for which contradictions of a theory are in large part also contradictions of the other theory.
We want now to underline the evidence of a few inconsistencies which are present in Special Relativity.

- The inconsistency of the scalar speed

In physics all speeds are vector physical quantities and therefore have vector nature.
In SR the speed loses its vector feature because the Theorem of Vector Addition of Speeds for inertial reference frames, derived from the (1)

$$\mathbf{v} = \mathbf{v'} + \mathbf{u} \tag{5}$$

is replaced with the Theorem of Scalar Addition of Speeds, derived from the (3)

$$v = \frac{v' + u}{1 + \frac{uv'}{c^2}} \tag{6}$$

Besides this theorem, derived from the principle of Constancy of the Speed of Light and from Lorentz' s Transformations, defines an exclusive and absolute role for the speed of light because for this neither the scalar addition is valid since the same theorem establishes that it is invariant with respect to any relative speed between the two reference frames, unlike all other speeds. It is manifestly in conflict with the Principle of Relativity that is based on the invariance of accelerations and on the non-invariance of speeds for inertial reference frames.

- The inconsistency of the kinematic space-time

Let us consider the reference frame supposed at rest S[O,x,y,z,t] and the moving reference frame S'[O',x',y',z',t'] which has the origin O' coinciding with O and the axis x' coinciding with the axis x at initial time t'=t=0, and moves with uniform speed u along x.
Let us consider a ray of light which covers the length $\Delta x'$ in the time $\Delta t'$ with respect to S', the *physical speed* of light with respect to S' is $c= \Delta x'/ \Delta t'$. In the order of Special Relativity, with respect to the resting reference frame S, the length $\Delta x'$ is subjected to a contraction $\Delta x= \Delta x'/\beta$ and the duration $\Delta t'$ is subjected to a dilation $\Delta t=\beta\Delta t'$ where β is given by the (4).
With respect to the resting reference frame S the speed of light c_s is given consequently by

$$c_s = \frac{\Delta x}{\Delta t} = \frac{\Delta x'}{\beta}\,\frac{1}{\beta\Delta t'} = \frac{c}{\beta^2} \neq c \tag{7}$$

in which $\beta\neq 1$ for $u\neq 0$.

This result represents much more than an inconsistency because it assumes the features of an internal contradiction of the Theory of Special Relativity between the Theorem of Addition of Speeds and Lorentz' s Transformations of the kinematic space-time that affirm the existence of a length contraction and of a time dilation.

- The inconsistency of vector mass

In Special Relativity, in the order of dynamics of slowly accelerated electron, if m_o is mass of resting electron, Einstein demonstrated that mass of moving electron with speed u with respect to the axis x of the resting reference frame S, had three components of mass with respect to S:

$$
\begin{aligned}
&\text{longitudinal mass along x:} \quad m_x = m_o\beta^3 \\
&\text{transversal mass along y:} \quad m_y = m_o\beta \qquad\qquad (8) \\
&\text{transversal mass along z:} \quad m_z = m_o\beta
\end{aligned}
$$

As per these considerations electron mass would assume a vector nature which has no physical meaning and which represents another gross inconsistency of Special Relativity. In fact to that end it isn' t possible to understand for instance the physical meaning of Newton' s law in which the applied force equals the inertial force that is given by the product of scalar mass for the vector acceleration. If in SR mass becomes a vector then that law has no meaning because representing a relation between two vectors, it would assume necessarily the feature of vector product and in the event that vector mass and vector acceleration had the same direction, Newton' s force would be null against all evidence.

5. General Relativity

In 1916 Einstein published in the same journal[4] a new scientific work "Fundamentals of the Theory of General Relativity", in which he had the object of:

"generalizing the theory of relativity for all moving reference frames, besides inertial references".

Einstein first claimed that it was possible to write nature laws with respect to any reference frame and then enunciated the following Principle of General Relativity:

"laws of nature are covariant with respect to any reference frame".

He proved that all non-inertial motions are a consequence of the gravitational field and of the presence of masses, for which the theory of general relativity was actually the theory of the gravitational field: if gravitational masses are null also the gravitational field is null and consequently again physics of inertial motions and Special Relativity are valid.

As regards the mathematical formalization of General Relativity, Einstein considered the definition of Minkowski' s linear element

$$ds^2 = dx_1^2 + dx_2^2 + dx_3^2 - c^2dt^2 \qquad (9)$$

which can be also written in the following way

$$ds^2 = dx_1^2 + dx_2^2 + dx_3^2 + (i\ cdt)^2 \qquad (10)$$

He modified the (9) in some point assuming for the linear element the antisymmetric expression

$$ds^2 = - dx_1^2 – dx_2^2 – dx_3^2 + dx_4^2 \qquad (11)$$

which can be written again

$$ds^2 = (i\ dx_1)^2 + (i\ dx_2)^2 + (i\ dx_3)^2 + dx_4^2 \qquad (12)$$

in which i is the imaginary unity, ix_1, ix_2, ix_3 are imaginary space coordinates and x_4 is the real time coordinate. In Minkowski' s space-time the space coordinates x_1, x_2, x_3 are real while the fourth coordinate ict tied to time is imaginary.
Besides while in Minkowski' s space-time the equation (9) respects the principle of conservation of physical dimensions through the constant c that represents the speed of light, in Einstein' s space-time the four coordinates are considered homogeneous similarly, even if they represent different physical quantities.
Later Einstein developed the concept of space-time and demonstrated that for non-inertial reference frames the Euclidean geometry was not valid.In fact he proved that the ratio between the length of circumference and the diameter of the same, equal to π for resting reference frames, was different for a reference frame with rotatory motion and therefore it was necessary to make use of the non-Euclidean geometry in presence of gravitational field because the linear element changed into the non-linear element.
Using the tensor calculus the non-linear element of space-time can be represented with the following relationship

$$ds^2 = \Sigma_{ij}\ g_{ij}\, dx_i\, dx_j \qquad i= 1, 2, 3, 4 \ ; \quad j= 1, 2, 3, 4 \qquad (13)$$

where coefficients g_{ij} are components of a tensor with 16 elements, called fundamental tensor. Components g_{ij} of the fundamental tensor are functions of space and time and describe the gravitational field. For inertial reference frames those components are constant and diminish to four.
Subsequently Einstein, through the tensor calculus, demonstrated a few effects due to the gravitational field, like the length contraction in radial direction, the time dilation due to the gravitational field which produces the cosmological redshift, the deflection of light with respect to the straight trajectory when it passes near celestial bodies, the displacement of Mercury' s perihelion.

General Relativity doesn' t present evident internal theoretical inconsistencies like Special Relativity, but only controversial and hardly acceptable initial stances like the introduction of imaginary coordinates, which have doubtful physical meaning, and the reduction of the kinematic reality to an only continuum of space-time that at times would be measurable by metres and other times by seconds. Since then GR assumes and accepts basic concepts of SR it is manifest that inconsistencies and contradictions of SR are valid also for GR.
GR seems to be rather a theory of equivalence among reference frames provided with any relative speed, based on a principle of covariance, than a generalization of the concept of relativity which instead is based on a principle of invariance and is valid only for inertial reference frames.
It needs to specify besides that all results got in GR can be derived also in different way and with a greater degree of precision, like for instance in the order of the Theory of Reference Frames with regard to deflection of light and to cosmological redshift.
Later Einstein searched for generalizing[5] further the GR in which he unified inertia and gravitation (principle of equivalence), aiming at a theory of the total field in which also electromagnetism was included. He claimed that in this generalization had leaved definitively the concept of inertial reference frame, which he considered unreal, and had achieved a complete identification of the total field with the continuous space-time.
Nevertheless Einstein himself regretted not being managed to include the atomistic feature of energy in the concept of total field and above all he regretted not being managed to find solutions of generalized equations of the total field. It prohibits to compare the theory with the experience and therefore Einstein' s attempt with regard to the total field must be considered an unsuccessful attempt.

6. The Theory of Light Emission

In 1908, three years after the publication of Einstein' s works on Special Relativity, W. Ritz together with others (Tolmann, etc.) enunciated the " Theory of Light Emission " (called also Ballistic Theory) in which he assumed, unlike Special Relativity,

"the speed of light is additional to the speed of source in concordance with the theorem of vector addition".

Observations on double stars, by Comstock and Castelnuovo, had the object of conferming that hypothesis, but De Sitter' s considerations on observation and superposition of light coming from double stars cast a shadow on Ritz' s theory and the convinction circulated that the ballistic hypothesis was erroneous.
Later M. La Rosa affirmed that De Sitter' s reasoning regarding the superposition of light was valid only in some case and that the ballistic hypothesis was able to give a more satisfactory explanation not only for double stars but also for complex or multiple stars and more in general for variable stars. La Rosa proved that the luminous intensity of a star in circular movement around a fixed point is variable and cyclic and its maximum value is greater than the luminous intensity of the still star. Besides the presence of two

components in the spectrum line induced to think the observed variable star was really a double star. He affirmed then only in some case (double stars at great distance) the phenomenon of the superposition supposed by De Sitter would be observable and he clinched that in general variable stars are composed always of double or multiple stars.
The Theory of Light Emission presents a few good intuitions but it is an incomplete theory because it limits itself to tackle only the question of the dependence of the speed of light on source and the question of its implications in a few cosmological ambits. It is unable to give satisfactory answers to a few important questions like for instance the symmetric nature of the Doppler effect whether in frequency or in wavelength, that is independent of who is in motion between observer and source, but depends only on the relative speed.
This theory is included partially into the most general Theory of Reference Frames in which the source is considered like a reference frame.

7. The Theory of Reference Frames

The Theory of Reference Frames (TR) results from the impossibility to define and to prove in experimental way the existence of both the absolute reference frame and ether, results from inconsistencies and contradictions of Special Relativity, results from the acceptance in General Relativity of concepts and mathematical models which seem rather to condition the physical reality than to describe and interpret that, results at last from the inadequacy and the incompleteness of the Emission Theory.
The innovative heart of this theory is the Principle of Reference[6]:

***"For any physical event a preferred reference frame exists and it coincides with the reference frame physically tied to the physical space in which the event happens. Moreover the privileged observer has to be placed symmetrically inside this preferred reference frame"*.**

This principle together with the Principle Generalized of Inertia and the Principle of Relativity allows to formulate a coherent scientific theory that allows to understand, to describe and to anticipate the greatest deal of observed and observable events. It is based on a new physico-mathematical definition of space and time[6]:

*"**Space** is three-dimensional with three space coordinates (x,y,z). The three coordinates are mathematically independent of each other and their interdependence can have only a physical meaning defined for instance by the kinematics of point.*
*The space considered in TR is at the moment the empty geometric space, without any physical property, defined only by a tern of Cartesian coordinates (x,y,z) and each time by an origin O. In our view the empty geometric space, with respect to the three coordinates, is **infinite, infinitesimal and discrete**. It is **infinite** because, for every distance "d" it is always possible for instance to double that distance without an objective limit to this possibility exists. It is **infinitesimal** because the same distance "d" can be for example time after time halved without an objective limit to this possibility exists. It is **discrete***

because the distance "d" can be maked always smaller without reach the zero distance which matchs the geometric point."...............
*" **Time** in TR is the measured time by a clock which is synchronized with the standard clock and is situated in the place where the physical event happens.*
This definition of time equals Einstein's definition, but the concept of simultaneity of events makes the difference between Special Relativity and the Theory of Reference Frames.".....

TR then makes use of an innovative concept concerning the reference frame which isn' t more considered a simple system of coordinates, like Einstein did for instance in SR, but:

*"it is a physico-mathematical complex system composed of kinematic coordinates of the three-dimensional space and of time (x,y,z,t), of one origin O and of the **physical space** in which event happens."*

The kinematic elaboration of these concepts allows to demonstrate the following new transformations of space-time, that are valid for reference frames which have any speed $\mathbf{u}[u_x,u_y,u_z]$ with respect to the reference frame supposed at rest

$$\mathbf{P[}x,y,z\mathbf{]} = \mathbf{P[}x',y',z'\mathbf{]} + \int_0^t \mathbf{u}\, dt$$

$$dt = \frac{m}{m'}\, dt' \qquad (14)$$

In the event of inertial reference frames (u=constant), mechanical systems don' t present variation of mass with respect to reference frames in relative motion and the (14) become

$$\mathbf{P[}x,y,z\mathbf{]} = \mathbf{P[}x',y',z'\mathbf{]} + \mathbf{u}\, t$$

$$t = t' \qquad (15)$$

The (15) equal Galilean-Newtonian transformations with the only difference that now t=t' is the inertial time and not the Newtonian absolute time.
For electrodynamic systems (charged elementary particles), whose electrodynamic mass[6] changes with the speed, always with respect to inertial reference frames, the (14) become

$$\mathbf{P[}x,y,z\mathbf{]} = \mathbf{P[}x',y',z'\mathbf{]} + \mathbf{u}\, t$$

$$t = t'\left(1 - \frac{\gamma^2}{2}\right) \qquad (16)$$

in which γ=u/c.

The Theory of Reference Frames resolves definitively the question concerning the speed of light and of electromagnetic waves that as per Maxwell' s equations seemed in conflict with the Principle of Relativity. That question consisted in the fact that, if the speed of light changes, then Maxwell' s equations are non-invariant for inertial reference frames because in the third of (2) the speed of light is present. Einstein resolved the problem introducing the postulate of the constancy of the speed of light which nevertheless has occasioned numerous inconsistencies. In TR the question is resolved distinguishing the physical speed of light from the relativistic speed.
The ***physical speed*** of light is constant and it represents the speed of light with respect to the preferred reference frame defined by the Principle of Reference, in which the physical event of propagation of light happens. The physical speed of light is the generally measured speed because the preferred reference frame coincides normally with the reference frame where the measure equipment is placed.
The ***relativistic speed*** of light has instead vector nature and it behaves like a normal speed and a normal vector, whose value is derived from the theorem of vector addition that is defined, for inertial reference frames, by the first of (15) or (16). It is applied to the physical speed of light and to the relative speed between the two reference frames.
The Theory of Reference Frames then, as per the Generalized Principle of Inertia, proves that also rotatory reference frames, with constant speed, and orbital reference frames are inertial and therefore it widens the Principle of Relativity also to these reference frames.
Further in the study of the electromagnetic field TR introduces Lorentz' s field inside the basic group of Maxwell' s equations in order to describe all electromagnetic events.
Through the "photon equations", derived by Maxwell' s equations,it is possible to reach the new concept of electromagnetic nanofield.
At last in the order of relativistic shifts in frequency and wavelength TR confirms the existence of the transversal Doppler effect, already theorized in SR, but in TR new mathematical expressions, whether for the longitudinal effect Doppler or for transversal effect Doppler, are demonstrated.
In his final theory of the unified total field Einstein reached the conclusion of deneying the existence of inertial reference frame, because he persuaded himself that it had an absolute nature that he didn' t accepted, but in the Theory of Reference Frames the inertial reference frame reacquires the Galilean initial relativistic meaning: for instance the still ship with respect to the quay or the ship with uniform motion along the quay, where the quay represents the inertial reference frame supposed at rest. Therefore the absolute inertial reference frame doesn' t exist.

References

[1] G. Galilei, Dialogue Concerning the Two Chief World Systems, editor:Batista Landini, Florence, 1632
[2] I. Newton, Mathematical Principles of the Nature Philosophy, 1686
[3] A. Einstein, On Electrodynamics of Moving Bodies, Annales of Physics, 1905
[4] A. Einstein, Fundamentals of the Theory of General Relativity, Annales of Physics, 1916
[5] M. Pantaleo, G.Polvani, P. Straneo, B.Finzi, F.Saveri, G. Armellini, P.Caldirola, A. Aliotta, Fifty Years of Relativity (Giuntine and Sansoni Editors, Florence, 1955)
[6] D.Sasso, Physico-Mathematical Fundamentals of the Theory of Reference Frames, viXra.org, 2013, id: 1309.0009