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Coordinates transformations using the Lorentz method

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Annotation

It is established that the basis of transformations using the Lorentz method is the Rule of Simultaneity, which explains the physical meaning of similar transformations. It is shown that the Lorentz method is applicable for both inertial reference systems (IRF) and non-inertial reference systems (NRS), regardless of the speed, type and direction of their mutual motion. The article explains the immutability of the speed of light in the transformation equations for different reference frames; the cause of different time readings in a moving frame of reference has been found; it is established that the Lorentz transformations do not prohibit movement at superluminal speed and allow the movement of light with variable velocity in a vacuum.

Keywords. Lorentz transformation, general Galileo transformation, inertial and non-inertial reference frames, simultaneity of an event, special relativity.

1. Introduction

Coordinate transformation equations allow us to determine the coordinates of some event in one inertial reference frame (IRF) through the known coordinates of the same event in another IRF. The basic transformations are: in classical physics they are Galilean transformations, in relativistic mechanics they are the well-known Lorentz transformations (1).

$$\begin{aligned} x' &= \frac{x - vt}{\sqrt{1-\beta^2}} & \qquad x &= \frac{x' + vt'}{\sqrt{1-\beta^2}} \\ y' &= y & y &= y' \\ z' &= z & z &= z' \\ t' &= \frac{t - \beta\frac{x}{c}}{\sqrt{1-\beta^2}} & t &= \frac{t' + \beta\frac{x'}{c}}{\sqrt{1-\beta^2}} \end{aligned} \tag{1}$$

where: $\beta = v/c$;

v – relative velocity of the investigated IRF (K) и (K');

c – speed of light.

There are several ways to derive the equations of these transformations.

One of them is the hyperbolic function method, in which the relative velocity (v) is replaced by the rotation angle (ψ) of the reference frame of the moving IRF(K') [1, p.25]. Another method uses the sphere surface equations, when the light sphere is incomprehensibly bifurcated: one remains in the stationary IRF(K), and the second one, being a clone of the first one, starts to move together with the moving IRF(K') [2, p.213]. In the third case, the forward and backward motion of a light beam in a moving IRF(K') is investigated [3, p.7].

However, these methods of obtaining formulas (1) do not explain the physical meaning of the kinematics of motion of the investigated IRFs, as evidenced by a number of issues that remain unexplained up to now.

Example one. At the initial period of motion of IRF(K') in the time interval ($t_0 < t < t_2$, where: $t_0 = 0$; $t_2 = vx/c^2$) the time (t') has a negative value, which is not commented in any way.

Example two. It is considered that the Lorentz transformation transforms into the Galilean transformation at the relative velocity of IRF (K) and (K') much less than the speed of light ($v << c$).

However, the coefficient ($\gamma = 1/\sqrt{1 - v^2/c^2}$) in its limit takes the value ($\gamma = 1$) at ($v = 0$). This means that in the absence of relative motion there can be no talk of any transformation in principle. And since this condition is essential, it must have a rigorous mathematical proof, and therefore the application of such a vague criterion ($v << c$) is inadmissible.

If we still assume the existence of the correspondence condition ($v << c$), then another criterion must be satisfied: ($x \rightarrow 0$). Otherwise, however small the expression ($v/c \rightarrow 0$), may be, it can always be compensated by the coordinate value ($x \rightarrow \infty$), and then the direct Lorentz transformation will take the following form:

$$x' = x - vt \qquad t' = t - vx/c^2$$

This circumstance for some reason is ignored, although it was once emphasized by L.Landau and E.Lifshitz [1, p.27].

Up to the present time, the Lorentz transformations have not received their explanation from the positions of classical physics.

The interpretation of transformations in the special theory of relativity (STR) by means of postulates was unsuccessful due to the fact that conventional measures of duration and dimensionality for some unknown reason became variable values, which cannot be in principle, as it would disappear the essence of what research work is, which is itself based on the comparison method.

The aspiration to understand the physical meaning of Lorentz transformations is still an actual topic. And the aim of this paper is not a new treatment of the external manifestations (results) of Lorentz transformations, but a satisfactory explanation of the essence of the mathematical apparatus of these transformations.

2. Reference frames in the Lorentz transformation

From the analysis of equations (1) it follows that instead of the speed of light (c) any other value of velocity (V) can be set – from this the Lorentz transformation will not lose its properties. Then the coefficient β can be written as:

$$\beta = v/V$$

Since velocity (v) characterizes the mutual kinematics of two investigated IRFs (K) and (K'), it should be recognized that velocity (V) characterizes the kinematics of another pair of IRFs. It means that in the Lorentz transformation there is additionally a third IRF, which we denote as (K_0). In this case the kinematics of motion of three IRFs can be represented by the following model (Fig. 1)

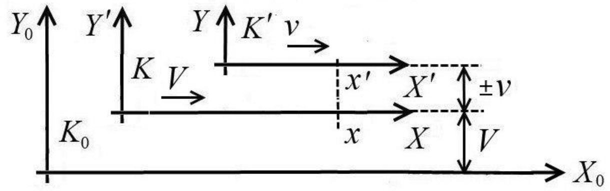

Fig.1 General kinematics for three IRFs
in the Lorentz transformation

As it is known, the motion of any object is relative, which will imply the obligatory presence of the second object, otherwise the talk about motion loses all sense. In a group of three objects (IRF) it is always possible to distinguish two of them that move relative to the third, and then the question arises of determining the privilege of the latter in order to give it a state of immobility.

Giving a privileged status to one or another IRF is always subject to certain rules: when one IRF out of a group of equal ones can be recognized as stationary by chance; when one object has an effect on a group of other objects or its properties are the same with respect to the others; when an observer makes a certain IRF privileged administratively.

With the definition of immobility (privilege) of any of the IRFs, the motion of the others becomes absolute. It is clear that in this case we are not talking about the absolute as a certain category of truth, but only about a mathematical technique applied to a certain group of objects (IRFs).

The conclusion follows: the Lorentz transformation translates the motion of the investigated IRFs (K) and (K') from the relative category towards the absolute one.

The assignment of velocity (V) in the equations of one or another IRF occurs either randomly or on the basis of physical properties of objects.

In the first case (by the example of the speed of light), the velocity parameters (V) can take the following values: ($V = c$), ($V = c + v$) or ($V = v$).

In the second case, one is guided by the properties of a light (sound) wave, when the coordinates of its perturbation center (not to be confused with the radiation source) do not change in time as long as the wave exists.

And if there is no relative velocity between the geometrical center of the perturbation and an arbitrarily chosen IRF, then such an IRF can be characterized as bound and endowed with velocity (V). Then the observer, being in the specified system, can always determine the absolute velocity of the wave. Any other IRF(K') moving relative to IRF(K_0) will act as an uncoupled one.

The coupling of two frames of reference can be judged by the properties of one of them, in particular, by the value of the wave front velocity: if in an arbitrary ISO the wave velocity turns out to be ($v_{\text{rel}} = V$), then these ISOs are coupled. If it turns out that ($v_{\text{rel}} \neq V$), then these systems are uncoupled.

Thus, in the Lorentz transformation the velocity (V) is always the velocity between the coupled reference frames. Moreover, an arbitrary reference frame (K_0) cannot under any conditions be coupled simultaneously with two other frames (K) and (K') if the latter move relative to each other. Hence, the unbound IRF(K') cannot have a velocity with respect to IRF(K_0) equal to (V).

3. Asymmetry of light beam motion in Lorentz transformation

The time of motion of the light beam in the unbound IRF(K') will be different from the time of motion in a similar IRF, but already bound. Depending on the direction of motion of the system (K'), the new time will be defined as:

$$t'_1 = t/(1 - \beta); \quad t'_2 = t/(1 + \beta) \qquad (2)$$

Then the total travel time of the light beam will be equal to:

$$t' = t'_1 + t'_2 \quad \rightarrow \quad t' = t/(1 - \beta^2) \qquad (3)$$

The difference of time of motion of light in IRF(K') at its different kinematic states is the asymmetry of motion of the light beam, defined as:

$$\Delta t'_A = t' - t \quad \rightarrow \quad \Delta t'_A = \beta^2 t' \qquad (4)$$

Thus, the asymmetry of the light beam motion always appears when the reference frame ceases to be related to the reference frame of the medium where the light wave front propagates. This means that the asymmetry of the light beam motion as a phenomenon exists objectively.

The time for light to overcome the distances by which ISO(K′) has moved in each of the directions (vt) and (vt') is defined as: (βt) and ($\beta t'$) (2). However, these two quantities are not suitable for recalculation of coordinates in a group of three IRFs, because they are variable quantities giving two uncertainties. This obstacle D. Larmor and independently of him the same H. Lorentz overcame quite simply: they expressed time (t) and (t') through coordinates (x) and (x') as: ($t = x/c$) and ($t' = x'/c$), and then:

$$\beta t \rightarrow \beta x/c; \quad \beta t' \rightarrow \beta x'/c$$

Thus the asymmetry parameters for the forward conversion became constant and for the reverse conversion became variable.

To understand how the asymmetry of light motion is present in the Lorentz transformation, it is necessary to replace the multidirectional motion of IRF(K') with respect to the light beam by a unidirectional motion with respect to the model in Fig. 1, and then the scheme of motion asymmetry in the general case will look as shown in Fig. 2, where: t - time in the forward transformation, t' - in the reverse transformation.

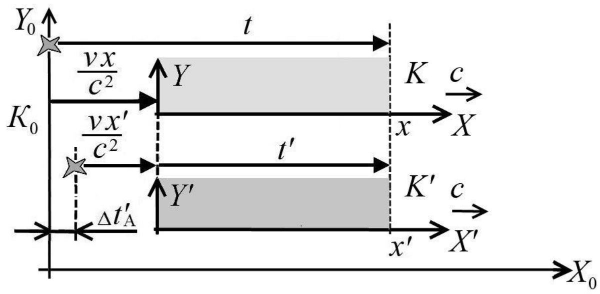

Fig.2 Asymmetry of motion in the Lorentz transformation

Then the asymmetry is defined through the displacement of systems (K) and (K'):

$$\Delta t'_A = vx'/c^2 - vx/c^2$$

where: $x' = vt'$; $x = vt$

Since the parameters of the asymmetry of the light motion are determined from the initial conditions, i.e. at ($t = 0$), then:

$$\Delta t'_A = \beta^2 t'$$

Thus, in the Lorentz transformation, the asymmetry of the light wave motion is also taken into account and has the same value as was obtained earlier (4).

The difference here is the following: while in a general in case the value of the motion asymmetry defined by as a result of calculations (3), then in the Lorentz transformation the asymmetry parameters are input into the equations initially through the values ($\beta x/c$) and ($\beta x'/c$). If in the general case the asymmetry of motion is defined through the relative velocity ($v_{rel} = c \pm v$), then in the Lorentz transformation the asymmetry is expressed through the coordinates (x) and (x'), which, in turn, allows us to operate calculations through the absolute velocity (c) in both frames of reference.

It should be added that the asymmetry of motion always occurs when there are at least three IRFs, regardless of the value of their relative velocities. The example with a light beam is a special case and serves as an illustration of the phenomenon itself.

4. Simultaneity of events

Any events that occurred simultaneously, regardless of their perception by observers, will always remain simultaneous, and therefore there can be no questions about the relativity of simultaneity in principle, since simultaneity is absolute and always primary, and the information received by observers about these events always is secondary.

The same is true for non-simultaneous events - they will never become simultaneous under any circumstances.

Meanwhile, the judgment regarding the simultaneity of events depends on the speed and direction of movement of observers relative to the points of these events, as well as on the distances to them. This is due to the fact that information transmission occurs at a finite speed (light, sound, mail), and therefore observers, being in different places, receive information about this event non-simultaneously.

It is clear that the non-simultaneous in receiving information does not affect the event itself, the nature phenomena and, moreover, the physical laws according to which the information about this event is transferred. And since the observers are always at a distance from the places of events, there is only one question – about the correct correlation of their current time with the time of the event.

For this purpose, the observer, for example, knowing the distance to the place where the event occurred, must make a correction to the current time by the time of signal traveling.

In kinematics with three reference frames it is also necessary to make a correct judgment about the position of all reference frames at any moment of time. In other words, the equations of the coordinate transformation must contain such corrections to compensate for the objectively existing asymmetry of the motion of light. And such corrections in the Lorentz transformation do indeed exist, the essence of which is as follows:

$$\Delta t'_A = \Delta t'_S \qquad (5)$$

where: $\Delta t'_A$ – parameters of asymmetry of light beam motion (sec);

$\Delta t'_S$ – correction to achieve the simultaneity condition (sec).

This is what the Lorentz method is all about: at presence in the equations of the correction ($\Delta t'_S$) the transformation of coordinates for three IRFs will be always fulfilled.

The compensation mechanism itself is realised, as a rule, in two ways: by shifting the reference frame and by shifting the time scale. Let us consider each of the methods separately.

5. Shifting the reference frame

The Galilean transformation is usually considered on the model in which the origin of coordinates of IRF (K) and (K') coincide. However, their origin may not coincide (Fig.3).

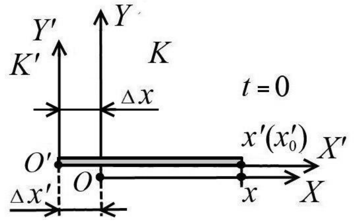

Fig.3 Scheme of shifting of two IRFs at (t = 0)

In this case the Galileo transformation will have the following entry:

$$x' = x - vt + \Delta x' \qquad x = x' + vt' - \Delta x \qquad (6)$$
$$t' = t \qquad t = t'$$

where: $\Delta x'$ (Δx) – displacement of the origin of coordinates of the two IRFs (K) and (K').

In such a transformation (we will call it as «Galilean general transformation») the displacement ($\Delta x'$) is not regulated by anything. In the Lorentz transformation, the displacement ($\Delta x'$) is directly related to the asymmetry of motion of IRFs (K) and (K') in IRF(K_0).

$$\Delta x' = v\Delta t'_S$$

considering (4), we find: $\Delta x' = \beta^2 x'$ (7)

In this case the scheme of IRF displacement in the Lorentz coordinate transformation will have the form as shown in Fig.4:

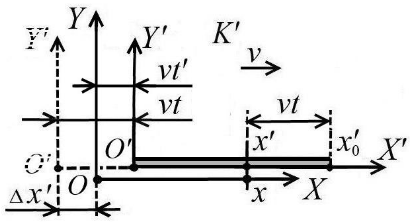

Fig.4 Schematic of the displacement of two IRFs at (t >0)

Application only the method of shifting means that simultaneity has been realised exclusively in the direct transformation, and therefore the reason for the inequality ($t < t'$) is the already taken into account asymmetry in IRF(K').

It follows that there is no offset in the inverse transformation ($\Delta x = 0$). It is then that the Galilean equations (6) with taking into account (7) are transformed into Lorentz transformations:

$$x' = \frac{x - vt}{1 - \beta^2} \qquad x = x' + vt' \qquad (8.1)$$

To find corrections (transformations) by time, let's modify the scheme in Fig.2 taking into account the shift of the origin by time ($\Delta t'_S$) (Fig.5).

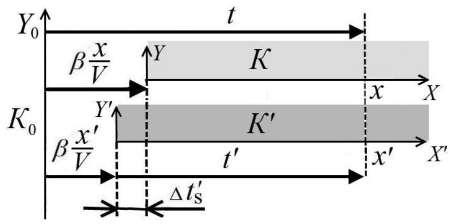

Fig.5 Asymmetry of light motion taking into account the displacement of IRF(K')

The time transformation will be defined by the following equations:

- for the direct transformation taking into account (4):

$$t' = t - \beta\frac{x}{V} + \Delta t'_S \quad \longrightarrow \quad t' = \frac{t - \beta\frac{x}{V}}{1-\beta^2} \qquad (8.2)$$

- for the inverse conversion:

$$t = t' + \beta x'/V \qquad (8.3)$$

Let us combine all four equations (8.1 – 8.3) and obtain the Lorentz coordinate transformation for the three IRFs (K), (K') and (K_0), in which the simultaneity of the event has been realised in the direct transformation.

$$x' = \frac{x - vt}{1-\beta^2} \qquad x = x' + vt'$$

$$t' = \frac{t - \beta\frac{x}{V}}{1-\beta^2} \qquad t = t' + \beta\frac{x'}{V} \qquad (8)$$

6. Offset of the time scale

The second method – time scale offset (or clock reading offset) – also compensates for the asymmetry ($\Delta t'_A$), however this correction is accounted for already in the system (K) as:

$$\Delta x = v\Delta t_S \qquad (9)$$

where: $\Delta t'_S = \Delta t_S$, because in this version ($x = x'$).

The essence of such a compensating mechanism is as follows. In the usual situation, two objects travelling on the same distance with different speeds will reach the finish line simultaneously if they start at different times differing by ($-\Delta t'$). It is clear that their clocks at the finish line will record the time of each (t) and (t') with the same difference: ($-\Delta t'$).

In the Lorentz transformation, the same objects at the same distance (x) start at the same time and move at the same speed. In this case, one of them has a stopwatch set up in advance at the start with an offset from the reading of the other stopwatch (t_0) by the value ($-\Delta t'_S = \beta x/V$) (Fig.6a).

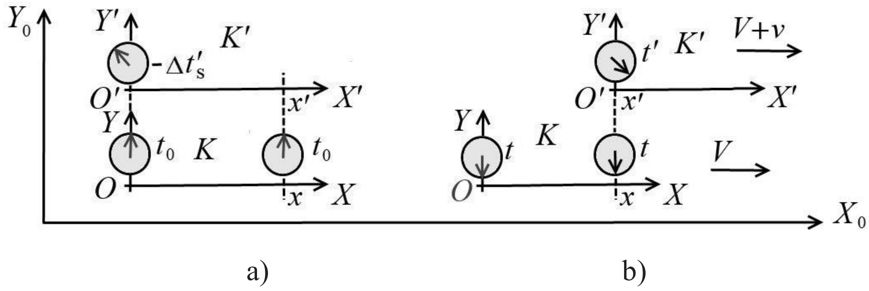

Fig.6 Schematic of time scale offset

At the finish line (Fig.6b), both stopwatches will record the readings (t') and (t) with a difference ($\Delta t'$), as if they were moving at different speeds, but with a delay ($\Delta t'$) of one of them at the start. It is very important to understand that with the same speed of movement of both objects, the duration of their movement will be the same, although the clock readings will be different.

$$t - t_0 = t' - \Delta t'_S$$

It means that clocks in each IRF go synchronously, i.e. the period of oscillation of their pendulum remains the same always, and therefore the measure of duration (time), which is produce by each of the clocks, in the process of motion remains unchanged in any IRF.

Consider the following notation of the Lorentz transformation under the same parameters of the reference frames (x, v, V) and require that the simultaneity of the event be realised in the inverse transformation ($\Delta x' = 0$) through the time scale offset.

In this case, the asymmetry compensation ($\Delta t'_S$) is accounted for already in IRF(K) through the distance (Δx). And since ($x' = x$), then ($\Delta x = \beta^2 x$) (7). In this case Galilean equations (6) concerning coordinate transformation are transformed into Lorentz equations:

$$x' = x - vt \qquad\qquad x = \frac{x' + vt'}{1 - \beta^2} \tag{10.1}$$

To find time transformations, we modify the scheme in Fig.2, and take the correction (compensation) ($\Delta t'_S$) to another frame of reference - in IRF(K) (Fig. 7)

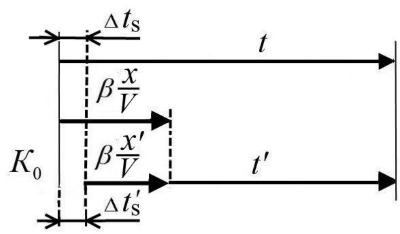

Fig.7 Asymmetry of motion taking into account the time scale offset in IRF(K')

Then in the forward transformation the time (t') will be defined as:

$$t' = t - \beta x/V \tag{10.2}$$

Similarly to (8.2) the time for the inverse transformation is found:

$$t = t' + \beta x'/V + \Delta t_S$$

and taking into account (4) and (5) we find:

$$t = \frac{t' + \beta \frac{x'}{V}}{1 - \beta^2} \tag{10.3}$$

Let us bring together all four equations (10.1 - 10.3) and obtain the Lorentz coordinate transformation for three IRFs (K), (K') и (K_0), in which the simultaneity of the event was realised already in the inverse transformation.

$$x' = x - vt \qquad x = \frac{x' + vt'}{1 - \beta^2}$$
$$t' = t - \beta\frac{x}{V} \qquad t = \frac{t' + \beta\frac{x'}{V}}{1 - \beta^2} \tag{10}$$

7. Rule of Simultaneity

The opportunity of coordinate transformations for three reference frames can be demonstrated not only by absolute values, but also by relative values. Recall that in the Galilean transformation with respect to three ISOs there will arise the asymmetry of the light wave motion: $t' = t + \Delta t'_A$

Let's introduce a correction factor into the specified equality, which we will call the «criterion (coefficient) of simultaneity (k^0_S)». Then this equality for the Lorentz transformation will take the following form:

$$k^0_S * t = t' - \Delta t'_A$$

taking into account (4) and at ($t' = t$) the simultaneity coefficient will have the following value:

$$k^0_S = 1 - \beta^2 \tag{11}$$

The introduced coefficient (k^0_S) is a generalising parameter that gives a general understanding of the mechanism of coordinate transformation for three IRFs. Its components are simultaneously present in both the forward (k_S) and the backward (k'_S) conversions in the following dependence:

$$k^0_S = k_S * k'_S$$

Applicable to the found transformation equations (8) and (10), the simultaneity coefficients (k_S) and (k'_S) will have the following values:

(8) $k_S = (1 - \beta^2)$, $k'_S = 1$ and (10) $k_S = 1$; $k'_S = (1 - \beta^2)$.

Taking into account the established regularity it is possible to formulate the following general rule for all coordinate transformations by the Lorentz method, which we will call the «Simultaneity Rule»:

For two frames of reference moving with different velocity with respect to a third frame, the coordinate transformation is always fulfilled if the simultaneity criteria for the forward and backward transformations obey the requirement:

$$k_S * k'_S = 1 - \beta^2 \tag{12}$$

Then the transformation of the coordinates for three inertial frames of reference by the Lorentz method can be written in a general form as follows:

$$x' = \frac{x - vt}{k_S} \qquad x = \frac{x' + vt'}{k'_S}$$
$$t' = \frac{t - \beta\frac{x}{V}}{k_S} \qquad t = \frac{t' + \beta\frac{x'}{V}}{k'_S} \tag{13}$$

The known Lorentz transformation (1) also obeys the Simultaneity Rule and is a special case of equation (13), which has ($k_S = k'_S$).

where: $k_S = \sqrt{1 - \beta^2}$ и $k'_S = \sqrt{1 - \beta^2}$

If the simultaneity coefficients are given, for example, values representing the relative speed of light (2) as: $k_S = (1 - \beta)$ and $k'_S = (1 + \beta)$, then in this case the coordinate transformation will have the following entry:

$$x' = \frac{x - vt}{1 - \beta} \qquad x = \frac{x' + vt'}{1 + \beta}$$

$$t' = \frac{t - \beta \frac{x}{V}}{1 - \beta} \qquad t = \frac{t' + \beta \frac{x'}{V}}{1 + \beta} \tag{14}$$

Here is another variant in which (k_S) is randomly equal to, for example, (n = 118).

Suppose that the velocity of IRF(K') is ($v = 0{,}95V$), and then, following (12), we obtain:

$$k'_S = (1 - 0{,}95^2)/118 = 0{,}00082627119...$$

In this case the coordinate transformations for three IRFs will look as follows:

$$x' = \frac{x - vt}{118} \qquad x = \frac{x' + vt'}{0{,}000826..}$$

$$t' = \frac{t - \beta \frac{x}{V}}{118} \qquad t = \frac{t' + \beta \frac{x'}{V}}{0{,}000826..} \tag{15}$$

As follows f rom the direct transformation (13), the value of the initial coordinate (x') in the uncoupled IRF(K') is determined by the choice of (k_S).

Meanwhile, there is also an inverse way of finding the coefficient (k_S), based on the parameters of the initial coordinates of the investigated IRFs (x) and (x'). In this case, the coefficient (kS) is defined as:

$$k_S = x/x' \tag{16}$$

The significance of equation (16) is that it is used to make the connection between the general Galileo transformation and the Lorentz transformation, and so this method can be called the «coordinate conjugation» method.

However, the equality (16) may not be fulfilled if the coefficient (k_S) is set to a different value administratively – the Lorentz transformations of the coordinates are still performed by changing (k'_S) according to the rule of simultaneity (12).

As we can see, with the same given kinematic parameters (x, v, V), the Simultaneity Rule (12) allows for a variety of equation records due to all possible combinations of coefficients by parameters (k_S) and (k'_S).

It should be understood that the values of the coefficients (k_S) and (k'_S) follow from the ratio of the IRF parameters (K) and (K'), or are given by the observer from the outside, and therefore they (coefficients), which is very important, cannot reflect any law of nature, and moreover change it, since they serve only as a technique (means) to achieve the goal – the feasibility of coordinate transformations at the transition from one frame of reference to another.

8. Conditions of feasibility of transformations by the Lorentz method

From the Simultaneity Rule (12, 13) it follows that the Lorentz method transformations of coordinates are fulfilled at any velocities of IRF, including the condition ($v > V$). For the special case it means that the Lorentz transformations do not impose a ban on the motion of objects with superluminal velocities ($v \geq c$).

However, there exists a condition when the transformations are not fulfilled. And such a condition is the absence of relative motion in at least one of the pairs of IRFs: K - K' ($v = 0$), K_0 - K' ($V = v$) or K_0 - K ($V = 0$). In this case two IRFs become a single system, and therefore in the transformation instead of three IRFs only two actually participate in the transformation. Then the at the transition from the merged IRF(K+K_0) to IRF(K') coordinates of an eventare defined by Galilean transformations.

$$x' = x - Vt \qquad x = x' + Vt' \qquad t' = t$$

There is no prohibition against such a record, even as applied to light, when the ($v = c$).

There are other arguments explaining why an object cannot move at superluminal speed. It is accepted that when ($v > c$), the expression $\sqrt{1 - v^2/c^2}$ becomes imaginary (i) [1, p.26]. However, this is an obvious misconception, since in the Lorentz transformation imaginary numbers do not exist, and this is due to the fact that the simultaneity coefficient (k^0_S) at ($v > c$) takes a negative value (11), and therefore, based on (12), the coefficients (k_S) and (k'_S) will always have values different in sign. In other words, with respect to the Lorentz transformation at ($v > c$) we are not talking about imaginary numbers, but about opposite numbers, when ($k_S = |-k'_S|$) or ($|-k_S| = k'_S$). Hence the conclusion: by ($v > c$), the equality ($k_S = k'_S$) is absent in principle, and therefore all judgements based on the absent number (i) are wrong. The impossibility of motion faster than the speed of light is also explained by the fact that the moving IRF(K') will not be able to catch up with the light wave. Of course, this is an error, since in this case the opposite happens - it is the moving system (K') that catches up with the light wave front. The peculiarity of such kinematics is that in addition to displacement of the origin of coordinates of IRF(K') by ($\Delta x'$), the coordinate (x') itself in the system of IRF(K) is also displaced by a distance ($-x_k$), which is defined as: $(-)x_k = x(1 - \beta)$ [4, p.59 - 60].

Thus, the Lorentz transformation is always fulfilled, regardless of the values of relative velocities (v) and (V).

9. Substitution of relative velocity for absolute velocity

Recall that in the coordinate transformation for three IRFs the asymmetry of the light motion (t'_A) was compensated by shifts of the reference frame and time scale. This allowed us to replace in the equations the relative velocity of the unbound IRF(K') ($c \pm v$) by the absolute velocity (c) while keeping the time parameters (t and t') (Fig.8).

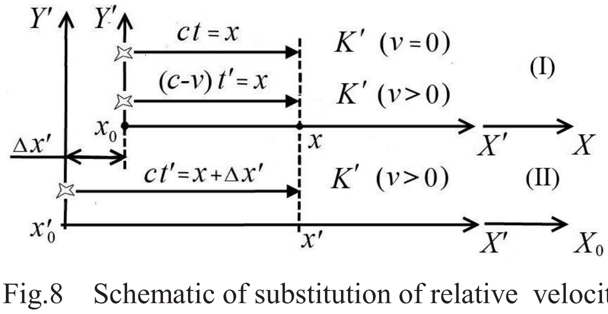

Fig.8 Schematic of substitution of relative velocity to absolute velocity in unbound IRF(K')

In general, the substitution of relative velocity for absolute velocity is as follows. Increasing the coordinate (x') by shifting the IRF origin (K') by ($\Delta x'$) leads to the fact that the light beam needs additional time ($\Delta t'$) to overcome this additional distance ($\Delta x'$).

$$x' = x + \Delta x' \quad \rightarrow \quad t' = t + \Delta t'$$

Taking into account (2), (4) and (7), we find that the parameters of the light beam motion in IRF (K') and (K) are related as:

$$\frac{x'(1-\beta^2)}{t'(1-\beta^2)} = \frac{x}{t}$$

at: (I) $c' = x'/t'$ and (II) $c = x/t$ (Fig. 8) we find that:

$$c' = c$$

As we see, the reason for this equality is quite simple - for different time intervals (t') and (t) the light ray passes different distances ($x' - x_0'$) > ($x - x_0$).

To see this, it suffices to analyze (1), where at ($t = 0$) there exists an inequality: ($x' > x$). It is so obvious that it is surprising – why still at derivation of Lorentz transformations proceed from a false condition when the origin of coordinates of IRF (K') and (K) coincide and their initial coordinates (x') and (x) equal.

The following conclusion follows from the above: a shift of the origin or a shift of the time scale (clock readings), or both simultaneously, allows the relative velocity ($c \pm v$) of an unbound IRF(K') in the IRF(K) system to be recalculated through the absolute velocity (c) in the IRF(K_0) system.

It follows that giving some unique properties to the speed of light is a fallacy, since a mathematical reception that allows one and the same kinematics to be recalculated in a different way cannot be the source of any new physical phenomena.

An additional example of this is the translation of coordinate transformations for four IRFs into transformations for three IRFs [4, p.69-77].

Let in a group of four IRFs two systems (K') and (K'') move relative to system (K) with corresponding velocities (v_1) and (v_2).

To find the coordinates of the event at the transition from IRF(K'') to IRF(K') it is necessary to make two parallel transformations in the systems ($K – K''$) and ($K – K'$) in order to exclude the parameters of the system (K). From all the variety of initial data, let us choose the conditions when ($k'_{S1} = k'_{S2}$) and ($k''_{S1} = k''_{S2}$).

According to the Rule of Simultaneity:

$$k'_{S1} * k'_{S2} = (1 - \beta_1^2); \qquad k''_{S1} * k''_{S2} = (1 - \beta_2^2)$$

where: $\beta_1 = v_1/c$; $\beta_2 = v_2/c$

Then the transformation for four IRFs will have the following entry:

$$x'' = \frac{x'(1+\beta_1\beta_2) - (v_1+v_2)t'}{\sqrt{(1-\beta_1^2)(1-\beta_2^2)}} \qquad x' = \frac{x''(1+\beta_1\beta_2) + (v_1+v_2)t''}{\sqrt{(1-\beta_1^2)(1-\beta_2^2)}}$$

$$t'' = \frac{t'(1+\beta_1\beta_2) - (\beta_1+\beta_2)x'/c}{\sqrt{(1-\beta_1^2)(1-\beta_2^2)}} \qquad t' = \frac{t''(1+\beta_1\beta_2) + (\beta_1+\beta_2)x''/c}{\sqrt{(1-\beta_1^2)(1-\beta_2^2)}} \qquad (17)$$

These transformations (17) can be simplified by excluding the «extra» system from the calculations. For this purpose it is enough to make one of them, let's say, IRF(K') connected with IRF(K_0). In this case, excluding system (K), equations (17) will take the usual form (13), where: ($V = c + v_1$) and ($v = v_1 + v_2$). And when system (K_0) is excluded: ($V = v_1$) and ($v = v_2$). And if we follow the STR paradigm, we can draw a wrong conclusion from the last example: the velocity, for example, of a rocket (v_1) in all IRFs will be constant.

Thus, the Lorentz transformation does not endow light with any exceptional properties, and therefore the light wave in relation to the unbound IRF has a relative velocity, and in the bound IRF – absolute.

10. Time in the Lorentz transformation

The duration of the movement of light in relation to an unrelated IRF(K') does not depend on the method of its determination. Time can be calculated either through the relative speed of light, or through the absolute – the result will be the same:

- in the system (K): $t' = x/(c^2 - v^2)$ $\rightarrow$ $t' = t/(1 - \beta^2)$
- in the system (K_0): $t' = (x + \Delta x')/c$ $\rightarrow$ $t' = t + \Delta t'_A$ $\rightarrow$ $t' = t/(1 - \beta^2)$

As it was shown above, such difference ($\Delta t'_A = t' - t$) is due to the passage of light of different distances ($c = x'/t'$) and ($c = x/t$). And there is no contradiction in this.

However, this difference, for example, in STR is interpreted as a phenomenon of «time dilation», the meaning of which is in the change of the measure of duration in a moving frame of reference (K') depending on the velocity of its displacement. The proof uses the equation for the inverse transformation (1), in which the object of study is no longer the relationship between the time readings (or so-called event coordinates) (t') and (t), but the duration of this event ($\Delta t'$) and (Δt) [1, p.28].

$$t_2 = \gamma(t'_2 + vx'/c^2)\ t_1$$
$$= \gamma(t'_1 + vx'/c^2)$$

at: $\Delta t = t_2 - t_1$; $\Delta t' = t'_2 - t'_1$

$$\Delta t = \gamma\ \Delta t' \qquad (18.1)$$

In other sources along with (18.1) the inverse formula is given [2, p.220].

$$\Delta t' = \gamma\ \Delta t \qquad (18.2)$$

The discrepancy between formulas (18.1) and (18.2) has been called the «paradox of time». In fact, there is no contradiction here – it is just that the first equation contains an error: the formula (18.1) holds only when ($x_1' \neq x_2'$), since the coordinate (x') is a variable quantity. If ($x_1' = x_2'$) (otherwise asymmetry exclusion will not take place), then formula (18.1) will be similar to formula (18.2).

Nevertheless, the difference of durations ($\Delta t' - \Delta t$) is interpreted in no other way than as a change in the measure of duration, which is certainly an epistemological error. One cannot explain one phenomenon by the result of another. If salt and sugar are white, it does not mean that salt is sweet.

If we express the Lorentz factor (γ) from the transformation equation (1) through (x') and (x), i.e., as ($\gamma = x'/x$), then equation (18.2) takes the form:

$$\Delta t' = \Delta t\ x'/x \qquad (18.3)$$

The same result follows from the Simultaneity Rule (12), where (γ), as a special case ($k_S = k'_S$), is the coefficient of simultaneity ($1/k_S = \gamma$). And then formula (18.2) can be written as ($\Delta t' = \Delta t/k_S$). And since the coefficient (k_S) can have any values depending on the initial displacement of the reference frame or time scale, the ratio ($\Delta t'/\Delta t$) can also take any values.

Thus, from (10) at (k_S = 1) the ratio ($\Delta t'/\Delta t$ = 1), and from (15) at (k_S = 118) the ratio ($\Delta t'/\Delta t$ = 1/118), which according to the version of STR should mean: in the first case - time does not slow down, and in the second case - time will slow down 118 times. And this is provided that in both cases the parameters of motion (v) and (V) are the same. .

To compare the time parameters of the two systems ($t' \leftrightarrow t$), it is not at all necessary to change the equations so that they begin to describe a completely different process – the time of the traveled path instead of recalculating the coordinates. For this purpose it is enough to analyze directly equation (1), and then it will appear that the time ratio: $t'/t = f(t)$ in the interval (from 0 to $+\infty$) will vary in the range (from $-\infty$ to γ) and in its limit never not equals (γ), while in STR this ratio is strictly constant and equal to ($t'/t = \gamma$) [4, p.20-24].

Lorentz transformations have one more important property: at the same parameters (x, v, k_S) the change of coordinate $x' = f(t)$ does not depend on the value of velocity (V) at all. And if instead of the speed of light in calculations (13) we use, for example, the speed of sound, the character of the change of $x' = f(t)$ will remain the same.

In this case, the change in velocity (V) will only affect the displacement time (t') of the system (K'). This means that in the Lorentz transformation the time of motion (t') can change its value not only from the distance traveled (x'), but also from the change of velocity (V) of the bound IRF(K). This fact completely refutes the interpretation of STR about the change of duration measure (time) depending on the velocity of motion of the unbound reference frame (K').

In the equation, the value of velocity (V) can change when, for example, the coupling of the reference frame (K_0) changes from IRF(K) to IRF(K'). Then the parameters (V) will change to ($V + v$). At the same time, the character of change of the coordinate $x' = f(t)$ will remain the same. The very change in velocity from (V) to ($V + v$) in the transformation equations entails a change in time (t′) due to the change in correction:

$$\beta x/V \quad \rightarrow \quad \beta x/(V + v)$$

The change in time (t'), in turn, is compensated by the change in the coefficient (k'_S) (12). As we see, at constant parameters (v) and (V) the duration of motion (t') can change its value depending on randomly assigning to any of the IRFs the status of a coupled system with (K_0).

It is clear that this compensatory mechanism does not have any influence the kinematics of motion and, moreover, cannot be the cause of occurrence of any physical phenomenon.

Thus, neither a direct comparison of time (t'/t), nor a comparison of the time for light to travel different paths ($\Delta x'/c \leftrightarrow \Delta x/c$), nor a change in velocity in coupled systems ($\Delta x'/V_1 \leftrightarrow \Delta x'/V_2$) not indicates a change in the measure of duration itself. In other words, the statement about time dilation has no physical cause, and as we know - there is no effect without a cause.

One more question remains unexplained: what is the reason for the emergence of the concept of «time dilation» or, in other words, why did it take a measure of duration to make a variable? And it is not difficult to answer this question.

In his work «On the electrodynamics of moving bodies», Einstein, investigating the relative motion of light, naturally obtained the asymmetry of the motion of light in IRF(K') [1, §3]. And then he faced a problem – how to resolve the contradiction:

$$c = x/t \quad \leftrightarrow \quad c \neq x/t' \qquad (19)$$

Recall that there is no such contradiction in the Lorentz transformation, since the asymmetry of the movement of light is compensated by either shifting the reference frames, or shifting the time scale, or both at the same time.

$$c = (x + \Delta x')/t'$$

Although Einstein derived the equations of Lorentz transformations himself, he did not understand the mechanism of such compensation. And then Einstein unreasonably, i.e. exclusively by mathematical (administrative) method, transformed inequality (19) into an equality by changing the measure of duration by substitutions a new term (γ):

$$c \neq x/t' \quad \rightarrow \quad c = x(\gamma/t')$$

And it was this simple technique ($1/t = \gamma/t'$) that was elevated to the rank of a physical phenomenon in nature and became known as «time dilation». In addition, such an interpretation of compensation mechanisms excluded the absolute reference frame (K_0) in the Lorentz transformation as unnecessary. And in order to give this uselessness a physical meaning, Einstein had to talk about the absence of ether.

As a result, motion began to exist without matter. And with a variable measure of duration (time) in science, it became possible to simultaneously start and finish two objects moving at the same distance at different speeds.

There is another circumstance that led Einstein to the wrong conclusion about the variable measure of duration. Thus, the movement of two objects moving at different speeds can be compared in the same time intervals, i.e. it is always possible to determine how far each object has traveled in the same period of time. It is clear that these distances traveled will be different.

When these same objects are endowed with the same speed, they will travel different distances in different time intervals to the simultaneous finish, which is also beyond doubt. Therefore, in the last example, the distances traveled by objects cannot be compared in the same time frame due to the different time of their movement. In this case, we can only talk about the ratio of the distances traveled, i.e. we can talk about the proportion: $x' = k\,x$.

An example is the movement of two pedestrians to the point where their paths intersect and where they arrive at the same time (Fig.1). Obviously, two pedestrians, having walked different distances to point x, will spend different time. It follows from this that one of them will always start its movement before the second. Einstein's mistake was that he began to consider different distances traveled in the same time frame. And therefore it became possible for two pedestrians to start and finish simultaneously at different distances, and the different duration of their movement began to be explained by the slowing down of time for the pedestrian who walked a long distance. This situation contradicts not only the observed phenomena. It also does not correspond to the Lorentz transformations.

Consider the diagram for equation (1) (Fig.9). Unlike the diagram in Fig.2 the beginning of the IRF reference frame (K') is located on the (Y) axis in the system (K) with coordinates (0, Δy). Since in equation (1) the coefficients of simultaneity are equal ($k_S = k'_S$), they can be expressed in terms of the angle of inclination of the trajectory of the system (K')

$$k_S = k'_S = cos\alpha, \text{ where: } cos\ \alpha = \sqrt{1 - \beta^2}$$

Then the diagram will look as follows (Fig.9):

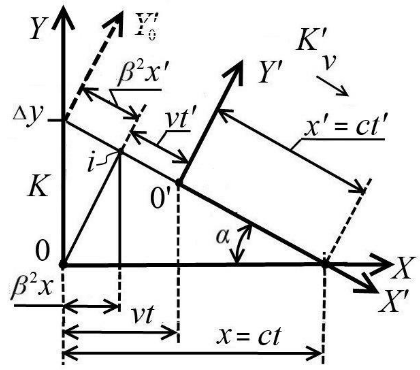

Fig. 9 Diagram of Lorentz transformations for ($k_S = k'_S$),
where: (K) – is a direct transformation, (K') – is the reverse.

From this graphical interpretation of the Lorentz transformations, it follows that a different time of movement of the light beam in the system (K'), as well as the time of movement of the system itself (K'), expressed in (vt'), is due to a different distance (x') in comparison with (x).

From Fig. 2 and 9 it follows that the time (t) and (t') are determined by one, we emphasize, one clock from the general frame of reference (K_0), and since the same clock cannot change the oscillation period of its pendulum only from the choice of IRF, the explanation of the time difference ($\Delta t'_A$) «time dilation» is a profound misconception.

Thus, the Einstein variant with compensation of asymmetry by changing the measure of duration directly contradicts the essence of the Lorentz transformations, since the measure of duration in transformations for different IRF is a constant value, and the simultaneity of the event is absolute.

11. Length of a segment in the Lorentz transformation

There exists another common prejudice where in a moving frame of reference (K') the length of a segment is shortened according to the formula:

$$L' = L_0\sqrt{1 - \beta^2}$$

The same equation for the inverse transformation (1) serves as proof for this (1) [1, c.27]. As we can see, in this case there is an epistemological error: the coordinates of the event (x') and (x) are not examined, but the distances traveled ($\Delta x'$) and (Δx), and only then the result of the comparison is transferred to the length of arbitrary segments (L') and (L). It is clear that such a methodology, based on a single equation torn from the system of equations (1), is untenable.

It is enough to build a similar proof on the equation of direct transformation, then the length of the segment will not decrease, but increase.

$$L_0 = L'\sqrt{1 - \beta^2}$$

If we proceed from the SRT concept of changing the length of a segment, then there is an obvious contradiction here. And if we proceed from the constancy of length, then there is no mistake.

So, from the diagram (Fig. 9) it can be seen that at ($t' = 0$) the origin of the IRF coordinates (K') is at point (i), which means that: ($L_1' = x'$). In the second case, for ($t = 0$), it follows that: ($L_2' = x' + \beta^2 x'$), where: ($\beta^2 x' = \Delta x'$) (7). At the same time, we must remember, in both examples ($L_0 = x$).

Thus, the judgement about the length of the segments relies only on the initial conditions when the inequality ($x > x_1'$) or ($x < x_2'$), which in the Lorentz transformation is laid down initially either at ($t' = 0$) or at ($t = 0$). And since the authors proving the length contraction of the segment proceed from the fact that at ($t' = 0$) and ($t = 0$) the coordinate origins of both reference frames (K) and (K') coincide, the inequality ($x \neq x'$) following from the Lorentz transformation has been interpreted as an unreasonable length contraction.

In actually, by taking into account the initial displacement of the mobile reference frame(K') by the value ($\Delta x'$), the length of the segment (L) will always be unchanged.

Let us consider an illustrative example from equation (8) when ($k'_S = 1$). If a segment of length (L) is placed in the system (K), its length will be defined as ($L = x_1 - x_0$), where: (x_0) is the origin of the system (K). The same segment in the reference frame (K') will have the coordinates: ($L = x_1' - \Delta x'$). It is clear that the points (x_1) and (x_1') coincide.

If the segment (L) is placed in another system - in the system (K'), its length will then be defined as ($L = x_2' - x_0'$), where: (x_0') is the origin of the system (K'). In the reference frame (K) the same section (L) will have coordinates of: ($L = x_2 + \Delta x'$).

Thus, one and the same segment of length (L) initially placed in different frames of reference has different coordinates ($x_1 \neq x_2$) and ($x_1' \neq x_2'$), however it does not follow from this that the physical length of the segment in different ISO will be different.

So Einstein's ignoring of the displacement ($\Delta x'$) led him to a utopia with the contraction of the length of the segment in the moving IRF(K') when he mistakenly equated ($x_1 - x_0 = x_1' - x_0'$) or ($x_2 - x_0 = x_2' - x_0'$), which is the same mistake.

12. The relationship between Galileo and Lorentz transformations

When deriving the Lorentz transformations (8, 10), the general Galilean transformations (6) were used as a basis. It is clear that the use of the Galilean transformation under new conditions (for three IRF) led to a modification of these equations, since additional correction coefficients were needed to compensate for the asymmetry of the movement of the light beam due to the presence of a third object. Therefore, the new concept of transformations in calculations it was necessary to switch from relative velocity ($V \pm v$) to absolute velocity (V). Nevertheless, the Galilean transformation remained the basis of the Lorentz transformation. To make sure of this, it is enough to equalize the asymmetry of motion with the corresponding coefficients of simultaneity, both in forward and reverse transformations:

$$k_S = (1 - \beta); \qquad k'_S = (1 + \beta).$$

Then equations (13) will take the form of equation (14). If we express time in reverse order, as ($x'/V = t'$) and ($x/V = t$), then equation (14) takes the form of the general Galilean transformation (6).

Thus, based on (8, 10, 14), we can conclude that coordinate transformations using the Lorentz method are a general Galilean transformation applied to three reference frames.

This circumstance is important. If the two studied systems in the Galilean transformation can be considered equivalent, then in the Lorentz transformation these same systems are no longer equivalent with respect to the third ISO, since the conditions of their motion are different.

Hence the conclusion: the principle of relativity, according to which all physical phenomena proceed equally in different frames of reference, is valid only under equal, we emphasise, equal conditions under which these phenomena manifest themselves. This circumstance indicates that there are no fundamental contradictions between Newton's mechanics and Maxwell's electrodynamics.

13. Coordinate transformations in non-inertial reference systems (NRS)

When deriving (proof) Lorentz transformations, mandatory requirements are imposed on his equations: they must meet the properties of linearity and equality of direct and inverse functions [2, p. 214].

The second requirement is clearly superfluous here, since equality exists a priori, otherwise the transformation will not be a transformation. As for the first requirement, the linearity of the equations, it is not justified in any way, and therefore it can be ignored.

Coordinate system is a method for determining the position and motion of a point (or physical body) in space. A reference frame is a specific coordinate system that is linked to a particular object. It follows from this that, regardless of the relative position of several reference systems at any given time, any given point (event) in space can be designated by the corresponding coordinates in each of these systems.

And since «лany moment in time» is nothing but the absolute simultaneity of an event, the nature of the movement of these reference frames does not impose any restrictions in the description of coordinates. Kinematic processes are studied in coordinate transformation, and therefore it is enough to know the laws of motion for the transformation operation, but the reason for the nonlinearity of such motion does not matter.

For example, the Galilean transformation applied to a moving IRF(K')moving rectilinearly with acceleration (a) will have the following entry:

$$x' = x - at^2/2 \qquad x = x' + a(t')^2/2 \qquad t' = t$$

It follows from the Rule of simultaneity (12) that the equality of asymmetry with its compensation (5) does not depend on the nature of their changes, the main thing here is the equality of two parameters (asymmetry and compensation), which allows us to talk about the possibility of applying Lorentz transformations during the transition from an inertial system to a non–inertial one (NRS).

Consider the transformation when the motion of the system (K') is nonlinear. Based on the rule of simultaneity and in the case when $v_x = f(t)$, the values of the coefficients of simultaneity will be determined as follows:

$$k_S * k'_S = 1 - [v_x(t)]^2/V^2$$

As an example, the equations of coordinate transformations using the Lorentz method for equidistant motion will look like this:

$$x' = \frac{x - \dfrac{at^2}{2}}{k_S} \qquad x = \frac{x' + \dfrac{att'}{2}}{k'_S}$$

$$t' = \frac{t - \dfrac{atx}{2V^2}}{k_S} \qquad t = \frac{t' + \dfrac{atx'}{2V^2}}{k'_S}$$

where: $k_S * k'_S = 1 - (at)^2/4V^2$;

a – acceleration of NRS(K') relative to IRF(K);

V – velocity of motion of IRF(K) relative to IRF(K_0).

The peculiarity of this variant is that the equation for the inverse transformation contains time (t) from the direct transformation ($att'/2$), which indicates the same measure of duration in different reference frames.

The next example. The change in the speed of movement between NRS(K') and IRF(K) can occur according to any law, for example, according to the harmonic one: $v_x = v\sin(\omega t)$, and then the transformation equations will take the following form:

$$x' = \frac{x - vt\sin(\omega t)}{k_S} \qquad x = \frac{x' + vt'\sin(\omega t)}{k'_S}$$

$$t' = \frac{t - \dfrac{vx\sin(\omega t)}{V^2}}{k_S} \qquad t = \frac{t' + \dfrac{vx'\sin(\omega t)}{V^2}}{k'_S}$$

where: $k_S * k'_S = 1 - v^2\sin^2(\omega t)/V^2$

In turn, the velocity between the reference systems (K_0) and (K) can also be fickle: [$V_x = f(t)$]. For example, when the axis (X') of the reference system (K') is shifted relative to the axis (X) of the system (K) by an amount (Δy), while the center of radiation, for example, of light remained on the (X) axis. In this case, the coordinate velocity of light (V_x) is taken into account for calculations, defined as:

$$V_x = V\sin\alpha = V\,\mathrm{tg}\alpha/\sqrt{1 + \mathrm{tg}^2\alpha}$$

where: $\mathrm{tg}\alpha = vt/\Delta y$

The following example. The velocities (V) and (v) vary according to the harmonic law, for example: [$v_x = v\sin(\omega_1 t)$] and [$V_x = V\cos(\omega_2 t)$]. In this case, the coordinate transformation equations for NRS(K) and NRS(K') will be as follows:

$$x' = \frac{x - vt\sin(\omega_1 t)}{k_S} \qquad x = \frac{x' + vt'\sin(\omega_1 t)}{k'_S}$$

$$t' = \frac{t - \dfrac{vx\sin(\omega_1 t)}{V^2\cos^2(\omega_2 t)}}{k_S} \qquad t = \frac{t' + \dfrac{vx'\sin(\omega_1 t)}{V^2\cos^2(\omega_2 t)}}{k'_S}$$

where: $k_S \cdot k'_S = 1 - \dfrac{v^2\sin^2(\omega_1 t)}{V^2\cos^2(\omega_2 t)}$

This means that the Lorentz transformations in relation to a particular case – the motion of a light wave – do not oblige us to assume that the speed of light in a vacuum is a constant value.

Thus, the Lorentz method coordinate transformation equations for non-inertial reference frames generally look like this:

$$x' = \frac{x - v_x(t) * t}{k_S} \qquad x = \frac{x' + v_x(t) * t'}{k'_S}$$

$$t' = \frac{t - \dfrac{v_x(t) * x}{[V_x(t)]^2}}{k_S} \qquad t = \frac{t + \dfrac{v_x(t) * x'}{[V_x(t)]^2}}{k'_S}$$

where: $k_S \cdot k'_S = 1 - \dfrac{[v_x(t)]^2}{[V_x(t)]^2}$

The Lorentz method is also applicable to rotational motion. In model consisting of three disks (K_0), (K) and (K') and located, for example, on the same axis, the transformation equations will have the following form:

$$\varphi' = \frac{\varphi - \omega t}{k_S} \qquad \varphi = \frac{\varphi' + \omega t'}{k'_S}$$

$$t' = \frac{t - \dfrac{\omega}{\omega_0^2}\varphi}{k_S} \qquad t = \frac{t' + \dfrac{\omega}{\omega_0^2}\varphi'}{k'_S} \tag{20}$$

where: $k_S * k'_S = 1 - \omega^2/\omega_0^2$

φ – the initially set rotation angle of the disc (K);

φ' – the angle of rotation of the disc (K');

ω_0 – the angular velocity of the disk (K) relative to (K_0);

ω – the angular velocity of the disk (K') relative to (K).

Here, the asymmetry of rotation ($t'_A = t' \omega^2/\omega_0^2$) is also compensated by increasing the initial angle of rotation of disk (K') as ($\Delta\varphi' = \varphi - \varphi'$), or by shifting the time scale ($\omega\Delta t'_S = \varphi - \varphi'$),or both at the same time. The coefficient (k_S) is defined similarly to (16) as ($k_S = \varphi/\varphi'$), where the values (φ) and (φ') at ($t = 0$). As we can see, there is a complete analogy between equations (20) and equations (13).

The example with three disks clearly shows the essence of transformations, and here it is necessary to pay attention to the following. From equation (20) in a rotating disk (K'), the unit of measurement of plane angles (degrees) should, according to STR logic, change its value: ($\varphi' = \gamma\,\varphi$), or in rad: ($\pi' = \gamma\,\pi$) similarly to reducing the length of a segment in a movable frame of reference [1, p.26]. Naturally, this is a misconception, since the angular measure for circles in degrees (radians) is a unchangeable value, like other measures of measurement - duration and dimension.

These measures themselves are abstract and conventional quantities, and therefore are not subject to physical study. Therefore, the reference to the Lorentz transformations as a proof of the change of measures in a moving frame of reference is a fundamental error of STR.

14. Conclusions

The Lorentz method of coordinate transformation is a general Galilean transformation applied to three reference systems, while two of them are connected, the relative velocity of which is accepted as absolute.

The Lorentz coordinate transformations are based on the concept of absolute simultaneity, otherwise coordinate transformations would be impossible.

The principle of absolute simultaneity is realized by introducing appropriate corrections (coefficients of simultaneity) into the general Galilean transformation, compensating for the asymmetry of the motion of the studied reference frames relative to the privileged one.

Coordinate transformations using the Lorentz method are always performed if the corrections for forward and reverse transformations obey the Rule of Simultaneity.

Lorentz transformations are applicable both for inertial reference frames and for non-inertial ones, regardless of the speed, type and direction of their mutual motion.

For a special case, this means that the Lorentz method of coordinate transformation does not prohibit the movement of any object with superluminal velocity and does not prohibit the movement of light in a vacuum with variable velocity.

Lorentz transformations do not refute the relativity of the speed of light and do not endow light with any special properties, since the transition from relative speed to absolute is a mathematical technique by which calculations for determining coordinates are transferred to an absolute frame of reference.

The time difference in different reference frames is due to light traveling different distances. In the equations of the Lorentz transformations, as in the general Galilean transformations, the measures of duration and extent, as well as the angular measures of the circle, remain constant in all reference frames.

From the Rule of Simultaneity it follows that the basis of the principle of relativity lies, first of all, in the equal conditions under which physical phenomena manifest themselves.

Thus, the Lorentz coordinate transformation is a mathematical apparatus in which, from the standpoint of classical physics, all parameters are consistent, consistent and logical, which indicates the correctness of their reflection of the world around us and fully meets common sense.

15. Literature

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