On the postulate of the constancy of the speed of light in the STR [1)]

The analysis of the hypothesis and conclusions of it

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The question about of whether the necessary postulate of the constancy of the speed of light for the construction of the Special Theory of Relativity was raised and discussed, at least two independent authors [1, 2]. The answer to this question is methodologically very important in recognition of the fact that the foundations of the output of the Galilean transformations and Lorentz are the same basic properties of substantial space and time of Newton. It turned out that in the classical physics "hiding" a contradiction in the substantial properties of space and time. What is the essence of this contradiction? The article attempts to answer this question.

Note that the authors of the mentioned works have received their findings generally avoiding mention of the words "light" and "the speed of its spread".

Arithmetization of space-time relations

We introduce after A.A. Friedman [3] the concept of arithmetization of space-time relations. As a result of the arithmetization procedure, each point of space receives three coordinates (x, y, z). By placing a clock at each point in space, we get a 4-coordinate system. The only requirement for the result of arithmetization at this stage is the condition of continuity: infinitely close space-time events must correspond to infinitely close points of the conceptual 4-space. Let us denote this coordinate system as a reference system Σ [2)] and call it a laboratory reference system. The result of the arithmetization can be represented as an opportunity in every point of space and at every moment of time "to find a label" with four coordinates (t, x, y, z). It is only necessary to remember that these four numbers are obtained as a result of arbitrary arithmetization with an arbitrary metric, and "lengths" and "time intervals" as characteristics of neighboring points of sets are not normalized measures. It's just Jordan's measures.

Let us consider the second reference frame Σ', which is obtained by *transforming the coordinates* of the laboratory system according to the formulas:

$$\begin{aligned} x' &= x - V\,t\,, \\ t' &= t\,. \end{aligned} \qquad (1)$$

If we trace from the system Σ the point $x' = 0$ of the origin Σ', we see that the coordinate of this point, by virtue of the first relation (1), changes according to $x = V\,t$. That is, the system Σ' in the laboratory frame of reference moves at a speed V along the common axis X.

We introduce the third reference system Σ'', which is also obtained by transforming the coordinates of the laboratory system, but according to the formulas:

$$\begin{aligned} x'' &= \frac{x - V\,t}{\sqrt{1 - V^2}}, \\ t'' &= \frac{t - V\,x}{\sqrt{1 - V^2}}. \end{aligned} \qquad (2)$$

[1)] **I beg your pardon for my not very good English!** The original text on Russian: http://vixra.org/pdf/1804.0331v1.pdf.

It so happened that the article [5] appeared before this work and therefore its results were not convincing enough. The purpose of this paper is to fill a gap in the arguments. See also [6, 7].

[2)] Formally, the reference system is called such a system, the arithmetization of space-time relations in which can be implemented using real physical procedures.

If, as in the previous case, we trace from the system Σ the point $x'' = 0$ of the origin Σ'', we see that the coordinate of this point, by virtue of the first relation (2), changes according $x = Vt$. Also, that is, the system Σ'' in the laboratory frame of reference moves at a speed V along the common axis X.

As a result of the rearifmetization of the space-time relations by formulas (1) and (2), observers associated with the reference systems Σ' and Σ'', will receive their own "set of labels" for the coordinates of 4-events [3] .

The possibilities of describing the movement [4].

Let's solve the "problem of meeting" of two observers. In fact, there is the coordinate method of arifmetization that appeared for solving problems of this type. This method does not require or imply the concepts of length, duration or their measurements.

Let the observer of the laboratory system Σ make an appointment to the observers connected with the systems Σ' and Σ'' at point x at time t. He himself began to move from the point $x = 0$ at time $t = 0$. To reach the point of encounter, it must move at a speed $v = x/t$.

Let us consider the possibility of "guessing" this point and get exactly there and at the right time by observers of the systems Σ' and Σ'' with re-charted coordinates of space-time events according to (1) and (2), using only their coordinate data and their velocity addition laws.

1. Coordinates of the meeting point in the system Σ' are determined according to (1).

If the observer of the system Σ' started moving from the point $x' = 0$ at the time $t' = 0$, then he will have to move at the speed v', which he must determine according to his law of velocity addition from (1). We have

$$dx' = dx - V\,dt\,, \qquad dt' = dt,$$

whence it follows that

$$v' = v - V. \tag{a}$$

As expected, we obtained the law of velocity addition, which coincides with the classical form.

If the observer of the Σ' system will move according to the indications of the "renormalized" speedometer according to (1), he must to get to the point laboratory reference frame specified by the observer Σ . Let check it.

At the point of the meeting of observers (x', t'), the condition must be fulfilled by the coordinates of the system Σ'.

$$x' = v't'\,. \tag{b}$$

Substituting (1), (a) in (b)we obtain: $x - Vt = (v - V)t = vt - Vt$ or

$$x = v\,t\ . \tag{c}$$

2. The coordinates of the meeting point in the system Σ'' are determined according to (2). If the observer of the system Σ'' started moving from the point $x'' = 0$ at the time $t'' = 0$, then he must to move at the speed v'', which he can determine according to his law of velocity addition from (2). We have

$$dx'' = \frac{dx - V\,dt}{\sqrt{1 - V^2}}, \qquad dt'' = \frac{dt - V\,dx}{\sqrt{1 - V^2}},$$

whence it follows that

$$v'' = \frac{v - V}{1 - vV}. \tag{a'}$$

As expected, we obtained the law of velocity addition, which coincides with the relativistic form.

If the observer of the Σ'' system will moves according to the indications of the "renormalized" speedometer according to (2), he must to get to the point laboratory reference frame specified by the observer Σ . Let's check it.

At the point of the meeting of observers (x'', t''), the condition must be fulfilled by the coordinates of the system Σ''

$$x'' = v''t''\,. \tag{b'}$$

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[3] The reference systems obtained by rearifmetization $\Sigma \to \Sigma'$ and $\Sigma \to \Sigma''$ 'with the help of (1) and (2) will be called for brevity Galilean's and Lorentz's frame of reference in connection with their laws of addition of velocities (a) and (a'). Note that these are only symbolic names.

[4] It is assumed that the synchronization condition is met: $x = x' = x'' = 0$, $t = t' = t'' = 0$.

Substituting (2), (a') into (b') we obtain:

$$\frac{x - V\,t}{\sqrt{1 - V^2}} = \frac{(v\ -\ V)\dfrac{t\ -\ V\,x}{\sqrt{1 - V^2}}}{1 - vV} \quad \text{or}$$

$(x -\ V\,t)(1 - vV) = (t\ -\ V\,x)(v\ -\ V)$, that is

$$x = v\,t \tag{c'}$$

The solutions of the problem of the meeting in different variants show that the coordination of space-time events is possible without involving the physical metric properties of space and time. Ordering and continuity are sufficient properties. With continuous arifmetization and continuous transformations of 4-coordinates, integral solutions are possible *with the use of the concept of velocity* v_x *as a derivative:* $v_x = dx/dt$.

Measurements. Standards. Metrization

Let us consider the features of *linear* transformations (1) and (2).

1. The Galilean transformations (1) leave invariant Jordan's measures of segments t and x: $\Delta t = \Delta t'$ and $\Delta x = \Delta x'$at $\Delta t = 0$.
2. From the Lorentz's transformations (2), the existence of a maximum velocity value follows. The property of maximum value provides its uniqueness and hence invariance with respect to Lorentz transformations (see (a')). The value of this speed in the relativistic system of units of measurement (RSU) is taken to be 1.

Thus, there are two possibilities for normalization of Jordan's measures with the help of different standards:

1. A pair of classical standards of length and time (the Galilean case (1)).
2. A single speed standard with a value equal to 1; here, the speed of light propagation in vacuum is used as a standard (Lorentz's case (2)).

   In the first case, we obtain a description of space-time relations by classical dynamics, in the second – by relativistic dynamics. It is this fact that leads to contradictory interpretations of the space-time relations in STR.

With help of continuous transformations

$$\tilde{x}^i = f^i(x^k), \qquad (i, k = 0,1,2,3) \tag{3}$$

we introduce into consideration the frame of reference $\tilde{\Sigma}'''$. The transformations (3) must be chosen so that the square of the differential form ds^2 takes the form:

$$ds^2 = \tilde{g}_{ik}(\tilde{x}^l)d\tilde{x}^i\,d\tilde{x}^k, \quad (i, k = 0,1,2,3), \tag{4}$$

and $\tilde{g}_{ik}$ satisfied the formal requirements of a metric tensor *pseudo-Riemann's* space. This frame of reference we will call pseudo-Riemannian. The prefix "pseudo" is necessary to denote the signature of the metric tensor $\tilde{g}_{ik}$ as $(+,-,-,-)$.

In this case, unlike (a) and (a$'$), the law of velocity transformation will be quite arbitrary due to the arbitrariness of the transformations themselves (3) and it will be difficult to call it the law of velocity *addition*, although the "meeting problem" will have its solution in this case as well.

For sufficiently smooth functions $\tilde{g}_{ik}(\tilde{x}^l)$ in the neighborhood of any point, the matrix $\tilde{g}_{ik}$ can be reduced locally to the diagonal form:

$$(g^o_{ik}) = \begin{Vmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{Vmatrix} \tag{5}$$

It is easy to verify that in this case (4) takes the form:

$$ds^2 = (d\tilde{x}^0)^2 - (d\tilde{x}^1)^2 - (d\tilde{x}^2)^2 - (d\tilde{x}^3)^2, \tag{6}$$

and when $d\tilde{x}^1 = d\tilde{x}^2 = d\tilde{x}^3 = 0$, the ratio (6) takes the form:

$$ds^2 = (d\tilde{x}^0)^2 = d\tau^2. \tag{7}$$

It can be seen that by virtue of (7), $d\tau$, like ds, are the invariants of transformations of the form (3), as an elements of 4-the length of the world line. Time τ, defined by (7), we call *eigentime*, and time defined as $\tilde{x}^0 = \tilde{t},\ (c = 1)$ - *coordinate time*.

In the general case (4) the relation between differential elements of the interval, eigentime and coordinate time is given by the expression [5)]:

$$ds^2 = d\tau^2 = \tilde{g}_{00}(\tilde{x}^l)(d\tilde{x}^0)^2, \tag{7'}$$

that makes it *necessary* to distinguish an eigentime and a coordinate time.

The main feature of the representation (4) is the invariance ds for arbitrary continuous transformations of the form (3), the consequence of which is the eigentime invariance τ for all transformations, including (1) and (2).

It would seem that (1) and (2) give two alternatives in the description of space-time relations, from which it is necessary to choose one. However, (3) combines them and adds a fundamentally new moment. Let us consider this in more detail.

First. Measuring the eigenvalue of time, length.

The coordinate values of the time interval, length, velocity $-\ \Delta t,\ \Delta x,\ v_x$, are determined by the relations:

$$\Delta t = t_2 - t_1, \qquad \Delta x = x_2 - x_1, \qquad v_x = dx/dt.$$

These values have not yet been physically measured by any standard. The only measures for them is Jordan's measures, but their" values "as for continuum subsets, are" equal", because between sets and subsets of can be established a one-to-one correspondence. All these sets have a unique property of ordering. The transformations (1) and (2) are linear. This means that these transformations will preserve linear ordering, and hence the 4-coordinates will have the property of affinity.

Thus, the coordinate spatiotemporal parameters have the property of initial ordering, which for linear transformations (1) and (2) acquires an affine (linear) status.

For the measurement of space-time characteristics it is necessary to find some standards. Since the standard by definition must be immutable, it is necessary to look for the standards among the invariants.

The eigentime interval τ is an invariant of general continuous transformations of the form (3). Thus, the value of τ will be identical in reference systems $\Sigma', \Sigma'', \tilde{\Sigma}'''$ at a point with coordinates associated with coordinate transformations(1), (2), (3). The measurement is carried out in the reference system Ξ, which is obtained by means of transformations $\xi^i = \xi^i(x^{i*})$, when the conditions are met:

$$d\xi^1 = d\xi^2 = d\xi^3 = 0, \qquad g_{00}^{(\Xi)} = 1\,. \tag{8}$$

Here: ξ^i – coordinates of a point in the system Ξ, which measures the interval of eigentime; x^{i*} – coordinates of one of the systems $\Sigma', \Sigma'', \tilde{\Sigma}'''$, if we are talking about one of them, or of any other. These conditions determine the requirements for the procedure of measuring eigentime: the first of them means the measurement of time by a motionless clock, the second - the equality of the "course" of hours at different points in space to get the ability to synchronize multiple hours localized at different points in space, that is, the coordination of "coordinate time" and "eigentime". In the frame of reference Ξ eigentime τ coincides with the interval of coordinate time ξ^0: $\tau = \xi_2^0 - \xi_1^0$.

[5)] L.D. Landau, E.M. Lifshitz. *Theoretical physics. v. II; §84, (84.1)*

The measurement of eigenlength or spatial distances is carried out by converting the coordinates $\eta^i = \eta(x^{i*})$ to the reference system Θ under the conditions:

$$\eta^0 = \text{const и } g_{0\alpha}^{(\Theta)} = 0, (\alpha = 1,2,3); \tag{9}$$
synchronization of the clock along the measured trajectory .

Here: η^0 is the time coordinate of a point in the Θ system. The requirement for the components of the metric tensor follows from the allocation of the spatial part $\gamma_{\alpha\beta}$ of the 4-metric according [6)]

$$\gamma_{\alpha\beta} = -g_{\alpha\beta} + \frac{g_{0\alpha} g_{0\beta}}{g_{11}} . \tag{10}$$

Then the square of the trajectory length is determined by the formula

$$l^2 = \int\limits_{\eta^0=\text{const}} \gamma_{\alpha\beta} dx^\alpha \, dx^\beta . \tag{11}$$

Integration into (11) is performed along the trajectory lying on the hypersurface $\eta^0 = \text{const}$.

The conditions on the metric tensor (8) and (9) determine the *synchronous* frame of reference.

Second. The expression (11) for length does not have the property of 4-covariance. Therefore, a different approach is needed to measure speeds. Let us use the fact that the representation of the pseudoeuclidity (5) is possible for each point of the 4-pseudo-riemannian space, and the only value of the maximum velocity determined by (a′) is an invariant of transformations (2). This suggests that it should be physically measurable. This value is assumed to be 1. Thus, there are new measures for measuring the space-time relations - the standard of time and the standard of the maximum speed of signal propagation. However, as it is easy to notice, the invariance of 4-interval is simply another formulation of the maximum velocity invariance. Taking its value equal to 1, we come to a single standard for measuring space-time relations instead of individual length and time.

Third. Affine covariance. The form (5) of the local representation for the metric tensor g_{ik}^{o} is also preserved under transformations (2), which leads to the formulation of the *Local Lorentz Invariance* (*LLI*) principle. The transformation (2) preserves the local view metrics (5), which is the subject of local Lorentz invariance

Summary

None of the systems $-\Sigma', \Sigma'', \tilde{\Sigma}'''$, is not "loaded" by metric properties. Initially, the 4-coordinates of these reference systems have only the property of ordering, and the systems Σ', Σ'' have the property of linear ordering, i.e. affinity. physically measurable metric arises when using measurement standards.

Such a standard in STR is the maximum speed *c* of propagation of the signal in the Lorentz frames of reference. The property of maximality provides it with the uniqueness of the value and invariance in the transformation of coordinates (2), which meets the requirements for the measurement standard. However, this standard is local and does not have the property of general covariance. Due to the property of local invariance, instead of the second postulate of STR, the principle of local Lorentz invariance (LLI) enters on the scene, which is an one of the components of the General Einstein equivalence principle (EEP) *).

6) L.D. Landau, E.M. Lifshitz. *Theoretical physics. v. II; §84, (84.7)*

The LLI principle states the covariance of the physics equations with respect to the Lorentz transformations (2) and gives the output of the concept of coordinate time having an affine property. To date, the principle itself is confirmed with phenomenal accuracy on the scale of macrophysics. To date, the principle itself is confirmed with phenomenal accuracy on the scale of macrophysics.

The same idea allows to endow by the metric property of its eigentime, the magnitude of which is invariant under all continuous transformations pseudo-riemannian space. The maximum speed c is the standard for measuring this time. Invariance of 4-interval, direct connection 4-interval with its eigentime, locality of eigentime measurement – all this determines the possibility to measure of the eigentime, using speed c as a standard. In the relativistic system of units, $c = 1$ is assumed. It is significant that this speed can be measured in the Galilean frame of reference with the help of classical standards of length and time. Modern physics associates the maximum speed c with the speed of light propagation in a vacuum. In the relativistic system of units, $c = 1$ is assumed. *It is significant that the speed can be measured in the Galilean frame of reference with the help of classical standards of length and time.* Modern physics associates the maximum speed c with the speed of light propagation in a vacuum.

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*) General Einstein equivalence principle (EEP):
weak equivalence principle (WEP),
the principle of local Lorentz invariance (LLI),
the principle of local positional invariance (LPI).

Литература

[1]. ЯП Терлецкий. *Вывод преобразований Лоренца без постулата о постоянстве скорости света.* В кн. Парадоксы теории относительности. М., "Наука", 1966, (стр. 23). https://www.dropbox.com/s/pjdb2qxxyu4eapi/Terletskii-2.pdf?dl=0

[2]. НД Мермин. *Теория относительности без постулата о постоянстве скорости света.* В сб. '86 Физика за рубежом. Серия Б. Сборник статей. М., "Мир". 1986, (стр. 173). https://www.dropbox.com/s/3qrsqm5e213wffd/Mernin-2.pdf?dl=0

[3]. АА Фридман. *Мир как пространство и время*. М., "Наука", 1965 г. https://www.dropbox.com/s/ofsb4p9xub99s3t/Fridman.djvu?dl=0

[4]. ВА Касимов. *Парадокс близнецов*. Новосибирск. 2014. https://www.academia.edu/32443266/

[5]. ВА Касимов. *О втором постулате СТО*. Новосибирск. 2015. https://www.academia.edu/32452588/

[6] ВА Касимов. *Пространство, время, движение*. "Сибпринт", Новосибирск, 2013 г. https://www.academia.edu/36065258/

[7] Касимов ВА. *Специальная теория относительности (без 2-го постулата). Общая теория относительности принципы).* "Сибпринт", Новосибирск, 2013 г. https://www.academia.edu/35877014/

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V.A. Kasimov. On the postulate of the constancy of the speed of light in the STR (English version)

Abstract
The question of whether the necessary postulate of the constancy of the speed of light for the construction of the Special Theory of Relativity was raised and discussed, at least two independent authors [1, 2]. The answer to this question is methodologically very important in recognition of the fact that the foundations of the output of the Galilean transformations and Lorentz are the same basic properties of substantial space and time of Newton. It turned out that in the classical physics "hiding" a contradiction in the substantial properties of space and time. What is the essence of this contradiction? The article attempts to answer this question.

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