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Replacement of Einstein's Relativity Theory with a new one: Why the second Postulate is superfluous?

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Abstract

My purpose consisted in creation of a new relativistic space-time theory instead of Einstein's Relativity Theory, but basing upon only one postulate. This could become feasible only if a law of light propagation in a moving inertial reference frame could be made a consequence of the relativity postulate. It was made a reality by discovery by P.M. Rapier of a quadratic dependence of light speed upon the speed of a light source. Considering various ways of making the second postulate superfluous the most short of them was through introducing into the theory of a new concept "light speed in a moving inertial reference frame" by means of usage of a four-dimensional Minkovski's formalism. This new concept speed was defined as equal to a fourth component of a four-dimensional speed of any moving particle. Then using this newly introduced concept the time-measurement unit was calculated for a moving light clock that occurred to be equal to the time measurement unit of a stationary light clock. And as a very happy event the time dilation effect was deleted from the theory.

Key words: special relativity theory, inertial reference frame, moving reference frame, stationary reference frame, light speed in a stationary inertial reference frame, light speed in a moving inertial reference frame, four-dimensional speed or velocity, Galilean speed or velocity, Lorentz speed or velocity, proper time, light clock, time measurement unit.

Foreword

The history shows, that all theories and sciences evolve in such a way, that realnesses visible by eyes are gradually changed by realnesses perceived mentally. For example, movement of the Sun and far stars and immovability of the Earth visible to Ptolemy's eyes after some time were replaced by movement of the Earth around the Sun and with respect to far stars perceptible by Copernicus's brain.

The first stage of any theory or any science therefore is based upon seeing any phenomenon by means of eyes. And the eye sees only the light – electromagnetic radiation with wavelengths between 380 nm (violet color) and 780 nm (red color). What else do we know about the light? We know that the light propagates in vacuum having the velocity equal to 299 792 458 m/s. At that this value is measured in the stationary inertial reference frame (IRF). At what speed the light propagates in any moving IRF we can only guess. In order to answer this question we, first of all, should form a concept "light speed (or velocity) in vacuum of a moving IRF". Why we must perform this task?

We must perform this task due to todays situation when we know only speed of light in a stationary IRF. Because it has happened in such a way, that in 1905 Albert Einstein [1] defined only speed of light in a stationary IRF and introduced two postulates:

1. A relativity postulate: "***The laws, by which the states of physical systems undergo change, are not affected, whether these changes of state be referred to the one or the other of two systems of co-ordinates in uniform translatory motion***".

2. A postulate of light speed independence on the speed of a light source: "***Any ray of light moves in the "stationary" system of co-ordinates with the determined velocity*** c_0***, whether the ray be emitted by a stationary or by a moving body***".

Keeping in mind that any of two IRFs, moving each with respect the other at some specific speed V, may be called as a stationary one (at that the other one should be considered as a moving one), from these two Einstein's postulates it was concluded, that the speed of light in vacuum of all IRF (irrespective of whether each of these IRF is considered to be a stationary one or a moving one) is equal to the same value c_0 = 299 792 458 m/s.

Such erroneous conclusion was used by Einstein himself when he derived Lorentz's transformation of coordinates from one IRF to another IRF, namely he wrote: "…***Light (as required by the principle of the constancy of the velocity of light, in combination with the principle of relativity) is also propagated with velocity*** c_0 ***when measured in the moving system***".

But neither Einstein in 1905, nor his numerous admirers in the past did not take into their minds, that an assumption about equality of light speed in a moving IRF to the light speed in a stationary IRF results in contradiction between the effect of time dilation in Einstein's special relativity theory (SRT) and the relativity principle.

Indeed, it is well known that a light clock (consisting of two parallel mirrors, a photoelectric sensor on one of mirrors, a pulse counter connected to the output of the photoelectric sensor and a light pulse circulating between mirrors) is a physical system, which must comply with the relativity principle.

Because the relativity principle with respect to such physical system as the light clock must read:

The laws, by which the indications of light clock undergo change, are not affected, whether these changes of indications be referred to the one or the other of two systems of co-ordinates in uniform translatory motion.

That means that time dilation effect existing in the SRT according to the relativity principle should be absent. Indeed, if we consider that distance between mirrors of a stationary light clock is equal to L_0, then the time measurement unit for a stationary light clock is equal to the value

$$T_0 = 2 \cdot L_0 / c_0 . \qquad (1)$$

And the time measurement unit for the same light clock, moving at the speed V in a direction perpendicular to planes of light clock mirrors, in case of an assumption that light speed in a moving light clock also is equal to c_0 will be equal to the value

$$T = \frac{L}{c_0 - V} + \frac{L}{c_0 + V} = \gamma \cdot T_0 , \qquad (2)$$

where $L = \frac{L_0}{\gamma} = L_0 \sqrt{1 - V^2 / c_0^2}$ is the distance (according to the SRT) between light clock mirrors, moving at the speed V.

Thus, the assumption that the light speed in a moving IRF is also equal to the same value c_0, leading to the existence of time dilation effect in the SRT, leads to a contradiction with the relativity principle (indications of a light clock depend on what IRF these indications are referred to). Therefore it is expedient to consider what value of the light speed in a moving IRF will not lead to a contradiction with the relativity principle, that is to consider what value of light speed in a moving IRF will result in equality of time measurement units for stationary and moving light clocks of the precisely similar design.

Introduction of a new physical concept

First of all let us form a new concept "light speed in vacuum of a moving IRF". It is unlikely that this concept has been considered as having some positive sense up until todays time. As opposed to this concept the concept "light speed in vacuum of a stationary IRF" was widely known because it was included into the Einstein's second postulate (see above) [1].

How can we practically perform measurement of the “light speed in vacuum of a moving IRF”? We can perform such measuring in accordance with figure 1.

Let us consider two IRFs K’ (x’,y’) and K (x,y) moving each with respect to another one at the velocity u (see fig. 1). In all points of the unprimed IRF K named with letters (points A_0, N, M) there are clocks that are synchronized (show the same time at any time moment of the IRF K). The primed IRF K’ in figure 1 is a stationary IRF. That means that an arbitrary light clock with stationary mirrors in points B_0 and B_1 of the primed IRF K’ is at rest in this primed IRF K’ and the moving unprimed IRF K is moving in a direction, that is parallel to planes of mirrors B_0 and B_1.

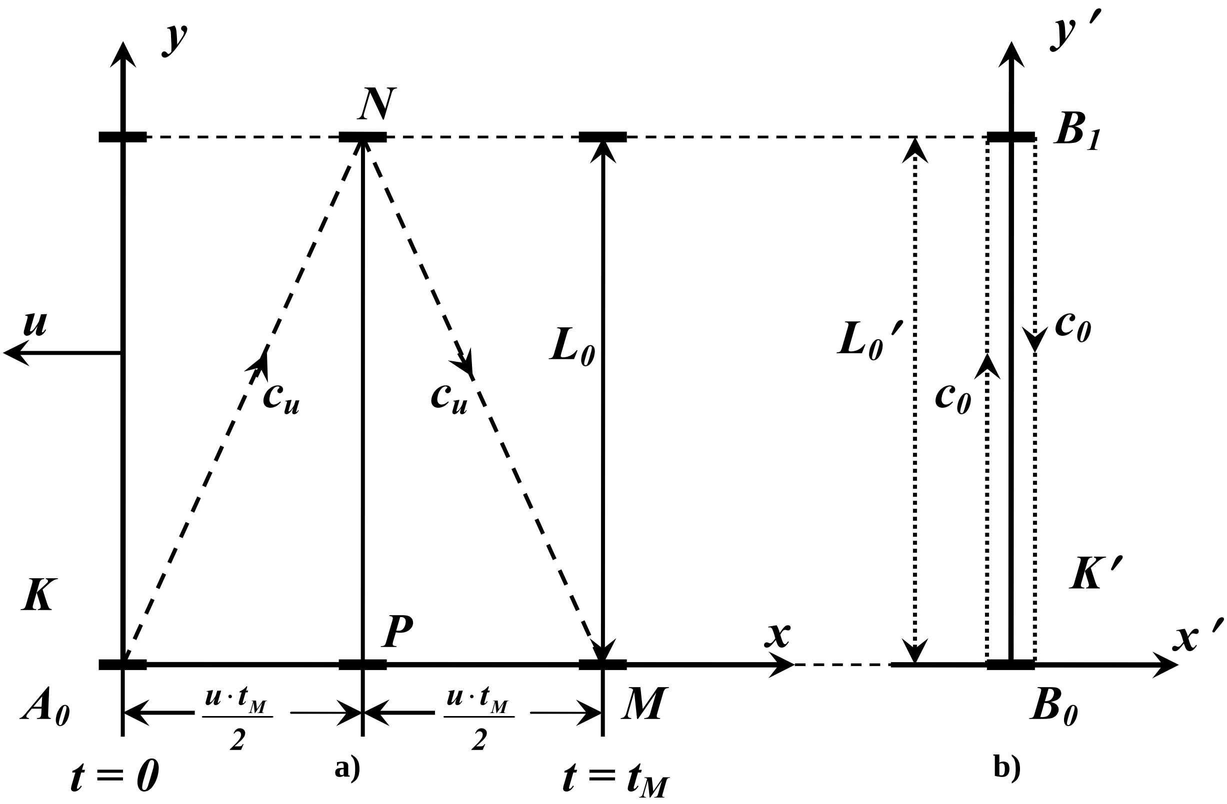

Fig. 1. Propagation of light in a light clock in two IRFs moving each with respect the other.

a) propagation of light in a «moving» IRF K from a point of view of an observer resting in a «stationary» IRF K′, light propagates in the moving IRF K along straight lines ***A_0N, NM*** *at the light speed* c_u*;*

b) propagation of light in a «stationary» IRF K′ from a point of view of an observer resting in the «stationary» IRF K′, light propagates in the “stationary” IRF K′ at the speed c_u.

At the zero time moment t_0 = t_0' **= 0** of the both systems, when a point B_0 of the IRF ***K'*** coincides with the point A_0 of the IRF ***K***, two light sources in the point B_0 radiate two light pulses, one of which propagates from the point B_0 to a point B_1 of the IRF ***K'*** and the second pulse propagates from the point B_0 to the point A_0, where a spot on the X axis of the unprimed coordinate system ***K*** is marked. When the light pulse radiated in the point B_0 arrives to the point B_1, a light source in the point B_1 radiates a light pulse that puts a spot mark in a point ***N*** of the IRF ***K.*** Simultaneously a pulse arrived from the point B_0 is reflected by the mirror in the point B_1 and moves back to the point B_0. When the pulse reflected from the point B_1 arrives back to the point B_0 a light source in the point B_0 puts a spot mark in the point ***M*** of the IRF ***K*** and stops a clock situated in the point ***M*** (at a time moment t_M).

Then an observer being at rest in the "moving" IRF ***K*** measures the optical length of light ray path $S = A_0N + NM$ in the moving IRF ***K*** and makes read out of the indication t_M of the clock being at rest in the point ***M*** of the IRF ***K*** and being stopped at a moment, when the light pulse in the IRF ***K'*** returns back to the point B_0 after reflection from the mirror in the point B_1. Then the "light speed in vacuum of the moving IRF" may be calculated using the formula

$$c_u = \frac{S}{t_M}. \qquad (3)$$

So the value "light speed in vacuum of the moving IRF" can be rather simply measured and calculated in the experiment, if the light in figure 1 propagates in vacuum.

By the way, as the time moment t_M of the light pulse arriving to the point ***M*** of the IRF ***K*** coincides with a time moment of the light pulse returning back to the point B_0 in the IRF ***K',*** and the optical length of light pulse path $S = A_0N + NM$ in the IRF ***K*** is greater than optical length of the light pulse path $S' = 2\,L_0$ in the stationary IRF ***K'***, the value of "light speed in a moving IRF" c_u exceeds the value of "light speed in the stationary IRF" $c_0 = \frac{S'}{t_M}$, that means that $c_u > c_0$. Thus, during the time travel of the light pulse from the point B_0 to the point B_1 and back from the point B_1 to the point B_0 at the speed c_0 in the stationary IRF ***K'*** the same light pulse performs in the moving IRF ***K*** a travel from the point A_0 through the point ***N*** to the point ***M*** at the greater speed c_u. So, considering a rectangular triangle A_0NP in the fig. 1, we have

$$c_u^2 = c_0^2 + u^2 \qquad (4)$$

or

$$c_u = \sqrt{c_0^2 + u^2}\ . \qquad (5)$$

Now let us consider the same situation from the point of view of the SRT in Minkovski's four-dimensional world [2, p. 12].

Real physical sense of the new concept

Terletskiy [3, p. 53] said "From a point of view of the four-dimensional geometry of space-time the real physical sense can be ascribed only to four-dimensionally covariant values. In mechanics of a particle such values are a four-dimensional scalar known as a proper mass ***m***, as well as four-dimensional vectors of the velocity $\vec{U}_k$, the acceleration $d(\vec{U}_k)/d(t)$ and the momentum $\vec{P}_k$".

First of all we shall consider now a four-dimensional vector of the velocity $\vec{U}_k$.

Formation of a four-dimensional vector (4-vector) of the velocity is introduced in the SRT similarly to a three-dimensional vector in the three-dimensional space, where position of a particle is specified by a three-dimensional radius-vector $\vec{r}$ and a three-dimensional vector of the velocity $\vec{V}$ is defined as a derivative from the three-dimensional radius-vector $\vec{V} = d\vec{r}/dt$.

To define a 4-vector of the velocity as a time derivative (Newton's fluxion) of the 4-vector $\vec{R}$ is prohibited in the SRT. We require a 4-vector of velocity, therefore we may divide the increment $d\vec{R}$ of a four-dimensional radius $\vec{R}$ only by a scalar. In the SRT neither the time, nor its differential are invariants of the Lorentz's transformation. Therefore in the SRT we can take as an invariant value depending upon time either the four-dimensional interval

$$ds^2 = c_0^2 dt^2 - dx^2 - dy^2 - dz^2 = c_0^2 dt'^2\ , \qquad (6)$$

or the proper time

$$d\tau = \frac{ds}{c_0} = dt\sqrt{1 - V^2/c_0^2} = \frac{dt}{\gamma}\ , \qquad (7)$$

where $\gamma = \dfrac{1}{\sqrt{1 - V^2/c_0^2}}$ is the relativistic factor, and ***V*** is the velocity of a particle.

So, let us introduce a 4-vector of a particle velocity

$$\vec{U} = \frac{d\vec{R}}{d\tau}\ . \qquad (8)$$

In the coordinate representation this 4-vector of the velocity $\vec{U}$ can be written in the following way

$$\boldsymbol{u_i} = \frac{\boldsymbol{dR_i}}{\boldsymbol{d\tau}}\,, \qquad (9)$$

where ***i*** = ***1, 2, 3, 4***.

It is well known that three first derivatives in the formula (9) can be written as

$$\boldsymbol{u_\alpha} = \frac{\boldsymbol{dx_\alpha}}{\boldsymbol{d\tau}} = \gamma\frac{\boldsymbol{dx_\alpha}}{\boldsymbol{dt}} = \gamma \boldsymbol{V_\alpha}\,, \qquad (10)$$

where α = 1, 2, 3; $V_\alpha = dx_\alpha / dt$ are projections of the 3-vector $\vec{V}$ onto the respective coordinate axis (***x, y, z***).

The values, defined by equalities (10), are the first three components of 4-dimensional Galilean vector $\vec{U}$ changing from zero to infinity (hereinafter the velocity, changing from zero to infinity we can name as Galilean velocity and designate it with a letter ***u***, in order to distinguish it from the Lorentz's velocity, changing from zero to the velocity of light in vacuum of the stationary IRF c_0, that we hereinafter will designate using a latter ***V***. At that relation between Lorentz's and Galilean velocities are defined by means of equalities [4]

$$\boldsymbol{u} = \frac{\boldsymbol{V}}{\sqrt{1 - V^2/c_0^2}}\,, \quad \boldsymbol{V} = \frac{\boldsymbol{u}}{\sqrt{1 + u^2/c_0^2}}\,. \qquad (11)$$

Taking into account that in the SRT $\boldsymbol{R_4} = \boldsymbol{c_0 t}$, as well as the equation (7), let us find the fourth component of the 4-velocity. We obtain

$$\boldsymbol{u_4} = \frac{\boldsymbol{dR_4}}{\boldsymbol{d\tau}} = \gamma\frac{\boldsymbol{d(c_0 t)}}{\boldsymbol{dt}} = \gamma \boldsymbol{c_0}\,. \qquad (12)$$

As from equalities (7), (11) and (12) it follows that

$$\gamma = \frac{1}{\sqrt{1 - V^2/c_0^2}} = \sqrt{1 + u^2/c_0^2}\,, \qquad (13)$$

then in the moving IRF (if V ≠ 0, γ ≠ 1) we obtain $u_4 = \gamma c_0$.

Consequently, the value

$$\boldsymbol{u_4} = \gamma \boldsymbol{c_0} = \boldsymbol{c_u} = \frac{\boldsymbol{c_0}}{\sqrt{1 - V^2/c_0^2}} = \boldsymbol{c_0}\sqrt{1 + u^2/c_0^2}\,, \qquad (14)$$

which is **the fourth component of the 4-velocity of a particle in vacuum of a moving IRF**, we define as the **light speed in vacuum of a moving IRF**.

Physically the light speed $\boldsymbol{c_u}$ in vacuum of a moving IRF can be in the SRT not equal to the value c_0 because of change of the longitudinal (along direction of movement) size of moving vacuum volumes in the result of which the values of the dielectric permittivity and magnetic permittivity of vacuum volumes can also be changed.

New calculation of a time measurement unit of a moving light clock

Now (**after introduction of the definition for the 4-velocity of light in vacuum of a moving IRF**) let us take a light clock (two parallel mirrors at a distance each from another equal to L_0, in the very *IRF*, where this light clock is at rest, between which, alternatively reflecting, a light pulse is circulating, on one of mirrors a source of light pulse, photo diode and pulse counter are situated).

The unit of time measurement of this light clock, stationary in an immovable IRF, is determined by equality (1).

Now let this light clock move so that planes of the both mirrors of this light clock are perpendicular to the light clock direction of movement.

As we have determined earlier, see equality (14), the light in vacuum of a moving IRF propagates at the speed

$$c_u = \gamma c_0 , \qquad (15)$$

where c_0 is the speed of light in vacuum of a stationary IRF; γ is the relativistic factor determined by expressions (13).

Then after radiation of the light by a source, situated on the backward mirror of the light clock, the velocity of light closing with the foremost mirror of the light clock will be equal to $(c_u - u)$, and the velocity of light closing with the backward mirror after light reflection from the foremost mirror will be equal to $(c_u + u)$, where c_u is the velocity of light in vacuum of a moving IRF, $\boldsymbol{u}$ is the Galilean velocity of light clock. Therefore the unit of time measurement by the moving light clock will be determined by the formula:

$$E = \frac{L}{(c_u - u)} + \frac{L}{(c_u + u)} , \qquad (16)$$

where $L = \frac{L_0}{\gamma}$ is the distance between mirrors of the moving light clock, measured in the IRF, with respect to which this light clock moves at the speed $\boldsymbol{u}$.

Having substituted into the formula (16) the values $L = \frac{L_0}{\gamma}$, $c_u = \gamma c_0$ and $\gamma = \sqrt{1 + \boldsymbol{u}^2 / c_0^2}$, we shall obtain that

$$E = \frac{2L_0}{c_0} . \qquad (17)$$

Thus, using the above stated new physical concept the time measurement unit of the moving light clock becomes equal to time measurement unit of the stationary clock (the right part of the formula (17) coincides with the right part of the formula (1)).

Now let us return to a case, shown in fig. 1, when the light clock is situated so that planes of its parallel mirrors are parallel to the direction of light clock movement.

A time interval between radiation of a light pulse from the point $\boldsymbol{B_0}$ and its return to the same point $\boldsymbol{B_0}$ in the stationary IRF ***K'*** after reflection from the mirror in the point $\boldsymbol{B_1}$ is equal to

$$\Delta t' = \frac{2 \cdot L_0}{c_0}. \qquad (18)$$

If we designate with symbols ***Δt*** a time interval in the moving IRF ***K*** between radiation of the same light pulse from the point $\boldsymbol{A_0}$ and a moment of its arrival to the point ***M,*** then the path passed by this light pulse in the moving IRF K can be determined using the Pythagorean theorem

$$S = 2\sqrt{L_0{}^2 + \left(\frac{u\Delta t}{2}\right)^2}. \qquad (19)$$

But the IRF *K* moves with respect the stationary IRF K' at the speed ***u*** (Galilean speed). Therefore we must consider, that speed of propagation of this light signal in the moving IRF *K* along straight lines $\boldsymbol{A_0N}$ and ***NM*** is determined according to the expression (15) (this means that it is equal to the speed of light in vacuum of the moving IRF). As a consequence the time interval $\Delta t = \boldsymbol{t_M - t}$ can be determined by dividing the light path *S*, determined by the equation (19), by the speed of light in the moving IRF *K*, determined by the expression (15). We shall obtain

$$\Delta t = \frac{2 \cdot \sqrt{L_0{}^2 + \left(\frac{u\Delta t}{2}\right)^2}}{c_0 \gamma}. \qquad (20)$$

Solving the equation (20) with respect to the value Δt , we have

$$\Delta t = \frac{2 \cdot L_0}{[c_0\sqrt{\gamma^2 - (u/c_0)^2}\,]}. \qquad (21)$$

Taking into account the equality (13), the expression (21) takes the form

$$\Delta t = \frac{2 \cdot L_0}{c_0}. \qquad (22)$$

The formulas (18) and (22) mean, that the time interval between some two events in the moving IRF ***K*** connected with propagation of light is equal to the time interval between the same events in the stationary IRF ***K '***.

Consequently, introduction of the concept "**the speed of light in vacuum of a moving IRF"** excludes from the space-time theory such an effect as time dilation in the moving IRF and converts into the unscientific space opera the statement about possibility of journey in the future of the Earth by means of long traveling in space at large speeds (close to the speed of light).

Discussion of results

But it is well known that in the SRT a moving clock (not only a light clock) dilates (lags, retards) with respect to a stationary clock. Physically the cause of this time dilation is well seen from equation (2) valid for a light clock. This equation (2) shows that in the SRT the duration of a time interval from a moment of a light pulse radiation by a light source on the backward mirror of a moving light clock to its reflection from the forward mirror of the light clock and till a moment of the same light pulse returning to the backward mirror of the moving light clock, is by the factor of $\gamma = \frac{1}{\sqrt{1 - V^2/c_0^2}}$ greater than the same time interval for a stationary light clock determined by equation (1).

After having introduced the concept “speed of light in a moving light clock” determined by equation (15) we calculated the duration of the time measurement unit in the moving light clock according to equation (16) and concluded that using this concept the old SRT became more physical. Because now physicist become very shy when they are requested to determine the time measurement units of stationary and moving light clock and compare each with other. As without the concept “speed of light in a moving light clock” it is very difficult to prove that the moving light clock has the same time measurement unit with the stationary light clock of the same design, now equality of time measurement units of the moving and the stationary light clocks are proved using the linear algebra. The speed of light in a moving light clock is greater by the factor of $\gamma = \frac{1}{\sqrt{1 - V^2/c_0^2}}$ than the speed of light in a stationary light clock. And the light path length in the moving light clock is greater by the factor of $\gamma = \frac{1}{\sqrt{1 - V^2/c_0^2}}$ than the light path length in the stationary light clock. That is why when we use the concept “light speed in a moving IRF” the time measurement units in the moving light clock and in the stationary light clock are equal. The light path length in the moving light clock in fig. 1

equals to $\boldsymbol{S = A_0N + NM = 2\sqrt{L_0^2 + \left(\frac{L_0}{c_0}\cdot u\right)^2} = 2L_0\sqrt{1+\frac{u^2}{c_0^2}} = 2L_0\gamma}$. The light path length in the stationary light clock is equal to $\boldsymbol{S' = 2L_0}$. Therefore $\frac{S}{c_u} = \frac{2L_0\gamma}{c_0\gamma} = \frac{2L_0}{c_0} = \frac{S'}{c_0}$.

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