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On the essence of time and Lorentz transformations

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Abstract

The reasons for the emergence and essence of the concept of time are discussed. It is argued that the concept of time in humans arose as a result of observing the movement of material objects and the course of various processes. The repeatability and periodicity of natural processes became the basis for the introduction of a quantitative measure of the duration of any movements and processes. The introduction of a quantitative measure made it possible to measure the duration of any movements and processes in comparison with the duration of stationary periodic processes chosen as units of measurement. The very same measure of the duration of any movement began to be called time. It is argued that the connection of the course of time with the stationary periodic motion of natural objects indicates the invariance of its course with respect to moving frames of reference. It is shown that time dilation and reduction in the size of spatial objects are the result of an incorrect interpretation of the results of Lorentz transformations.

Keywords: Time, Space, Principle of relativity, Lorentz transformations.

Introduction

The interval invariance and Lorentz transformations that form the basis of the special theory of relativity, which have changed ideas about space and time, are a consequence of the assumption of the constancy of the speed of light in inertial frames of reference. According to such representations, space and time form an interconnected space-time continuum. The results of the Lorentz transformations are usually interpreted as a reduction in the size of spatial objects and a slowdown in the course of time in a moving frame of reference in relation to the course of time and to the dimensions of the same objects in a stationary frame. According to the transformations, a spatial object located in a fixed frame of reference, having a size L and measured in a frame moving with a speed v, has a different size, which is determined by the expression $L' = L/\gamma$, where

$$\gamma = \frac{1}{\sqrt{1-v^2/c^2}} \tag{1}$$

The expression for time conversion between systems has a similar form: $\Delta T' = \Delta T/\gamma$. That is, the same object measured by different reference systems does not have the same measurement result. Similarly, the time interval between two events in a fixed reference frame ΔT turns out to be not equal to the time interval between the same events, measured in a moving reference frame. Note that the "reduction" of the size of the object and the "deceleration" of the passage of time is determined by the same factorγ^{-1}. The indicated changes in the course of time and in the sizes of objects are obtained as a result of transformations, but they indicate the expected results of direct measurements.

Here I draw the reader's attention to the essence of the concept of "measurement". Measurement is the operation of comparing the size of the measured object with the size of a standard object, which is usually called a unit of measurement, for example, a meter, a second, etc. Usually, when interpreting the results of Lorentz transformations, it is assumed that the units of measurement of space and time in the considered inertial systems remain unchanged. However, measuring an object using the same units of measure cannot produce a different measurement result. Thus, we have a contradiction between the results of Lorentz transformations and the results of measurements when using the same units of measurement.

This contradiction became the reason for the search for its resolution. This work is devoted to the analysis of the causes of the contradiction and to the elucidation, as it seems to me, of the essence of the real content of the Lorentz transformations. Awareness of the essence of the transformations allowed me to come to a different interpretation of the concept of time, its origin and the establishment of its connection with the world movement.

About the concept of time

The concept of time in humans arose as a result of observing the movement of material objects and the course of various processes. The repeatability and periodicity of natural processes made it possible to introduce a quantitative measure of the duration of any movements and processes. The introduction of a quantitative measure made it possible to measure the duration of movements and processes in comparison with the duration of stationary periodic processes, which were used to select the units of measurement. At the same time, the measure of the duration of movement began to be called time.

The movement of the Earth is stationary and practically does not change during the life of a person and even the life of many generations. This stationary motion of the Earth with a strictly periodic change of day and night was chosen as the standard for determining the unit of time. People began to normalize all other processes and movements in relation to the period of rotation of the Earth around its axis or in relation to the duration of its revolution around the Sun - a year. As a result, the movement of the Earth and the passage of time became unambiguously consistent.

The Earth is not the only object in outer space that performs stationary periodic motion. The motions of many planets and stars also turn out to be stationary, and therefore the ratios of the durations of their periods of motion to the periods of motion of the Earth remain unchanged indefinitely. This allows us to choose as the unit of time duration the period of revolution or a part of time period of motion of any such space object.

The movement of such objects is not connected with the choice of any reference system, its speed and the nature of the movement. The unambiguous relationship between the motions of all stationary objects moving with different velocities indicates the uniformity and invariance of the course of time in all observable space. The course of time turns out to be a universal characteristic of the entire world movement. With this understanding of time, its course cannot depend on the speed of the spacecraft and any other object moving in space.

On the "contradictions" resulting from a misinterpretation of the transformations

A. Einstein formulates the principle of relativity, according to which the speed of light remains unchanged in all inertial frames of reference and does not depend on the state of motion of the radiating body. In his seminal work [1], he writes: “... for all coordinate systems for which the equations of mechanics are valid, the same electrodynamic and optical laws are valid, as has already been proven for first-order quantities. We intend to turn this assumption (the content of which will be called the “principle of relativity” in what follows) into a premise and make, in addition, an additional assumption, which is only in apparent contradiction with the first one, namely, that light in vacuum always propagates with a certain speed V [1], independent of the state of motion of the radiating body.” Thus, he extended the action of Galileo's principle of relativity from the laws of mechanics to electrodynamic and optical laws.

To derive transformations between coordinate systems, A. Einstein considers the propagation of light in a rod moving at a speed v of length L and located along the direction of motion. At the same time, he considers the speed of light to be the same both in a fixed frame and in a coordinate system associated with the rod. Under this assumption, in the reference frame associated with the rod, the time of passage of the light pulse along the rod in both directions will be equal to $t' = 2L/c$. In a stationary system with respect to the rod, the light pulse moves in one case after the speed $c - v$, and in the opposite direction its speed is equal to $c + v$. In this case, the time it takes for the pulse to travel in both directions is

$$t = \frac{2L}{c(1 - v^2/c^2)} \tag{2}$$

In a stationary frame of reference, light spends more time propagating the rod than on the same process in the frame of reference associated with the rod. Such a result in the theory of relativity is represented as a slower course of time in a moving frame compared to the course of time in a stationary frame of reference.

Using the principles of relativity and the constancy of the speed of light, A. Einstein obtained transformations of spatial coordinates and time, which were later called the Lorentz transformation. The results of transformations create the illusion of slowing down of time and reduction of sizes of spatial objects. Recognition of such illusion as reality led to contradictions between the results of transformations and reality on the one hand and the principle of relativity, using which they were obtained, on the other hand. The length of a rod at rest in a stationary system turns out to be shorter as a result of measurements in a moving system, if the Lorentz transformations are to be believed. The same discrepancy is given by transformations when measuring the time intervals between two events, the clock of a stationary system and the clock of a moving system. Changes in the length of the rod and in the course of time occur with a proportionality factor γ^{-1}.

The transformations show that the reduction in the spatial dimensions of objects takes place only in the direction of motion of the frame of reference. In the direction transverse to the movement, the spatial dimensions of objects are the same in the stationary and in the moving frame of reference. The inconsistency of the transformation results will be shown in the following examples.

In theory, each of the two moving inertial frames can be taken as stationary. At the same time, in a moving system, according to the Lorentz transformations, the passage of time slows down relative to the passage of time in a stationary system, and the size of objects decreases in the same proportion in the direction of their speed of movement. Thus, if a clock is placed in each of the systems, the speed of which coincides with the speed of the system, then the time readings in them cannot be subject to transformations. Their course must comply with the principle of relativity, according to

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[1] A. Einstein designated the speed of light with such a symbol. The symbol c is commonly used today to represent the speed of light.

which the clocks in both systems must run the same way. In paragraph 2 of the work of A. Einstein [1], he explains this feature of the principle of relativity: “The laws by which the states of physical systems change do not depend on which of the two coordinate systems moving uniformly and rectilinearly relative to each other, these changes states are related.” In this case, the readings of the same clock change according to the same laws.

Following the theory of relativity, one can take as a fixed system a system relative to which two other inertial systems are moving with an equal in magnitude but opposite in direction speed. In this case, in moving systems, the clocks must run synchronously from the point of view of the stationary system. In this case, each moving system can be chosen as a stationary system, as a result of which, in the other two systems, the course of time should slow down with different rates of deceleration, which is also beyond the scope of the possible. A clock mechanism cannot show two different passages of time in the same process. Here again the internal inconsistency of the theory appears. The Lorentz transformations are obtained using the principle of relativity and, nevertheless, the results of the transformations are in conflict with the principle of relativity.

Naturally, the question arises about the reasons for such a contradiction, when measurements of the dimensions of the same object, as well as measurements of the time interval between two events in one frame of reference, do not give the same result as measurements in other frames of reference. Proponents of the theory of relativity explain these differences by the special properties of space and time. At the same time, the assumption that the units of measurement of space and time in all frames of reference remain the same and do not depend on the speed of the system is not questioned.

The results of measuring the time intervals between two events are obtained by comparing their durations with the unit of time. If the units of measurement are the same in different IFs, then the measurement results of any time interval between events should be the same, regardless of the reference frame in which these measurements are carried out. Differences in the results of measurements are a consequence of the use of units of measurement of different scales.

The difference in the scales of the units of measurement follows directly from the Lorentz transformations. Let's show it on the example of the formula for time conversion [1].

$$t' = (t - vx/c^2)/\sqrt{1 - v^2/c^2}, \tag{3}$$

from which follows the transformation of time intervals between events in the stationary and moving systems $\Delta t' = \Delta t/\gamma$. As a unit of time, we take one second in a moving frame of reference and consider the case when the speed of this frame is equal to half the speed of light $v = 0.5s$. Wherein $\gamma = 0.866$. Substituting in the formula $\Delta t' = 1s$, we get $\Delta t = 1.15$s. The time interval of one second between two events in the moving frame translates to 1.15 seconds in the stationary reference frame. This means that the time unit second in a moving frame of reference has duration of 1.15 times the duration of a second in a stationary frame.

No less indicative is the example with the transformation of the spatial coordinate. The Lorentz transformation of a spatial coordinate differs from the transformation of a coordinate in classical mechanics only by the relativistic factor γ on the right side of the formula

$$x' = \gamma(x - vt) \tag{4}$$

For the case of classical mechanics, it suffices to put γ =1. Assume that the unit of measurement is centimeter. In the case of γ =1, we will also get the conversion result in centimeters. If we want to express the conversion result in meters, it is enough to divide the right side of equation (4) by 100. That is, put γ =1/100. We do not consider the new unit of measurement as before the centimeter. Thus, the numerical factor in the transformation of coordinates in classical mechanics changes the scale of the units of measurement of the object's size. We do not consider the new unit of measure as still a centimeter. Thus, the numerical multiplier in the coordinate transformation in classical mechanics changes the scale of units of object size. We do not consider the new unit of measure as still a centimeter. Thus, the numerical multiplier γin the coordinate transformation in classical mechanics changes the scale of units of object size. The same function is performed by the relativistic factor γ in the Lorentz transformations.

Changes in the scales of the units of measurement of space and time arose as a result of keeping the speed of light unchanged in inertial frames of reference. The constancy of the speed of light is achieved by proportionally changing the scale of the units of measurement of spatial objects and time. By proportionally changing their scales in moving frames, the transformations ensure the invariance of not only the speed of light, but also the speed of relative motion between frames of reference. Indeed, the value of the speed of the system is determined by the ratio of the path traveled by the system to the time spent on this path, and it turns out to be the same in units of space and time in both systems

$$v = \Delta S/\Delta T = \Delta S'/\Delta T'.$$

If we multiply the numerator and denominator of the expression for the speed by the same coefficient, then for any object, including light, the speed value will remain unchanged. This is what the Lorentz transformations do, changing the scales of the units of measurement of space and time by multiplying them by the relativistic factor γ. The results of the transformation do not depend on the choice of any of the two moving systems as a fixed one. In another moving frame of reference, the scales of the unit of measurement will change using the same factor γ.

On the experimental refutation of the Lorentz transformations

In 1913, the French physicist Georges Sagnac published two articles in which he presented the results of experiments to test the Lorentz transformations carried out using a rotating interferometer [2, 3]. The peculiarity of the experiments was that two beams of light emitted by a source rotating together with the interferometer and propagating along the interferometer ring in opposite directions pass the same distance relative to the light source before meeting. Under the reality of Lorentz transformations, no interference should be observed at the meeting point of light beams. In Sagnac's experiments, interference was observed and depended on the speed of rotation of the interferometer, which testified to the dependence of the speed of light on the speed of the frame of reference. Proponents of the theory of relativity do not consider the results of Sagnac's experiments to be a refutation of the theory of relativity, referring to the fact that the Sagnac interferometer was not an inertial system. On the contrary, the observation of interference is presented as a confirmation of SRT, since the experiment demonstrates the implementation of the principle of relativity, according to which the magnitude of the speed of light does not depend on the movement of the radiation source. At the same time, the fact that under the conditions of the laboratory frame of reference, classical mechanics gives the same result in terms of the speed of light as the special theory of relativity is ignored [4].

I propose to discuss the possible results of such an experiment, in which the conditions of inertial reference systems are satisfied. Let us place two resting light-conducting rods of the same length L in a fixed system so that they form a right angle. Let's direct one of the rods in the direction of the moving inertial system. At the ends of the rods we place reflective mirrors [2].

If at the same time light signals are sent along the rods from the point of contact of the rods, then after reflection they must simultaneously return to the starting point, without creating interference in the conditions of a fixed frame of reference. In a moving frame of reference, the speed of light is the same in both rods. The length of the rod located across the direction of motion of the system remains the same as in the fixed system - L. The rod located in the direction of motion of the system will have a length. $L' = L/\gamma$.

The light moving along the transverse rod will spend time $\Delta T = 2L/c$ in both frames of reference for movement in both directions, therefore$\Delta T' = \Delta T$. In a moving reference frame, the light will spend time $\Delta T_{//}' = 2L'/c = 2L/\gamma c$ to move in a parallel rod. Thus, in a moving reference frame, the time of arrival of the reflected signals at the meeting point is different. As a result, from the point of view of the observer associated with the moving frame of reference, interference should be observed.

In a fixed frame of reference, the absence of interference is a consequence of the experimental conditions and therefore is beyond doubt. Such a result directly excludes the possibility of observing interference from the point of view of any other frame of reference, including an inertial frame moving with a speed v. You can't see something that isn't there. In this case we are discussing a mental experiment, but its results are sufficient to conclude that the results of the Lorentz transformations are misinterpreted. In fact, there will be no reduction of sizes of the parallel rod and therefore the interference will not occur regardless of the frame of reference in which it is expected.

Thus, the Lorentz transformations transform the scales of units of space and time without changing the real sizes of measured objects and without influencing the course of temporal processes.

Discussion of results

I anticipate the objections of supporters of the traditional view of the results of the Lorentz transformations, who usually refer to the results of the Michelson-Morley experiments and to the substantial increase in the lifetime of relativistic muons as compared with their decay time at rest. These objections are easily dismissed by the following arguments.

The Michelson-Morley experiments were performed in air at atmospheric pressure. Air has a coefficient of light refraction not equal to one (n~1.00029) [6]. The speed of light in air does not depend on the direction of propagation and is determined by the formula $c_a=c/n$. Thus, Michelson's experiment was doomed in advance to failure.

The slowing rate of decay of relativistic muons is the result of a significant increase in their relativistic mass. The energy of cosmic muons is on the order of 10^{12}eV/c^2. This means an increase in their mass by four orders of magnitude. If the force that causes the muon to decay is unchanged, its decay time increases due to the relativistic increase in the mass of the muon fission products.

Lorentz transformations create the appearance of changing the scales of space and time in moving systems. This effect is achieved by introducing a relativistic factor in the transformation formulas, as a result of which the sizes of the units of measurement of the length of spatial objects and the course of time change. In reality, the sizes of spatial objects and the course of time in reference systems remain unchanged.

The independence of the course of time from the choice of reference system is a consequence of the coordinated motion of cosmic objects throughout the visible space. From the reasoning given in the second section of the work, it follows that time can be considered as a physical process covering the entire world space in which movement occurs, and which allows you to determine the measure of movement by comparing the movement of some objects with the movement of other objects. The course of the time process can be normalized by the stationary periodic motion of one of the moving objects. In this case, the rate of movement of other material objects can be expressed in units of measure of the movement of the object, through which we normalize the course of the temporal process.

References

1. Einstein. Zur Eiektrodynamik der beivegter Korper. Ann. Phys. 1905;17:891-921.
2. Sagnac MG. C.R. Acad. Sci 157-708; engl. - Sagnac G., The Luminiferous Ether is detected as a Wind Effect Relative to the Ether Using a Uniformly Rotating Interferometer, The Abraham Zelmanov Journal. 1913-2008;1:74. ISSN 1654-9163.
3. Sagnac MG. C.R. Acad. Sci 157 1410; engl. - Sagnac G., Regarding the Proof for the Existence of a Luminiferous Ether Using a Rotating Interferometer Experiment, The Abraham Zelmanov Journal, 1913;1:77. 2008, ISSN 1654-9163.
4. Malykin GB. The Sagnac effect: Correct and incorrect explanations, UFN. 2000;170(12):1325-1349.
5. Michelson, Albert Abraham, Morley Edward Williams. On the Relative Motion of the Earth and the Luminiferous Ether. American Journal of Science. 1887;3(203):333–345.
6. Edlén B. The Refractive Index of Air // Metrologia. — 1966, 71. ISS. 2. — Doi:10.1088/0026-1394/2/2/002.

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[2] This design is a variation of the Michelson interferometer [5].