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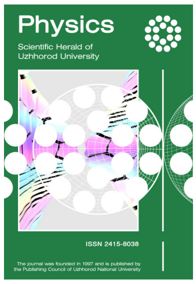

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Alternative Representation of Space and Time: Geometric Solution of Problems of Relativity Theory

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Abstract

Relevance. The relevance of the stated subject of this scientific research is due to the importance of theoretical issues of alternative representation of the categories of space and time from the point of view of developing geometric solutions to problems of relativity theory, which are important in solving numerous practical issues encountered in various fields of modern science and technology.

Purpose. The purpose of this research work is to form an alternative view of the categories of space and time, which are of significant practical importance for creating geometric solutions to problems that reflect certain principles of the theory of relativity.

Methods. The basis of the methodological approach to the construction of research works in this scientific study was a combination of a systematic analysis of the features of compiling an alternative representation of the categories of space and time with an analytical study of the features of constructing geometric solutions to problems that reflect various problematic aspects of the general theory of relativity.

Results. The results of this research work reflect the entire course of scientific research, and indicate the absence of contradictions in the very fact of the existence of alternative space-time models, as not meeting the fundamental principles of the special theory of relativity.

Conclusions. The results and conclusions of this research have significant practical significance from the point of view of forming new ideas about the provisions of the special theory of relativity and the possibilities of practical use of geometric models to solve complex problems of this theory, through the use of corrected ideas about the real properties of space and time, and are also of significant importance for employees of design bureaus engaged in the development of the latest samples of high-tech equipment and using the principles of special relativity in their calculations

Keywords: physical theories, space, geometric aspects, science, scientific concepts

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Introduction

According to numerous scientific publications concerning the role and place of the theory of relativity in the world scientific paradigm, there are many scientists who almost unconditionally accept this theory, without casting any doubts on it [1]. In addition, there are scientific studies that declare the very conditions of the problem statement to be far-fetched (over-idealized) and the possibilities of observing specific events, as well as the paradoxes that occur (in particular, the "clock paradox"), to be unrealistic. The concepts of "space" and "time" raise many questions, and the latter criterion attracts the most attention, becoming periodically the object of fierce disputes. The situation is eloquently illustrated by the thesis of Aristotle, who called time the most "unknown" of the entire unknown.

Numerous ideas about the attitudes of various ancient peoples and civilizations reach us today from the depths of centuries. In particular, of particular interest is the study of symbols conducted by the ancient Sumerians and devoted to the study of a six-pointed star [2]. From the Sumerian civilization, this symbol passed to Egypt, after which it came to the Jews, being now known as the "Star of David". In this context, it is noteworthy that the original interpretation of this symbol of two united equilateral triangles was the unity of three-dimensional space and the same three-dimensional time. The connection of space-time turns out to be six-dimensional!

The four-dimensional model of time and space, better known as the Minkowski model, by analogy with the three-dimensional space of classical physics, has an absolute character. In a way, the Minkowski spatial model can be regarded as an extrapolation of the absolute three-dimensional Euclidean space to an additional dimension [3]. Therefore, such criteria as uniformity and isotropy can characterize this space in four dimensions, if we do not take into account the boundaries set by the cone of light. In the SRT, space-time is passive, since not all bodies and fields have a counter effect on it, being located and moving in this space-time.

In the Minkowski space, concepts such as simultaneity or different timing of events are interpreted from the position of observers (for example: A and B), which move relative to each other [4]. To facilitate perception as much as possible, we will consider a straight horizontal line containing many objects at a particular time usually denotes a two-dimensional model of space-time, which lends to visual representation in the drawing plane, despite that one-dimensional space, and a straight vertical line denotes one-dimensional time. Lines that show the position of an object at certain time intervals are the trajectories of objects moving directly in space-time. Lines located at a certain angle of inclination display the trajectories of moving objects. At the same time, it should be taken into account that all events were located on the same horizontal line that occurred at the same time. Other events were on the same line that took place in the same place, located strictly vertically. All these geometric images are called world lines of the trajectories of moving and resting objects in space-time [5]. Any of the points of the world lines should be perceived as an event in space at a specific time interval.

The lack of geometric models for solving problems of relativity theory, capable of clarifying the issue under study, was the main problem of scientific research of alternative representations of space and time. This scientific research sets to expand alternative ideas about the properties of space and time, using a wide range of possibilities for solving problems of the theory of relativity by geometric methods.

Materials and methods

This research is based on the methodological approach, which includes an alternative systematic analysis of space and time and an analytical study of geometric solutions to problems reflecting various problematic aspects of the general theory of relativity. The study of the features of geometric solutions to problems reflecting the problematic aspects of general relativity involves the construction of graphical representations of various kinds of events that are important in the context of displaying the basic laws that affect the expansion of alternative representations regarding the parameters of space and time from the point of view of the principles of relativity theory.

The theoretical basis of this research work is numerous studies by Ukrainian and a number of international scientists that reflect various aspects of constructing geometric solutions to problems of relativity theory that are of significant practical importance in the context of the development of alternative ideas about the properties of space and time. Thus, the theoretical basis of this scientific work was selected and compiled in strict accordance with the stated topic and should contribute to its maximum qualitative disclosure.

This scientific research was carried out in several main stages.

At the first stage of this research, a theoretical study was carried out of available publications in Ukrainian and international sources devoted to the study of the properties of space and time in the context of the general theory of relativity, which generally contributes to a qualitative theoretical basis for further research. In addition, at this stage of scientific research, an alternative systematic analysis of space and time was carried out, which lays the groundwork for further scientific research and combined with the accumulated theoretical base.

At the second stage of this research, an analytical study was carried out of geometric solutions to problems reflecting various problematic aspects of the general theory of relativity. This study included graphical dependencies of different events that are important in the context of the main patterns affecting the expansion of alternative representations regarding the parameters of space and time from the point of view of the principles of relativity theory. In addition, at the second stage of this scientific study, an analytical comparison was carried out of the results obtained during it with the results and conclusions of other researchers on alternative ideas about the properties of space and time in the context of the general theory of relativity, which generally contributes to objective ideas about the results obtained in this scientific study.

At the final stage of this scientific research, during it, the conclusions were formulated based on the obtained results, acting as their logical reflection and summing up the entire spectrum of scientific research that was carried out in this work. The results of the study of alternative ideas about the properties of space and time through the geometric solution of the problems of relativity theory and the conclusions formulated on their basis can serve as a qualitative foundation to continue scientific research.

Results

The scientific study of the possibilities of forming alternative representations regarding the properties of the categories of space and time by creating geometric solutions to problems of relativity theory has resulted in the following.

When creating geometric solutions, special attention should be paid to the units of measurement used [6]. In particular, space is divided into equal segments that turn out to be multiples of the length nl_{Pl}. At the same time, time is divided into equal segments, which turn out to be multiples of the Planck time nt_{Pl}.

The travel speed of objects should be taken in parts of the speed of light ***c***. Because:

$$c = lPl/tPl, \tag{1}$$

then the value of the speed in two-thirds of the speed of light in the presented figures will have the form:

$$V = (2/3)c = (2\,nlPl)/(3\,ntPl). \tag{2}$$

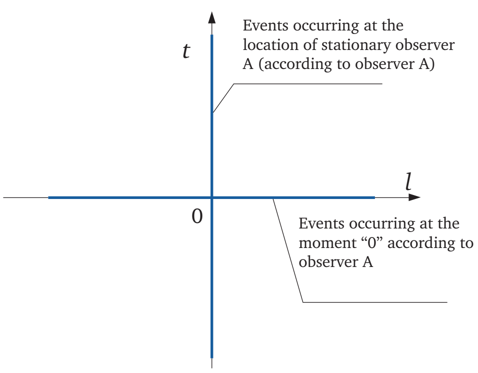

Figure 1. Two-dimensional space-time model
Source: developed by the author

Figures 2 and 3 show the trajectories of objects represented as inclined lines. Simultaneously occurring events are reflected on the horizontally located straight line, while events that occurred in the same place are spread out on the vertical straight line.

When the observer B is moving at a speed V=(2/3) c from the distance between points 0 and K_b will be the value Δ_B when B meets with the observer A, as shown in Figure 4. Also, it follows from this figure that all linear dimensions will not be identical of the system of moving observer B (in the direction of movement), in projection onto the space of stationary observer A, (the projection of the linear size of the moving system $(t_B;l_B)$ on the stationary one $(t_A;l_A)$ must uniformly decrease) because the linear dimensions of stationary observer A will be significantly smaller than the actual ones for moving observer B. A comparison of calculations of relativistic reduction of lengths and simple geometric parameters do not provide full and equivalent values Δ_A (distance from 0 to K_A).

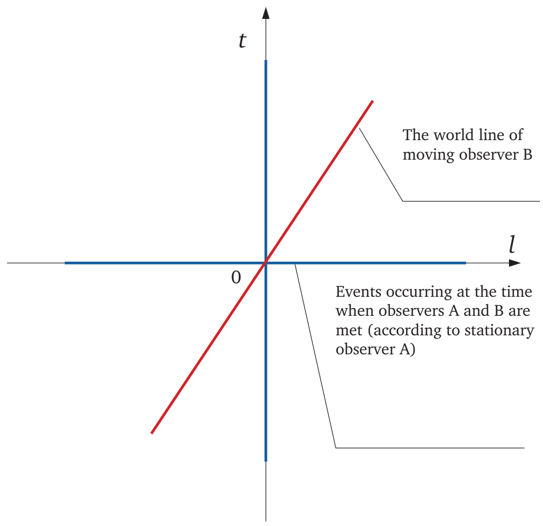

Figure 2. The inclined line is the trajectory of objects
Source: developed by the author.

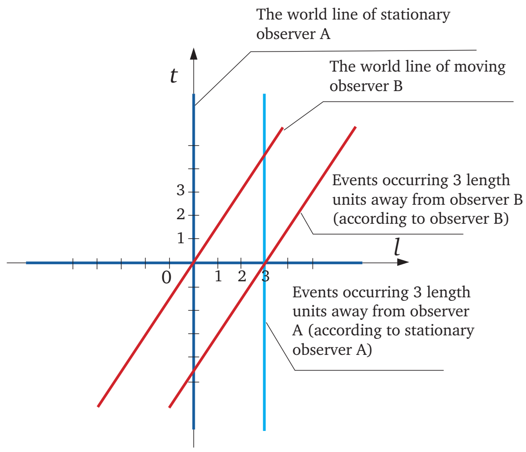

Figure 3. The inclined line is the trajectory of objects
Source: developed by the author

The laws of physics apply equally in all systems where rectilinear and uniform motion takes place. For this reason, the system of observer B should be considered as stationary. In such a state of affairs, the world line of moving observer B coincides in the system of stationary observer A with the time axis in the system of observer B (as shown in Fig. 4), and the spatial axis is perpendicular to the time axis.

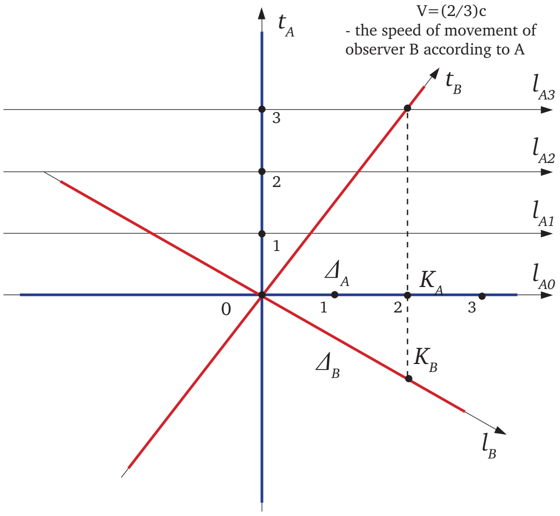

Figure 4. Coincidence of axes and observation systems A and B
Source: developed by the author

Figure 5 shows the movement of observer B relative to the location of observer A with the same velocity V=(2/3) c. The front of a flash of light displays the passage of time on the plane; within one plane it has the form of concentric circles, the radius of which is equal to

$$R\,n = R\,n - 1 + 1\,tu, \qquad (3)$$

and the center is located at the reference point 0, which simultaneously acts as the beginning of measurements and the meeting point. Since $c=l_{Pl}/t_{Pl}$ and any of the units of length is a multiple of the Planck length in Figure 5, and the unit on the conditional axis of time (radius of the sphere) is a multiple of the Planck time, then graphically it is necessary to mark the same single segments on the axes of length and time values.

The location of the world line of the observer B in motion is completely superimposed on the conditional time axis, so this world line passes directly through the point of contact of the two observers O, as well as the point T_B. The latter indicates the place where observer B is located, moving relative to observer A at a speed of V=(2/3) c, after passing two units of length in 3 units of time since their meeting.

Figure 5 can be modified somewhat by moving the center of the coordinate system of observer B to the center of the coordinate system of observer A, as shown in Figure 6. Such a combination does not change the essence of the matter at all, while simplifying the understanding of the situation [7]. From the data presented in Figure 6, it follows that observer A will be at point T_{AB} when observer B (in his opinion) will be at point T_B. In other words, the events T_{AB} and T_B do not differ in time at all for observer A. For observer B, the events T_B and T_{BA} occur simultaneously. Events L_A and L_B occur at the same time and spatial distance for observer A.

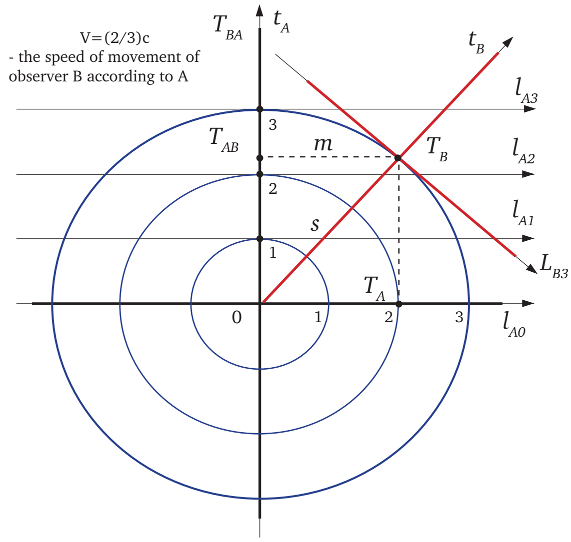

Figure 5. Moving observer B relative to the location of observer A
Source: developed by the author

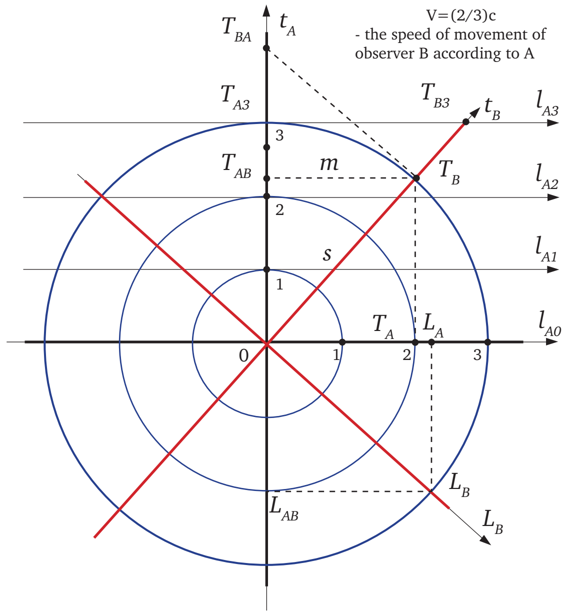

Figure 6. Combining the centers of the coordinate systems of observers A and B
Source: developed by the author

Geometric transformations according to Figure 6 have the following form:

$$V = \frac{2}{3}c = \frac{m}{s}c; \quad (4)$$

$$t = s = \frac{m}{V}c; \quad (5)$$

$$l = m = \frac{Vs}{c}. \quad (6)$$

Consider geometrically identical triangles $\Delta\ OT_{AB}\ T_B$ *and* $\Delta\ OL_A\ L_B$,

$$\Delta OT\ AT\ B\ and\ \Delta\ OL\ AB\ L\ B. \quad (7)$$

Because

$$|OL\ A/=/L\ AB\ L\ B|, \quad (8)$$

that

$$|OLA| = \sqrt{|OL_B|^2 - |OL_{AB}|^2} = \sqrt{s^2 - m^2} \quad (9)$$

$$|OL\ A| = \sqrt{3^2 - 2^2} = 2{,}236\ units, \quad (10)$$

This corresponds to the linear parameters in Figure 6 and the relativistic reduction of the longitudinal linear dimension in a dynamic system (from the position of a static observer A).

After converting formula (9), the right part is substituted into it, under the value of the root $(V = \frac{m}{s}c)$:

$$|OLA| = \sqrt{(\frac{m}{V}c)^2 - (\frac{Vs}{c})^2} = \sqrt{\frac{m^2c^2}{V^2} - \frac{V^2s^2}{c^2}} = \sqrt{\frac{m^2c^2s^2}{m^2c^2} - \frac{V^2s^2}{c^2}} = \sqrt{s^2 - s^2\frac{V^2}{c^2}} = \sqrt{s^2(1 - \left(\frac{V}{c}\right)^2)} = s\sqrt{1 - \left(\frac{V}{c}\right)^2} \quad (11)$$

As a result, we have the formula:

$$|OLA| = s\sqrt{1 - \left(\frac{V}{c}\right)^2}. \quad (12)$$

This formula is identical to the formula of the special theory of relativity obtained to describe the relativistic effect of reducing the longitudinal linear parameters of a moving system from the position of an observer at complete rest.

The presented logic of scientific research is applicable to calculate the deceleration rate of the running clock. If we assume that moving observer (Fig. 6) B will not be able to change the work of its watches in point T_B, but can see the acceleration of watches of static observer A directly at the point of its stay T_{BA} (as events T_B and T_{BA} occur in one and the same time from the perspective of observer B). At point T_{A3}, static observer A will be able to note an increase in the clock speed of observer B at point T_{B3} (since both events T_{A3} and T_{B3} take place at the same time, from the position of static observer A). Everything is logical, due to the inertia of the systems under study and the similarity of the flow of all physical processes that take place in them [8].

The course of the clock can be output as follows, according to the data presented in Figure 6:

$$|T\ ABT\ B| = m; \quad (13)$$

$$|OT\ B| = s = tA; \quad (14)$$

$$|OT\ AB| = t\ B; \quad (15)$$

Consider similar triangles $\Delta\ OT_{AB}\ T_B$ and $\Delta\ T_B\ T_{AB}\ T_{BA}$, for which the following algebraic relations can be considered valid:

$$|OT\ AB| = \sqrt{s^2 - m^2}, \quad (16)$$

$$\frac{|T_{AB}T_{BA}|}{|T_{AB}T_B|} = \frac{|T_{AB}T_B|}{|OT_{AB}|}, \quad (17)$$

$$|T_{AB}T_{BA}| = \frac{|T_{AB}T_B||T_{AB}T_B|}{|OT_{AB}|} = \frac{m^2}{\sqrt{s^2-m^2}}, \quad (18)$$

$$|OT_{BA}| = |OT_{AB}| + |T_{AB}T_{BA}|, \quad (19)$$

$$|OT_{BA}| = \sqrt{s^2 - m^2} + \frac{m^2}{\sqrt{s^2-m^2}} = \frac{1}{\sqrt{s^2-m^2}}(s^2 - m^2 + m^2) = \frac{s^2}{\sqrt{s^2-m^2}}. \quad (20)$$

All substitutions and abbreviations are performed in strict and complete accordance with the previous calculation:

$$\frac{s^2}{\sqrt{s^2-m^2}} = \frac{s^2}{s\sqrt{1-\left(\frac{V}{c}\right)^2}} = \frac{s}{\sqrt{1-\left(\frac{V}{c}\right)^2}} = \frac{t_A}{\sqrt{1-\left(\frac{V}{c}\right)^2}}. \quad (21)$$

The result will be a formula for the sequence of relativistic deceleration of the clock mechanism:

$$t_B = \frac{t_A}{\sqrt{1-\left(\frac{V}{c}\right)^2}} \quad (22)$$

Thus, the fundamental principles of special relativity in the context of creating an alternative space-time model work and can be clearly demonstrated. This fact testifies to the fundamental possibility of creating an alternative model of the space-time characteristics of a physical object that does not conflict with the principles of special relativity. This is extremely important from the point of view of understanding space-time relationships and contributes to a general improvement in the understanding of modern concepts of constructing alternative models of space and time for their use to assess the quality of physical processes occurring in various spheres of modern scientific and social life.

Discussion

The invariance of the well-known equations of electrodynamics in relation to a specific group of transformations should be in constant, close connection with the various characteristics of transformations of partial differentials of the parameters of space and time. In the event that a connection of this kind will have observable consequences, then they can be expressed in certain problems of electrodynamics of bodies in a state of constant motion, despite the fact that the radiation source, the receiver, the interface of the media, as well as the media themselves move at very different speeds. In this context, there is a substantial interest in the experimental verification of the electrodynamic equations in the two- or three-dimensional case of displacements in the medium, taking into account the dispersion parameters [9].

Now, there are enough theories that are not at the forefront of modern science, moreover, today science has grown so much that millions of scientists are not able to fully grasp and comprehend it. Not all scientific questions have answers, even though science can put forward one answer option for the public and at the same time have several spare ones that determine the directions of subsequent scientific research in the future. At the same time, the public often does not realize that there are secondary answers to well-known questions that are available to the attention of the public [10].

Concerning the provisions of the Minkowski model, which represents the speed of light in the form of the world line at an angle of 45°C to the abscissa axis and the boundary of a space-time cone, in an alternative representation to this concept, the world line of a ray of light coincides with the line of one-dimensional space specifically at the origin emanating from the point of residence of a stationary observer at time $t=0$. In other words, this line goes directly through the origin of the observer's coordinate system and the point with the initial coordinates. This confirms the thesis that there is a connection of a photon exclusively with time, but by no means with space [2]. At the same time, it should be taken into account that time flows evenly for a static observer in an alternative model. For an observer who is in a dynamic state, when he moves in the direction from the observer who is at rest, time flows evenly, and when moving to a resting observer, such uniformity is lost. This allows a static observer to conclude that the object is gradually accelerating as it moves towards him.

Any event can be a logical consequence or cause of another event taking into account a time interval for the signal to pass between two given events. In particular, when the light is turned on at a distance of three magnitudes of length from a static observer, the movement of this light signal will take exactly three units of time, and this signal will be visible to the observer no earlier than through these three-time units. Until the time interval expires, the observer will be unaware of the very fact of turning on the light source [11].

In science, the temporal concept exists in close relationship with the principle of causality, which is used to order causal events within a certain period. In a substantial to temporal concept, a certain, previously established order acts as a primary factor and is introduced as a separate, independent postulate. Within the limits of the relativistic concept, for the consistent definition of a given temporal order, it is not the fact of establishment itself that is accepted, but the "fundamental possibility of establishing" a causal relationship between subjects and phenomena in the time field.

Since causes precede the effects in all situations, it becomes quite obvious that an introduction and an expanded understanding of the so-called temporal order is required to determine a given order of occurrence of the cause. At the same time, a strong connection should be taken into account between spatial and temporal characteristics. There is a close connection between these characteristics and the causal characteristic [12]. At the same time, for the entire temporal order, the concept of time in the present refers to the entire space, while in the causal aspect; the term "present" will refer to the event and its consequences. In this context, it is possible to formulate and suggest that in order to obtain objective and maximally complete information about the event and the nature of its course; it is not enough just to expect a signal (coming from the event-cause). To do this, a static observer should recognize information, relative to whom all phenomena occur in the system of its measurement: to send a signal to an event with a high probability of its return, or to agree in advance on the use of a certain system of signals from the observed system.

In particular, to determine the exact distance of the mirror from the observer, it is enough to direct a beam of light to a certain point, after reflection from which the beam will return and the time of its movement will become the estimated time of the experiment. It is necessary to pay attention to the fact that there is a coincidence of the world line of the beam velocity with the speed of light with the main spatial axis. From the point of view of the cause, it is not possible to obtain any information about the ray of light until it meets the observer [13]. Only after this meeting, it becomes possible to control the speed of movement of the light beam from the point of direction to the end.

Obtaining objective information about the nature of the relationship between spatial and temporal characteristics requires a certain amount of time, and its duration depends both on the speed of information dissemination and on the final location of the event. Any information that can be obtained by observing space-time relationships determines the results that can be obtained only if all experimental conditions are met, and these results are in full accordance with the basic postulates of the special theory of relativity.

In modern conditions, the search for new and discussion of existing, well-known consequences of the special theory of relativity, in particular, such as the search and propagation of gravity waves, the reflection of electromagnetic waves by objects of large size, and other consequences that have a significant impact on the resolution of problems of astrogation, can be manifested in various aspects of the influence on the processes of electromagnetic radiation propagation on the scale of space objects and should be taken into account when forming a more accurate space-time interpretation of events [14].

To date, there is a development of the trend of practical application of the principles of special relativity in various fields of science and technology, in particular, in electrodynamics and other scientific disciplines directly related to the theory of the electromagnetic field. In addition, this circumstance largely causes an increase in interest in conducting experimental verification of the basic equations of electrodynamics with different characteristics of the motion of media and in systems with different numbers of measurements. From the point of view of obtaining the possibility of conducting such experiments, in the very near future we should expect the identification of optimal spatio-temporal characteristics in terms of improving the quality of such experiments and the possibility of practical solutions with their help to actual problems of modern science and technology.

Various theories representing the categories of space and time and giving concrete ideas about their properties and most important characteristics contribute to the emergence of many physical interpretations of the true nature of these quantities [15]. The situation radically changes from the subjectivization of the parameters under consideration to the recognition of space and time as a fundamental category of any matter. To date, no scientific discipline, be it philosophy, physics, chemistry or higher mathematics has formed and presented clear definitions regarding the essence of the concepts of space and time and their physical meaning. Despite all these scientific disciplines, like many others, widely use these concepts. It should be noted that today the concepts of space and time play such an important role in the process of modern physical cognition that there is no such physical process that could be described qualitatively without the use of these categories. All scientific disciplines that exist today always strive for the highest quality representation of meaning, therefore, the importance of displaying the physical meaning of the concepts of space and time will not lose relevance in the context of the formation of new and interpretation of old scientific postulates [16].

The space-time characteristics indicated in Minkowski's research are only physical images, physical and mathematical concepts that are devoid of the properties of objective reality. The basic provisions of the geometry of real space and time can be determined by the characteristics of the motion of matter, as well as the entire spectrum of interaction of a material nature. Since the main characteristic of the space-time continuum is the ability to move, various variations of movement, as well as interactions of a purely material nature, determine a set of certain space-time characteristics [17]. For example, the so-called Minkowski space qualitatively reflects the metric characteristics of time and space, which can be caused by interactions of the electromagnetic order.

Within the framework of special relativity, the categories of space and time can be expressed as "pseudo-Euclidean diversity". Such a circumstance determines one of the fundamental differences between temporal and spatial coordinates. This is the Lorentz translation invariance of time and space. From this circumstance, the fundamental effects of the special theory of relativity directly follow, such as the relativity of length and duration, and the relativity of the simultaneous flow of various events occurring at different points in space [18].

It is appropriate to note the prevailing interpretation of the status of the property of space and time in modern relativistic physics. The principles of the special theory of relativity affirm the physical meaning of the interval of space and time, while essentially performing the opposition of the relative nature of the intervals of time and space in their constant connection with motion. Considering the greatest value of the speed of light as the limiting speed of any physical interaction, this theory has clearly demonstrated that any cause-and-effect relationships between physical phenomena and quantities cannot be realized without establishing the dependence between various aspects of the coordination of these physical quantities in the space-time field [19]. The connection between any two events can be established only if the light radiation between them passes a greater distance than there is a geometric distance, or passes a similar distance. In all other cases, these two events cannot be considered connected by a spatio-temporal connection, since excessively large distances between them and moments of the message should be taken into account.

Conclusions

The conducted scientific study of alternative ideas about the characteristics of space and time from the point of view of the fundamental principles of comparative relativity theory led to the following conclusions.

An alternative model of ideas about the properties of space-time acts as a model of a private subjective substance "observer-space-time", which includes the observer as an integral part of the general model. At the same time, there is an inextricable connection between alternative ideas about the space-time continuum and the absolute space-time, which is in a state of constant expansion, where, in the presence of a three-dimensional Euclidean space, the absolute parameter of time has an isotropic, one-dimensional characteristic and any spatial point different from others retains the same characteristic of time at every moment. At the same time, the existence of an alternative space-time continuum begins immediately at the beginning of the experiment, since in this context there is a control of current events, subject to the creation of a preliminary agreement on options for obtaining information about events that have already occurred or without it, which affects the quality of the final information. Alternative ideas about the properties of space and time do not exclude the simultaneous existence of the past and the present. At the same time, the three-dimensionality of the time parameter determines its causal nature and close relationship with the temporal nature of the categories of space and time.

The light beam moving from the observer has no connection with time, it is connected exclusively only with space. When moving towards the observer, his connection with time is also evident. Time is anisotropic, as well as alternative space-time. All cause-and-effect relationships proceed with strict reference to time, since from the event that is the cause to the event that is the consequence, information is transmitted uniformly, at the same speed. With the described variant of obtaining information, it is not possible to notice any changes in the development of events around the observer. Instantaneous conclusions about remote events give results that are absolutely consistent with the principles of relativity theory. The model clearly demonstrates the geometry of space-time, as well as the cause of such information distortions.

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Альтернативна репрезентація простору та часу: геометричне розв'язання задач теорії відносності

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Анотація

Актуальність. Актуальність даного наукового дослідження зумовлена важливістю теоретичних питань альтернативного представлення категорій простору і часу з точки зору розробки геометричних розв'язків проблем теорії відносності, які є важливими у вирішенні багатьох практичних проблем, що виникають у різних галузях сучасної науки і техніки.

Мета. Метою даної роботи є формування альтернативного погляду на категорії простору і часу, що мають важливе практичне значення для створення геометричних розв'язків проблем, які відображають окремі принципи теорії відносності.

Методи. В основу методологічного підходу до побудови дослідницької роботи в даній науковій праці було покладено поєднання системного аналізу особливостей складання альтернативного представлення категорій простору і часу з аналітичним дослідженням особливостей побудови геометричних рішень проблем, що відображають різні аспекти загальної теорії відносності.

Результати. Результати даної дослідницької роботи відображають весь хід наукових досліджень і свідчать про відсутність протиріч у самому факті існування альтернативних просторово-часових моделей, як таких, що не відповідають фундаментальним принципам спеціальної теорії відносності.

Висновки. Результати та висновки цього дослідження мають важливе практичне значення з точки зору формування нових уявлень про положення спеціальної теорії відносності та можливості практичного використання геометричних моделей для вирішення складних проблем цієї теорії шляхом використання відкоригованих уявлень про реальні властивості простору і часу, а також мають важливе значення для співробітників конструкторських бюро, які займаються розробкою новітніх зразків високотехнологічної продукції і використовують у своїх розрахунках принципи спеціальної теорії відносності

Ключові слова: фізичні теорії, простір, геометричні аспекти, наука, наукові концепції