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Experimental Confirmation of the Hypothesis about the Physical Essence of Time

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Abstract

The results of an experimental verification of the hypothesis about the physical essence of time as the traveled distance of the three-dimensional space of the expanding Universe in the direction of the orthogonal fourth spatial dimension are presented.

Keywords

Physical Essence of Time, Expansion of the Universe, The Speed of Light

1. Introduction

The question of the physical essence of time is one of the most difficult in modern physics, which does not have an unambiguous answer. "Time is the most unknown of all unknown things," said the Greek philosopher Aristotle. Little has changed since then. In modern theories, time is considered one of the components of a four-dimensional space-time, but time is always distinguished from spatial components [1]-[3]. In A. Einstein's theory of relativity, there is no universal time at all; every object moving or located in a powerful gravitational field can have its own speed of flow [4]-[6].

In [7], a hypothesis was formulated that gives a clear definition of the physical essence of time as the displacement of the three-dimensional space of the Universe in the direction of the orthogonal fourth spatial dimension. Giving all the axes of four-dimensional space-time a space-like character was allowed by Einstein [2] [8], but the idea did not receive further development.

The consequences of this hypothesis do not contradict any modern scientific position and provide explanations for phenomena that currently have no indisputable scientific explanation. The hypothesis explains the abnormally high temperature of the solar corona and the isothermicity of its plasma; the existence of the solar wind, explains the effect of time dilation in strong gravitational fields, allows us to derive an analytical expression for the Hubble constant, and explains the inflationary expansion of the Universe in the early stages of its appearance [7] [9] [10]. The formulated hypothesis makes it possible to explain the red shift of radiation from distant objects without involving the Doppler effect, which makes it possible to abandon the hypothesis of the apparent accelerated expansion of the Universe and eliminate the need to introduce such a new and inexplicable entity as dark energy into physics [7] [11]-[13].

One of the consequences of the hypothesis is the conclusion that the propagation speed of radiation with a large red shift is low. The most important feature of the hypothesis is the possibility of experimental verification of this position. Previous experiments with cosmic microwave background radiation and radio emission from the Sun have confirmed the existence of the hypothesis [14] [15]. The purpose of this work is to find new evidence of its validity.

2. The Speed of Propagation of Radiation with Red Shift

Currently, three types of radiation frequency red shift are known: cosmological due to the general expansion of the Universe, gravitational in strong gravitational fields, and Doppler due to the motion of objects relative to each other. It is obvious that when objects run away, the wavelength increases due to an increase in the distance between them at the Doppler red shift and due to the general expansion of space at the cosmological red shift. According to the general theory of relativity, the gravitational red shift occurs due to the different speed of time at the point of emission of radiation and at the point of its reception in the presence of a difference in gravitational potentials [5] [16].

Within the framework of the formulated hypothesis, these three types of red shift are also possible, including those acting simultaneously, but they, with the exception of the Doppler effect, have a different explanation. The cosmological red shift receives an additional shift due to the different orientations in four-dimensional space of vectors orthogonal to three-dimensional space at the points of emission of radiation and its reception, and the gravitational shift is fully explained by the different orientation of these vectors relative to the direction of expansion of the Universe, and hence the speed of time at the points of emission of radiation and its reception [16].

An additional consequence of the formulated hypothesis is a decrease in the propagation speed of red-shifted radiation compared to the speed of light at the point of their formation. The cosmic microwave background radiation has one of the largest cosmological redshifts, and the Sun can serve as an example of a source of gravitational redshift of cosmic origin. Both of these assumptions have been experimentally confirmed in the course of the conducted studies [14] [15]. The low rate of radiation propagation does not contradict the provisions of modern science, because the speed of light in the framework of the general theory of relativity should vary depending on the curvature of space [2].

According to the hypothesis, the rate of radiation propagation is interrelated with its red shift; therefore, a low rate of neutron star radiation propagation should be expected, providing a very large gravitational red shift due to the significant inclination of closely spaced regions of three-dimensional space relative to the direction of its expansion due to the small size of the star with a very large mass. Experimental verification of this assumption is possible because not far from the solar system, according to cosmic standards, there is one of the most powerful sources of radio emission in our Galaxy at frequencies above 1 GHz—the radio source Cassiopeia A (Cas A), which is the remnants of a supernova outbreak with a neutron star in the center [17].

3. Methodology, Equipment, Conditions, and Results of the Experiment

Earlier, during experiments, an original technique for measuring the propagation speed of radiation with a large red shift was developed, based on the difference in speeds before and after reflection from the mirror of a parabolic antenna [14]. After reflection, the induced radiation propagates from the metal surface of the mirror to the antenna irradiator at the speed of light almost instantaneously, and the incoming radiation reaches the surface with various delays, which makes it possible to determine the propagation speed based on the time of signal correlation.

For the experiment, a parabolic mirror offset antenna with a width of the main lobe of the antenna directivity pattern (ADP) of 1˚ and receiving equipment with an analysis band of 1 GHz in the atmospheric transparency range of 12 GHz were used.

The constellation Cassiopeia can always be observed at latitudes above 34˚ in the northern hemisphere; therefore, the antenna was installed permanently, with the orientation of maximum ADP to the north, at two tilt angles: 78.5˚ and 16˚.

The duration of the signal sampling was 0.5s with a duty cycle of 12. The measurements were carried out for 15 to 30 minutes when the Cas A radio source passed through the main lobe of the ADP. The autocorrelation function (ACF) $\psi(\tau)$ was averaged over 30 - 60 half-second samples of the signal. Control measurements of the ACF of clear sky noise were also carried out for one hour before and after the passage of the radio source.

Based on the results of previous studies [14] [15], measurements were carried out at different cloud densities, which affect the refraction of the trajectory of radio waves, and hence the length of the path to the antenna in the atmosphere.

Figure 1 shows, as a reference, the ACF of the received signal of a clear sky with a calm atmosphere for 60 minutes after the radiation source Cas A passes the main lobe of ADP and at an elevation angle of the maximum of ADP equal to 78.5˚ relative to the horizon.

When a radio source passes through the ADP, the ACF of the signal changes significantly. **Figure 2** shows the average values of the ACF of radiation of the

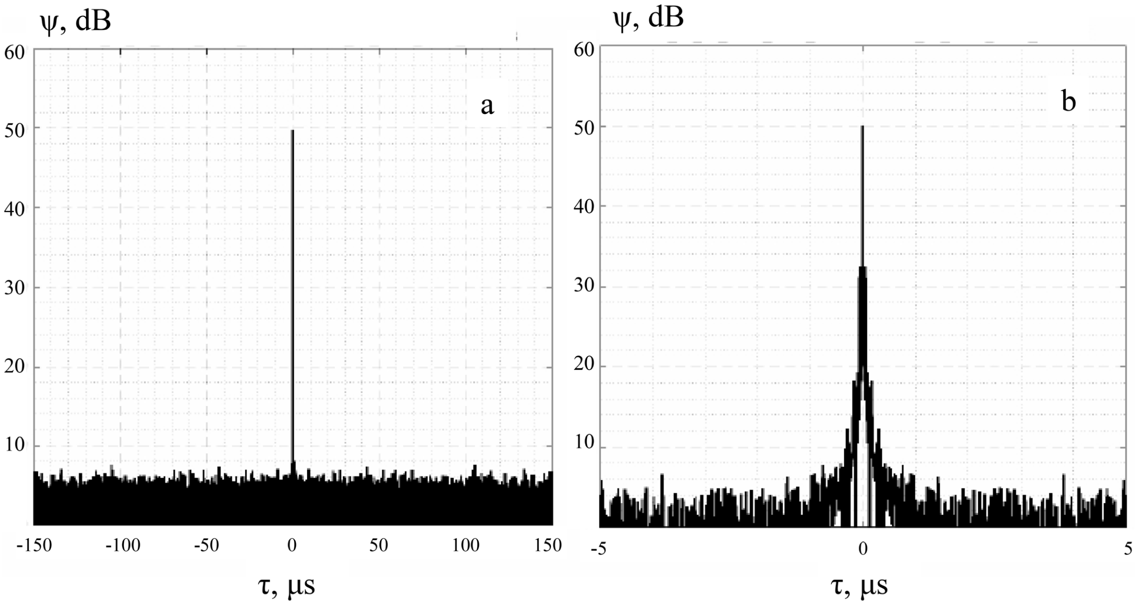

Figure 1. ACF $\psi(\tau)$ of the received signal of a clear sky with a calm atmosphere.

neutron star Cas A at different cloud densities as it passes through the maximum of ADP.

Assuming that only rays that do not experience significant refraction in the atmosphere enter the main lobe of the diagram whith cirrostratus clouds, based on Figure 2(a) it can be concluded that the correlation time of these signals does not exceed 1 μs, which, with the maximum possible beam path difference of 0.87 m for the antenna used [14], corresponds to their propagation speed for 870 km/s. The obtained value is approximate due to the relatively rapid movement of the radio emission source and rapid uncontrolled changes in cloud density and atmospheric turbulence, as well as the impossibility of a long period of ACF averaging due to the lack of a tracking antenna system.

However, another effect was discovered during the experiment, which allows us to measure the propagation speed of radiation in a different way. It is important to note that further experiments were carried out at an elevation angle of the maximum ADP of 16˚ relative to the horizon in clear weather.

Figure 3(a) and Figure 3(b) show the ACF of the received radiation with a difference of 4 minutes and 80 minutes before the passage of Cas A through the ADP, when it was approximately 20˚ west of its maximum. As can be seen in the figures, the unexpected peaks of ACF gradually move away from the initial position of $\tau \approx 50$ μs towards higher values and disappear approximately 60 minutes before the maximum of the ADP passes.

However, approximately 20 minutes before the passage of Cas A through the maximum of ADP, ACF peaks occur again at a delay time of $\tau \approx 9$ μs , as shown in Figure 4(a) and Figure 4(b), displaying ACF with a difference of 19 minutes. Approximately 5 minutes after passing the maximum, the peaks gradually disappear too.

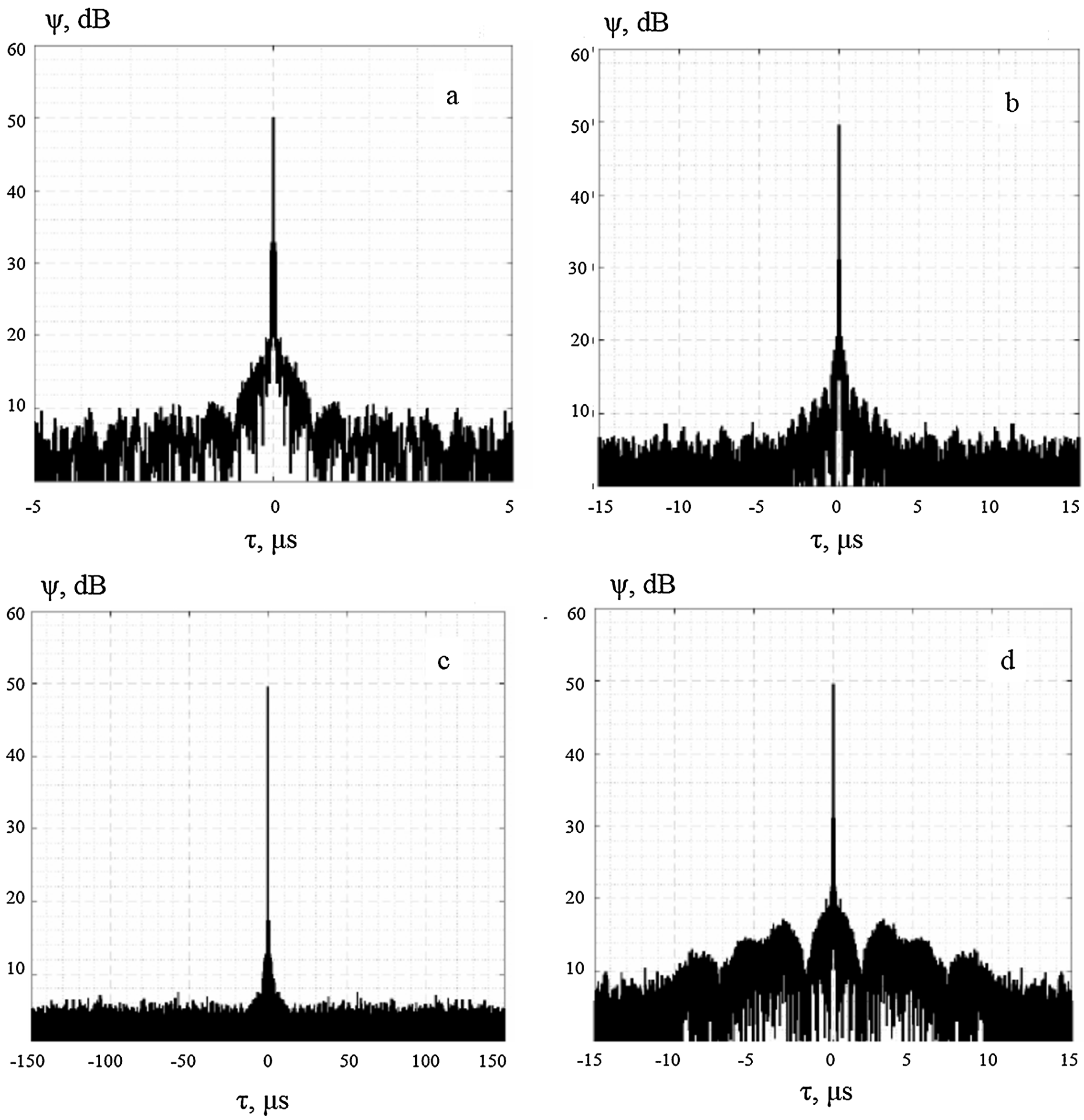

Figure 2. ACF $\psi(\tau)$ of radio emissions of Cas A with cirrostratus clouds (a), altocumulus clouds (b), and stratocumulus clouds (c), (d).

An analysis of the possible sources of additional ACF peaks has shown that the cause is bi-ray propagation radio waves due to the small elevation angle of the maximum ADP [18] [19]. Indeed, the receiving antenna is located at a height of 57 m, and below 35 - 45 m in the line of sight, there are inclined roofs of nearby buildings, which are the points of reflection. The first roof, at an average distance of 160 m, is oriented from north to south and has a length of 45 m, while the second, at a distance of 130 m and a length of 55 m, is oriented from west to east. Both roofs are located west of the antenna's line of sight, so the beam path difference increases as the Cas A moves from west to east.

The distances and viewing angles of possible re-reflection points were measured, and the differences in the course of the direct and reflected beam for each

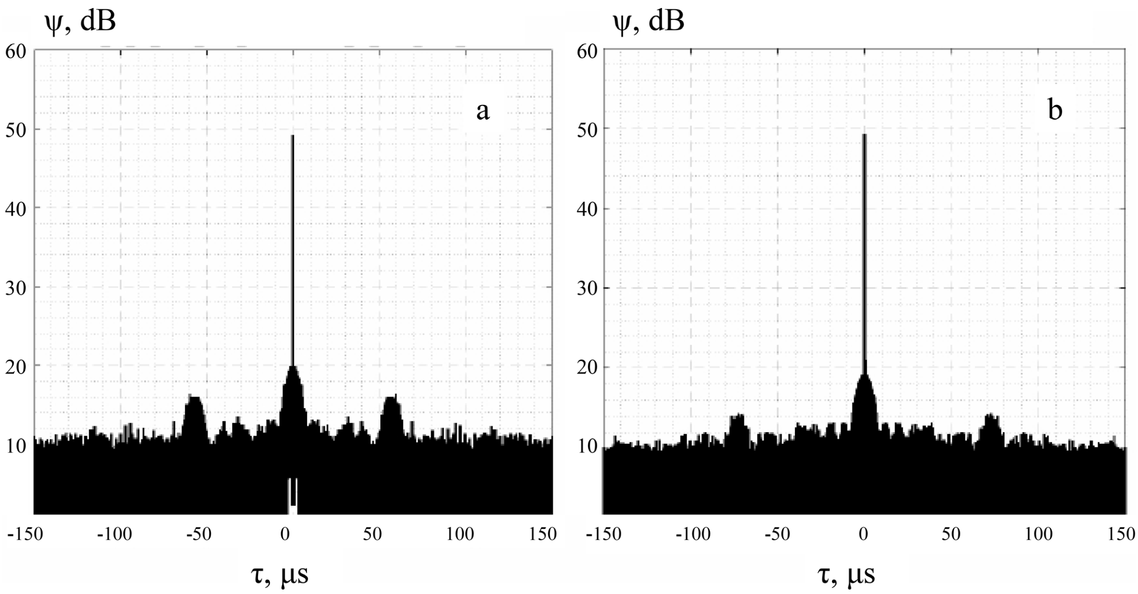

Figure 3. ACF $\psi(\tau)$ of the radio emission of Cas A for 80 minutes (a) and 76 minutes (b) before passing the main lobe of ADP.

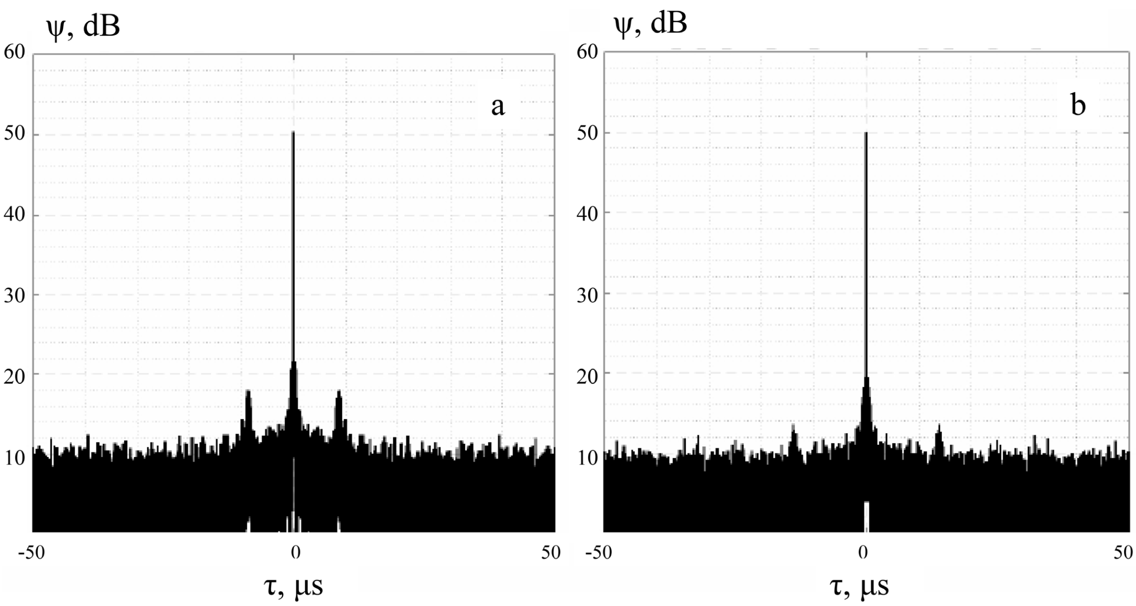

Figure 4. ACF $\psi(\tau)$ of the radio emission of Cas A for 20 minutes (a) and 1 minute (b) before passing the main lobe of ADP.

position of Cas A were calculated at the moment when the detected additional signals hit the side lobes of the ADP.

The position of the additional peaks shown in Figure 3(a) corresponds to a beam travel difference of approximately 42 m, and the position shown in Figure 4(a) corresponds to a travel difference of 9 m. With a delay time of 55 μs and 9 μs, respectively, this corresponds to a propagation speed of 764 km/s and 1000 km/s. The different widths of the ACF peaks can be explained by the different spatial orientation of the reflecting surfaces.

The method of measuring the speed of radio emissions using bi-ray propagation also does not provide high accuracy, since it is difficult to accurately determine the point of re-reflection of the signal, and the influence of atmospheric phenomena and many other factors is great. However, the results obtained in two different ways (870 km/s, 764 km/s, and 1000 km/s) suggest that the expected low rate of propagation of neutron star radio emission is at least two orders of magnitude lower than the accepted value of the speed of light, which confirms the hypothesis about the physical essence of time.

Of course, the received radiation cannot be the radiation of the neutron star itself. The supernova broke out 300 years ago for an Earth observer and is located at a distance of 11,000 light-years [17]. Therefore, the radiation received, propagating at a speed of 1000 km/s, was emitted more than 3 million years ago by the progenitor of the neutron star. This is also evidenced by the relatively small difference in the propagation speeds of radio emission from the Sun and from Cassiopeia A. The source of the radio emission was probably a supermassive star in the active phase of development before the explosion.

As an example of the influence of atmospheric fluctuations, we can cite the ACF of the radio emission of Cas A at the maximum of ADP with high atmospheric turbulence in absolutely clear weather, shown in **Figure 5**.

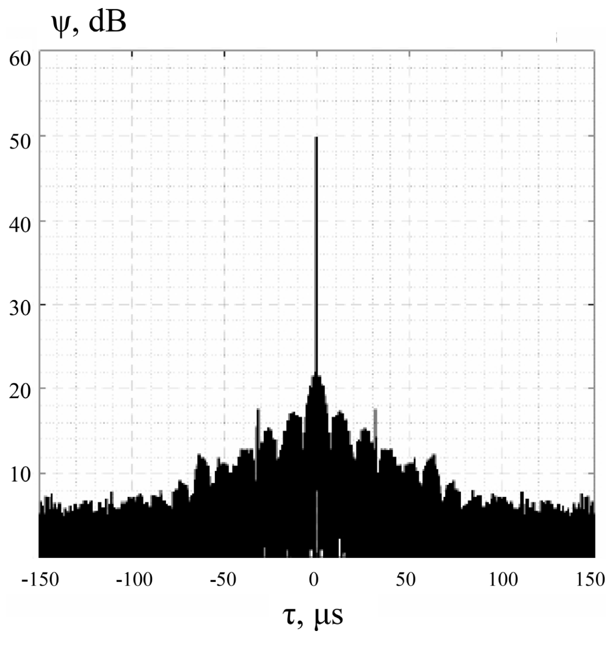

Figure 5. ACF $\psi(\tau)$ of radio emission of Cas A during the passage of the maximum ADP in a turbulent atmosphere.

Due to the low speed of propagation of radiation, the ACF expands to $\tau \approx 100\ \mu s$, which at a speed of light of 300,000 km/s would correspond to an unrealistic beam path difference of 30 km. It should also be noted that due to numerous refractions, some of the rays are re-reflected from the more distant of the two possible points, causing an ACF peak near the delay of $\tau \approx 60\ \mu s$ (**Figure 5**), as shown in **Figure**

3(a).

The low rate of propagation of radio emission from the supermassive progenitor of a neutron star suggests that radio emission from black holes is also possible. This radiation should have an extremely large red shift and an extremely low propagation speed, comparable to the speed of cosmic microwave background radiation, *i.e.*, it is possible that Stephen Hawking called the evaporation of black holes [3] [20] [21].

4. Conclusions

The experiments carried out confirmed the prediction of the hypothesis put forward about the low speed of propagation of radiation with a large red shift, which confirms the validity of the hypothesis about the physical essence of time.

The expected low rate of propagation of radio emission from the supermassive progenitor of a neutron star located relatively close in our Galaxy turned out to be 750 - 1000 km/s. As a result of a series of previously conducted experiments, the speeds were obtained from 123 km/s for cosmic microwave background radiation to 3500 km/s for solar radio emission. Thus, the propagation speed of cosmic radio emissions can be two to three orders of magnitude less than the accepted value of the speed of light.

In accordance with the predictions of the hypothesis, the rate of radiation generated in free space in the absence of significant masses of matter bending space reaches maximum values, and these possible values increase with the expansion of space, *i.e.*, over time. Therefore, the speed of light is the limit for a given point in space, but it is not a fundamental constant and can be either less than or significantly greater than 300,000 km/s.

Author Contributions

V. A. Tokarev: the idea and theoretical justification for the experiment; design and construction of the experimental setup; conducting the experiment; interpreting the experimental results; writing the article. G. I. Kuleshov: conducting the experiment; performing calculations of the autocorrelation function of the received signals.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Newton, I. (1989) Mathematical Principles of Natural Philosophy (Translated by Krylov, A.N.). Nauka Publisher, 30 p. (In Russian)

[2] Einstein, A. (1965) Collection of Scientific Papers. On the Special and General Theory of Relativity. Vol. I. Nauka Publisher, 700 p. (In Russian)

[3] Hawking, S.V. (1988) A Brief History of Time: From the Big Bang to Black Holes. Bantam Books.

[4] Einstein, A. (1967) Collection of Scientific Papers. Evolution of Physics. Vol. IV. Nauka

Publisher, 599 p. (In Russian)

[5] Landau, L.D. and Lifshits, E.M. (2002) The Classical Theory of Fields: Volume 2. 5th Edtion, Stereotype, Fizmatlit. (In Russian)

[6] Pound, R.V. and Rebka, G.A. (1960) Apparent Weight of Photons. *Physical Review Letters*, **4**, 337-341. https://doi.org/10.1103/physrevlett.4.337

[7] Tokarev, V.A. (2023) Four-Dimensional Model of Space. *Journal of Physics & Astronomy*, **11**, 349. https://www.tsijournals.com/articles/fourdimensional-model-of-space-16239.html

[8] Einstein, A. (1965) Collection of Scientific Papers. Formal Foundations of the General Theory of Relativity (p. 378). Vol. I. Nauka Publisher, 700 p. (In Russian)

[9] Tokarev, V.A. (2023) Solar Corona Heating. *Journal of Physics & Astronomy*, **11**, 359. https://www.tsijournals.com/articles/solar-corona-heating-16278.html

[10] Tokarev, V.A. (2025) The Hubble Constant in Four-Dimensional Space. *Journal of High Energy Physics*, *Gravitation and Cosmology*, **11**, 1633-1639. https://doi.org/10.4236/jhepgc.2025.114099

[11] Livio, M. and Riess, A.G. (2017) A Rebus of Dark Energy. *In the World of Science*, No. 5-6, 50-57. (In Russian)

[12] Stern, B. and Rubakov, V. (2020) Astrophysics: The Troitsky Variant. AST, 34-51. (In Russia)

[13] Weinberg, S. (1989) The Problem of Psychological Safety. *Scientific Journal*, **158**, 640-678. (In Russian)

[14] Tokarev, V.A. and Kuleshov, G.I. (2023) The Speed of Propagation of Background Radiation. *Journal of Physics & Astronomy*, **11**, 348.

[15] Tokarev, V.A. and Kuleshov, G.I. (2025) Autocorrelation Function of Solar Radio Emission in the 12 GHz Band. *Global Journal of Science Frontier Research*, **24**, 50-54.

[16] Einstein, A. (1966) Collection of Scientific Papers. Time, Space and Gravity. Vol. II. Nauka, 718, 878. (In Russian)

[17] Fesen, R.A., Hammell, M.C., Morse, J., Chevalier, R.A., Borkowski, K.J., Dopita, M.A., *et al*. (2006) The Expansion Asymmetry and Age of the Cassiopeia a Supernova Remnant. *The Astrophysical Journal*, **645**, 283-292. https://doi.org/10.1086/504254

[18] Rytov, S.M., Kravtsov, Y.A. and Tatarsky, V.I. (1978) Introduction to Statistical Radio-Physics. Part II. Random Fields. Nauka, 297-335. (In Russian)

[19] Andrianov, M.N., Kostenko, V.I. and Likhachev, S.F. (2018) On Increasing the Spectral Efficiency and Transmissivity in the Data Transmission Channel on the Spacecraft–ground Tracking Station Line. *Cosmic Research*, **56**, 75-83. https://doi.org/10.1134/s001095251801001x

[20] Hawking, S.W. (1974) Black Hole Explosions? *Nature*, **248**, 30-31. https://doi.org/10.1038/248030a0

[21] Helfer, A.D. (2003) Do Black Holes Radiate? *Reports on Progress in Physics*, **66**, 943-1008. https://doi.org/10.1088/0034-4885/66/6/202