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The Hubble Constant in Four-Dimensional Space

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Abstract

The possibility of determining the Hubble constant is considered based on the hypothesis of the physical essence of time as our perception of the displacement of the three-dimensional space of the Universe due to its own expansion in the direction of orthogonal to this space, the fourth spatial dimension. The coincidence of the values of the Hubble constant obtained as a result of the study with the currently generally accepted values, together with the results of previous experiments, is another undoubted confirmation of the hypothesis about the physical essence of time.

Keywords

Expansion of the Universe, Hubble Constant, Physical Essence of Time

1. Introduction

The Hubble constant H_0 plays an important role in our understanding of the evolution of the Universe, although its exact meaning and time variation have not been definitively determined. The importance of accurately determining the Hubble constant is confirmed, for example, by the fact that its inverse value corresponds to the age of the Universe $t_0 \approx 1/H_0$, it also determines the scale of the Universe. The Hubble constant is a constant value for all regions of the expanding Universe only at each stage of its evolution; however, it has now been established that the very value of this conditional constant $H(t)$ has changed during the existence of the Universe [1].

There are two main methods for determining the Hubble constant. The first method consists in detecting distant objects with known luminosity, the so-called standard candles, which can serve as cepheids or type Ia supernova, determining the distance to them from the relative brightness measured by photometric meth-

ods, and then measuring the rate of removal by the redshift of their spectrum [1]-[6]. The second method of determining the Hubble constant examines the distortions of the radio frequency spectrum of cosmic microwave background radiation caused by baryon acoustic oscillations that existed in plasma before the epoch of recombination (up to 380,000 years after the origin of the Universe) [1] [7]-[10].

Both methods cannot give an absolute result, since they depend on unknown or changing factors, such as the possibility of time changes in the speed of light and other cosmological parameters, the proportion of matter and radiation density, the presence of gas and dust clouds, as well as the presence or absence of dark matter and dark energy, which are taken into account in calculations, but the existence of which have not yet been proven [1].

Moreover, the values of H_0 obtained by these methods differ significantly from each other, which is known as the Hubble tension, which currently has no generally accepted explanation [1] [11]-[15]. In addition, these methods for determining H_0 work at opposite ends of the timeline of the Universe's existence, skipping intermediate values of $H(t)$.

Thus, determining the exact values of the Hubble constant and the laws of its change remains a very urgent task.

2. Four-Dimensional Space

From the point of view of modern physics, time is one of the coordinates of a single space-time, and it is always emphasized that time is not a spatial axis [16]. In [17], a model of a sphere-like Universe expanding in four-dimensional space is considered, in which time is the displacement of the three-dimensional space of the Universe in the direction orthogonal to this space of the fourth spatial dimension. Time in the proposed model is determined by the distance traveled in the direction of the fourth spatial dimension, and the actual speed from the point of view of four-dimensional space and the uniformity of motion do not matter. It is even possible to completely stop the expansion of the Universe indefinitely without any changes available to a three-dimensional observer. We are able to observe the passage of time only by moving something, and the very possibility of movement is provided by the expansion of the Universe.

The conclusions following from this hypothesis do not contradict the generally accepted provisions of modern physics and are confirmed by a number of simple and easily repeatable experiments conducted using a specially developed technique based on the difference in the propagation speeds of radiation with different redshifts before and after reflection from a parabolic mirror [18].

For example, A. Einstein's statement about the inconstancy of the speed of light in a vacuum within the framework of the general theory of relativity is confirmed [16]. The measurement of the speed of propagation of the cosmic microwave background radiation showed that it is 123 km/s [18]. A. Einstein's prediction about the possibility of a redshift of radiation generated by massive stars has also been experimentally confirmed [19]. According to the hypothesis put forward,

radiation generated in a region of space with high curvature near a massive object not only receives a redshift, but also has a relatively low propagation speed. According to the predictions, the propagation speed of the Sun's radio emission in the frequency range of 12 GHz was approximately 3000 - 3500 km/s [20].

Within the framework of the proposed hypothesis, an extremely simple explanation for the abnormally high temperature of the solar corona and the existence of the solar wind is possible. Each point in space, depending on its curvature, corresponds to its own value of the speed of light c_x, therefore, as it moves away from the Sun, the speed of light increases proportionally to the power of 3/2 of the relative distance R_x from its surface R_0

$$c_x = c_0 \times R_x^{3/2},$$

which, taking into account the laws of conservation of energy and momentum, leads to an increase in the speed v_x, and consequently the temperature T_x of ionized particles, regardless of their mass, it is proportional to the third power of the relative distance from the surface of the Sun [21]

$$T_x = T_o \times R_x^3.$$

The hypothesis about the physical essence of time allows us to abandon the concept of solid matter [22] and imagine elementary particles in the form of extremely high-frequency electromagnetic waves moving along a ring at points in space curved by their own energy [17]. This representation of matter explains the particle-wave dualism of particles, the probabilistic nature of their interaction, and the paradoxes of the spin of elementary particles, since the axis of rotation of electromagnetic waves lies outside our space, and also allows us to abandon the magical complete transformation of solid matter into radiation, since all transformations in the collision of elementary particles can be explained by the appearance of new frequencies of electromagnetic waves on the nonlinearities of curved space are similar to a radio frequency mixer [17].

Electrons, which can also be rolled up into a ring in a normal state, with a certain configuration of space formed by the surrounding material that is stable at low temperature, can abruptly unfold and begin to propagate in the form of a flat electromagnetic wave, which is another possible explanation for the effect of superconductivity.

The presented hypothesis also makes it possible to explain the redshift of radiation from distant objects without involving the Doppler effect, which leads to a significant revision of the scale of cosmological distances and the rejection of the theory of accelerated expansion of the Universe, and therefore the abandonment of the search for dark energy. The dependence of the speed of light on the curvature of space at constant energy leads to a difference in the masses of externally similar objects, which is perceived as the presence of dark matter [17].

The proposed definition of the physical essence of time fully corresponds to the position of the general theory of relativity on time dilation in strong gravitational fields, since with a strong curvature of space, the speed of its movement in the

direction orthogonal to this space is less than the speed of movement of space free of large masses in the direction coinciding with the general direction of expansion of the Universe [17].

It is easy to see that the hypothesis under consideration makes it possible to determine the size of the entire sphere-like Universe. With an experimentally obtained estimate of the expansion speed of 123,000 km/s and an age of 13.8 billion years, its radius can be estimated at 1.75 Gpc [18].

Given the significant potential of the proposed hypothesis and the special form of defining time as the movement of the expanding Universe along the fourth spatial coordinate, it is of interest to consider the correspondence of estimates of the Hubble constant within the framework of the proposed model and in existing cosmological theories.

3. The Hubble Constant

As a result of the experiments with cosmic microwave background radiation, it was found that the radius of the Universe increases by $S = 123{,}000$ km in a time that we perceive as one second [18]. Accordingly, every second the circumference of the Universe increases by $\Delta L = 2\pi S$ km for any value of the time of its existence, and the entire circumference of the Universe is equal to $L = 2\pi S t_0$, where t_0 is the lifetime of the Universe in seconds. Accordingly, the Hubble constant in the proposed model is equal to $H_0 = \Delta L/L = 2\pi S/(2\pi S t_0) = 1/t_0$, which fully corresponds to the currently accepted value [1]. When determining the Hubble constant in terms of expansion speed per one megaparsec of distance, the equation takes the form

$$H_0 = 3.085678 \times 10^{19}/t_0 \left[(\text{km/s})/\text{Mpc}\right]. \quad (1)$$

If the lifetime of the Universe is $t_0 = 13.8$ billions of years or 4355×10^{17} s, then $H_0 = 70.85$ (km/s)/Mpc, which also corresponds to current estimates [7]. **Figure 1** shows a graph of the dependence of the Hubble constant on the age of the Universe, constructed according to Equation (1).

Within the framework of the proposed model, the Hubble constant is determined only for geometric reasons and does not depend on the presence of matter or radiation of any kind, *i.e.*, it does not depend on cosmological parameters. Time always flows at the same speed—we perceive every 123,000 km traveled as one second, regardless of the speed of movement in the fourth dimension. Therefore, the extremely high values of the Hubble constant in the early Universe (up to about half a billion years), which can be perceived as an inflationary expansion or a Big Bang, are associated only with its relatively small intrinsic size.

Thus, in a four-dimensional world with a known rate of expansion of space at the present time and in the local region of the Universe closest to us, as potentially the most accurate value, the values of the Hubble constant can be obtained at any other moment of the Universe's existence, and its age can also be calculated with high accuracy, regardless of any cosmological parameters. On the other hand, for

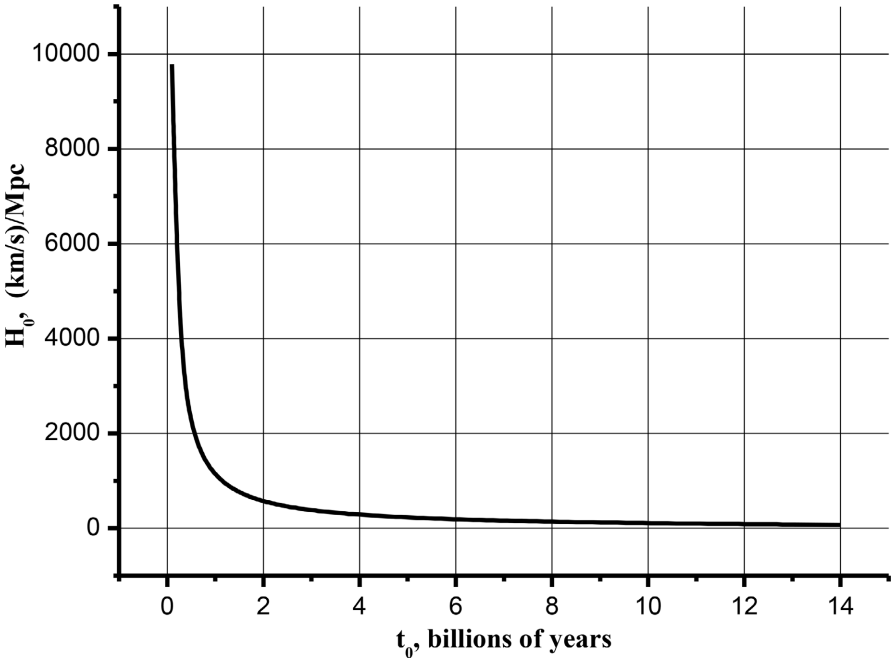

Figure 1. The dependence of the Hubble constant H_0 on the age of the Universe t_0.

any time of the Universe's existence, the corresponding value of the Hubble constant can be determined, which is practically impossible for all other methods.

The coincidence of the values of the Hubble constant, determined based on completely different cosmological theories, confirms the existence of the hypothesis about the physical essence of time. At the same time, the need to introduce such indefinite entities into cosmological models that affect changes in the rate of expansion as dark energy and dark matter is rejected [1] [17]. The reason for the inflationary expansion of the early Universe and its deceleration over time, time dilation in strong gravitational fields, is easily explained, and a new simple explanation is given for the effect of superconductivity and even the abnormally high temperature of the solar corona and the existence of the solar wind [21]. The unambiguous correspondence of the age of the Universe t_0 and all values of the Hubble constant H_0 to one precisely measured value at any given time of the Universe's existence is one of the advantages of the hypothesis of time as the expansion of the Universe in the fourth spatial dimension compared to all other theories.

4. Conclusion

The hypothesis about the physical essence of time as our perception of the Universe moving in the direction of the fourth spatial dimension orthogonal to it due to its own expansion allows us to establish an unambiguous interdependence between the expansion rate H_0 and the age of the Universe t_0, which practically coincides with modern estimates obtained from astronomical observations. This coincidence is another confirmation of the validity of the formulated hypothesis about the four-dimensionality of the world in which we exist.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Verkhodanov, O.V. (2021) Background Radiation and Modern Cosmological Model. *Astronomical Journal*, **98**, 179-196.

[2] Dan, S., Macri, L.M., Yuan, W., Stefano, C. and Riess, A.G. (2019) Large Magellanic Cloud Cepheid Standards Provide a 1% Foundation for the Determination of the Hubble Constant and Stronger Evidence for Physics beyond LambdaCDM. arXiv:1903.07603.

[3] Riess, A.G., Yuan, W.L., Macri, L.M., *et al.* (2022) A Comprehensive Measurement of the Local Value of the Hubble Constant with 1 km s^{-1} Mpc^{-1} Uncertainty from the Hubble Space Telescope and the SH0ES Team. https://arxiv.org/pdf/2112.04510.pdf

[4] Riess, A.G., *et al.* (2016) A 2.4% Determination of the Local Value of the Hubble Constant. *The Astrophysical Journal*, **826**, Article 56.

[5] Tom, S., Lucy, H. and Nigel, M. (2018) GAIA Cepheid Parallaxes and Local Hole. arXiv:1810.02595v2.

[6] Riess, A.G., Strolger, L., Tonry, J., Casertano, S., Ferguson, H.C., Mobasher, B., *et al.* (2004) Type Ia Supernova Discoveries at Z > 1 from Thehubble Space Telescope: Evidence for Past Deceleration and Constraints on Dark Energy Evolution. *The Astrophysical Journal*, **607**, 665-687. https://doi.org/10.1086/383612

[7] Riess, A.G., Anand, G.S., Yuan, W., Casertano, S., Dolphin, A., Macri, L.M., *et al.* (2024) JWST Observations Reject Unrecognized Crowding of Cepheid Photometry as an Explanation for the Hubble Tension at 8σ Confidence. *The Astrophysical Journal Letters*, **962**, L17. https://doi.org/10.3847/2041-8213/ad1ddd

[8] Li, S., Riess, A.G., Casertano, S., Anand, G.S., Scolnic, D.M., Yuan, W., *et al.* (2024) Reconnaissance with JWST of the J-Region Asymptotic Giant Branch in Distance Ladder Galaxies: From Irregular Luminosity Functions to Approximation of the Hubble Constant. *The Astrophysical Journal*, **966**, Article 20. https://doi.org/10.3847/1538-4357/ad2f2b

[9] Ade, P.A.R., *et al.* (2013) Planck 2013 Results. I. Overview of Products and Scientific Results. *Astronomy and Astrophysics*, **571**, Article No. A1. https://doi.org/10.1051/0004-6361/201321529

[10] Aghanim, N., *et al.* (2016) Planck Intermediate Results. XLVI. Reduction of Large-scale Systematic Effects in HFI Polarization Maps and Estimation of the Reionization Optical Depth. arXiv:1605.02985.

[11] Bassett, B. and Hlozek, R. (2010) Baryon Acoustic Oscillations. In: *Dark Energy*, Cambridge University Press, 246-278. https://doi.org/10.1017/cbo9781139193627.010

[12] DESI Collaboration (2024) DESI 2024 VI: Cosmological Constraints from the Measurements of Baryon Acoustic Oscillations. arXiv:2404.03002.

[13] Freedman, W.L. (2021) Measurements of the Hubble Constant: Tensions in Perspective. *The Astrophysical Journal*, **919**, Article 16. https://doi.org/10.3847/1538-4357/ac0e95

[14] Kang, Y., Lee, Y., Kim, Y., Chung, C. and Ree, C.H. (2020) Early-Type Host Galaxies of Type Ia Supernovae. II. Evidence for Luminosity Evolution in Supernova Cosmology. *The Astrophysical Journal*, **889**, 8. https://doi.org/10.3847/1538-4357/ab5afc

[15] Riess, A.G., Casertano, S., Yuan, W., Macri, L., Anderson, J., MacKenty, J.W., *et al.* (2018) New Parallaxes of Galactic Cepheids from Spatially Scanning the Hubble

Space Telescope: Implications for the Hubble Constant. *The Astrophysical Journal*, **855**, Article 136. https://doi.org/10.3847/1538-4357/aaadb7

[16] Einshtein, A. (1965) Collection of Scientific Papers. On the Special and General Theory of Relativity. Vol. 1, Наука, 700 p.

[17] Tokarev, V.A. (2023) Four-Dimensional Model of Space. *Journal of Physics & Astronomy*, **11**, Article 349.

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

[19] Einshtein, A. (1966) Collection of Scientific Papers. Space, Time and Gravity. Vol. 2, Наука, 881 p.

[20] Tokarev, V.A. and Kuleshov, G.I. (2023) Autocorrelation Function of Solar Radio Emission in the 12 GHz Band. *Global Journal of Science Frontier Research*, **24**, 51-54.

[21] Tokarev, V.A. (2023) Solar Corona Heating. *Journal of Physics & Astronomy*, **11**, Article 359.

[22] Einshtein, A. (1967) Collection of Scientific Papers. Evolution of Physics. Vol. 4, Наука, 599 p.