SYSTEM OF COSMOLOGICAL EQUATIONS FOR THE MATHEMATICAL DERIVATION OF THE PARAMETERS OF THE OBSERVABLE UNIVERSE.

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Abstract. *The parameters of the observable universe are, in principle, computable. They can be mathematically derived with high precision. A system of cosmological equations has been obtained that allows one to mathematically derive the values of the parameters of the observable Universe with unprecedented accuracy. The system of equations was formed by combining separate cosmological equations derived at different times by renowned scientists. The parameters of the observable Universe are the roots of the system of algebraic equations, which eliminates the ambiguity of their values. The solution to the inverse problem gives the entire package of parameters of the observable Universe with an accuracy close to the accuracy of the gravitational constant G. Mass of the observable Universe:* ***Mu = 1.15348… •10^53 kg; radius: Ru = 0.856594…•10^26 m; time: Tu = 2.85729… •10^17 s; cosmological constant: Λ = 1.36285…•10^-52 m^-2; acceleration constant (new parameter of the Universe): Ao = 10.4922…•10^-10 m/s^2.*** *All values of the derived parameters of the Universe are verified with high accuracy using fundamental constants well known in physics.*

Keywords: *cosmological equations, система космологических уравнений , parameters of the observable Universe, fine-tuning of the Universe.*

1. Introduction

At various times, prominent scientists (Schrödinger, Bleksley, Milne, Dirac, Teller, Rice) discovered equations linking the parameters of the observable Universe with fundamental physical constants [1-4]. Erwin Schrödinger attempted to formulate Mach's principle mathematically and, as early as 1925, proposed the equation $\mathbf{GM_U = c^2R_U}$ [1]. A similar equation, $\mathbf{MuG = c^2Ru}$, was derived by Bleksley [2]. Milne in 1936 proposed the equation $\mathbf{GM_U = c^3T_U}$ [3]. The Tully–Fisher relation, well known for galaxies, also holds for the Universe: $\mathbf{GM_UA_0 = c^4}$

Other cosmological equations are also known. They were proposed by Dirac [5, 6], Weinberg [7], Teller [8], Hoyle [9], and Carvalho [10]. The value of cosmological equations is that they are based on experimental values of the parameters of the Universe. Despite the fact that the parameters of the Universe are measured with very low accuracy, this has not prevented the identification of their connection with fundamental physical constants [1-10]. This opens the possibility of "pulling" the accuracy of the parameters of the Universe to the accuracy of the fundamental physical constants.

Using the known equations individually leads to inconsistent values of the Universe's parameters. Known equations containing three or more parameters of the Universe do not provide an unambiguous solution. For example, the Schrödinger equation ($\mathbf{GM_U = c^2R_U}$) yields an infinite number of pairs $\mathbf{M_U}$ -- $\mathbf{R_U}$ that satisfy the equation. Substituting highly imprecise experimental values into an equation containing highly precise constants of the microworld negates the very idea of mathematically calculating the parameters of the universe. As a result, the purpose of combining

highly precise constants of the microworld and low-precision constants of the macroworld in a single equation is lost.

2. Solving the inverse problem to deduce the values of the parameters of the observable Universe.

Experimental values of the parameters of the Universe are known with very low accuracy. This accuracy of parameters is not sufficient to solve fundamental problems of cosmology and test quantum theories of gravity. When experimental methods fail, a solution must be sought mathematically. The differential equations known in physics and cosmology do not allow us to directly obtain the parameters of the Universe. Next we will discuss the parameters of the observable universe in our era.

We have found a solution to this problem. To do this, we solve the inverse problem: using known cosmological equations, we determine the values of the parameters of the Universe that satisfy a group of disparate equations. The known cosmological equations [1 - 4] are consequences from which the characteristics of a physical object (the Universe) can be reconstructed. Since all the equations presented relate to a single physical object—the Universe—we have grouped and combined the equations into a system of algebraic equations. The transition from disparate cosmological equations to a SYSTEM OF COSMOLOGICAL EQUATIONS is a key step in solving the inverse problem. We do not use experimental values of the parameters of the Universe due to their extremely low accuracy. This isn't about searching for random numerical coincidences, but rather a rigorous, deterministic system of algebraic equations of the observable Universe, where all parameters are calculated analytically.

Since fundamental physical constants are included in the equations, then without introducing any adjustable coefficients, the system of equations yields the values of the parameters of the Universe with an accuracy close to the accuracy of the gravitational constant. Solving the system of equations yields the entire package of Universe parameters. The parameters of the observable Universe are the roots of the system of algebraic equations.

The system of cosmological equations includes "a priori" parameters represented by the gravitational constant G and the fundamental physical constants. This leads to an unambiguous result for the entire package of Universe parameters. Each cosmological equation combines the parameters of the Universe and fundamental physical constants. This approach is consistent with Mach's principle. Mach's principle postulates that the local properties of the microworld are not isolated intrinsic properties, but are determined by the structure and properties of the entire Universe.

3. The System of Algebraic Equations of the Universe.

To calculate the parameters of the Universe, we combined the disparate cosmological equations of Schrödinger, Bleksley (1), Milne (2), and Tully-Fisher (3) into a single system of cosmological equations. To these equations, we added two equations (4) and (5) that we had previously obtained. The result is a system of five algebraic equations containing all the necessary parameters of the Universe.

$$GM_U = c^2R_U \quad (1)$$

$$GM_U = c^3T_U \quad (2)$$
$$GM_UA_0 = c^4 \quad (3)$$
$$M_U\Lambda cr_e^3 = \hbar \quad (4)$$
$$GM_U\Lambda = A_0 \quad (5).$$

Where: M_U is the mass of the Universe, G is the gravitational constant, c is the speed of light, Ru is the radius of the Universe, r_e is the electron radius, ħ is Planck's constant, Ao is the constant of the Universe's acceleration, T_U is the time of the Universe, and Λ is the cosmological constant.

The system of algebraic equations of the Universe is shown in Figure 1.

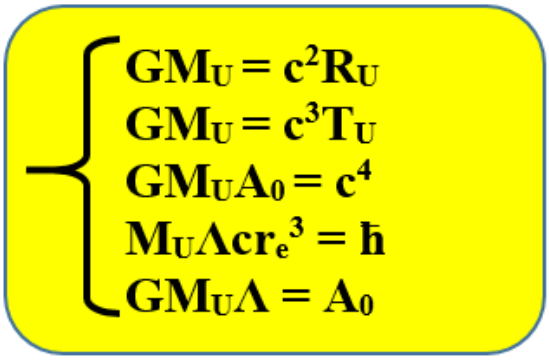


Figure 1. System of algebraic equations of the Universe.

4. The parameters of the observable Universe are the roots of a system of algebraic equations.

The parameters of the Universe are the mathematical roots of a system of algebraic equations. All calculated values of the parameters of the Universe have an accuracy close to that of the gravitational constant. This is an unprecedented level of accuracy for the parameters of the observable Universe. Previously, the values of these parameters were known only approximately in cosmology and astrophysics. For example, instead of an approximate value for the mass of the observable Universe ($M_U \approx 1.45 \cdot 10^{53}$ kg), we obtained its value (**M_U = 1.15348… • 10^{53} kg**). The values of the parameters of the observed Universe (**M_U = 1.15348… •10^{53} kg, R_U = 0.856594…•10^{26} m, T_U = 2.85729… •10^{17} s, Λ = 1.36285…•10^{-52} m^{-2}, A_0 = 10.4922…•10^{-10} m/s^2**) are derived with an accuracy of 5 - 6 digits. Figure 2 shows a group of parameters of the Universe, which are obtained as the roots of the system (Fig. 1) of algebraic equations.

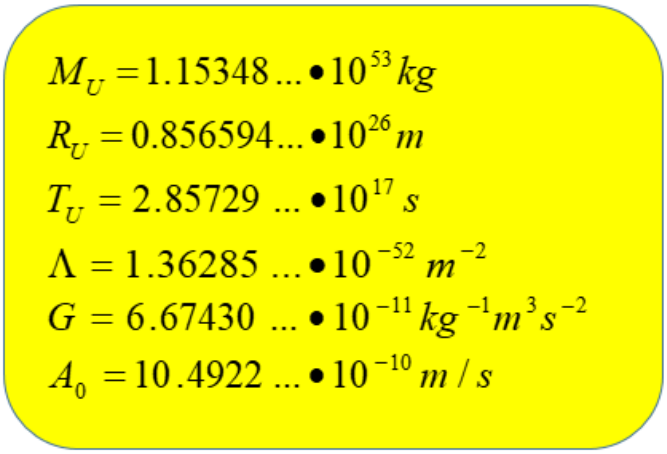


Fig. 2. Values of the parameters of the Universe derived from the system of cosmological equations.

The system of algebraic equations of the Universe has made it possible to completely eliminate the use of inaccurate experimental values of the Universe's parameters, eliminate the need to adjust the parameters of the Universe to measured values, and eliminate numerological fitting. As a result, the roots of the system of algebraic equations turn out to be fundamental mathematical constants and codes of the Universe, rather than random physical quantities.

5. The acceleration constant $A_0 = 10.4922 \bullet 10^{-10}$ m/s² is a new parameter of the observable Universe.

One of the roots of the system of algebraic equations of the Universe is a new parameter of the Universe: the cosmological acceleration $A_0 = 10.4922 \bullet 10^{-10}$ m/s². This acceleration constant is the basis for the new law of gravity: $F_{Cos} = mA_0 = mc^2\sqrt{\Lambda}$. The constant $A_0 = 10.4922 \bullet 10^{-10}$ m/s². complements the family of acceleration constants known in physics:

- Planck acceleration $a_P = \mathbf{5.56073 \times 10^{51}}$ m/s².
- classical limiting acceleration $a_{max} = \mathbf{3.1894046 \times 10^{31}}$ m/s².
- critical Schwinger acceleration as = $\mathbf{2.3274210 \times 10^{29}}$ m/s².
- gravitational acceleration created by the mass of an electron at a distance of its classical radius $\mathbf{a_g = 7.65651 \times 10^{-12}\ m/s^2}$.
- MOND critical acceleration: $a_0 \approx 1.2 \times 10^{-10}$ m/s².

6. Verification of the Derived Parameters of the Observable Universe

We will verify the derived parameters of the observable Universe by calculating them using well-known constants in physics. Correct parameter values should yield the values of the fundamental constants. Incorrect parameter values will prevent us from obtaining the constants known in physics. We will check for constants known in QED, GTR, and classical physics:

1. The following five combinations of universe parameters ($\mathbf{GM_U^2/R_U^2}$, $\mathbf{M_UA_0}$, $\mathbf{M_UR_U/T_U^2}$, $\mathbf{M_Uc^2\sqrt{\Lambda}}$, $\mathbf{GMu^2\Lambda}$) yield the Planck force with high accuracy. $\mathbf{F_P = 1.21027 \times 10^{44}\ N}$:

$$\mathbf{F_P = GM_U^2/R_U^2 = M_UA_0 = M_UR_U/T_U^2 = M_Uc^2\sqrt{\Lambda} = GMu^2\Lambda = 1.21027 \times 10^{44}\ N} \qquad \mathbf{(6)}$$

Physics used only one formula ($\mathbf{c^4/G}$) for calculating the Planck force without using Planck units. We presented five more formulas based on the derived parameters of the universe.

2. Combinations of the parameters of the Universe $\mathbf{M_U R_U \text{^} 2 \Lambda^2 T_U}$, $\mathbf{M_U R_U A_0/T_U}$, $\mathbf{M_U R_U \Lambda A_0 T_U}$, $\mathbf{M_U/R_U}$, $\mathbf{M_U \bullet R_U A_0^2}$ give the following well-known constants in physics: $\mathbf{4.49174 \bullet 10^{18}\ kg\ s\ m^{-2}}$, **3.62825•10^52 W, 4.03681•10^35 kg/s, 1.34659•10^27 kg/m, 1.08774•10^61 W•m/s.** Combinations of the parameters of the Universe are reduced to the formula cn/G for n = 1, 2, …5. They are reduced with high accuracy to the fundamental Planck constants.

3. Dimensionless combinations of the parameters of the universe ($\mathbf{M r_e/m_e Ru}$ and $\mathbf{MuRu\Lambda r_e/m_e}$) give the famous large Weyl number: $\mathbf{D_0 = 4.1656 \bullet 10^{42}}$

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$$\mathbf{M_U r_e/m_e Ru = MuRu\Lambda r_e/m_e = D_0 = 4.1656 \bullet 10^{42}}\ (7)$$

4. The combination of the parameters of the universe **Ru, Tu, G, Mu** gives the cosmological analogue of Kepler's Third Law: $\mathbf{Ru^3/Tu^2 = GMu}$

5. The combination of the parameters of the universe **Ru, Tu, Mu, ħ** gives the cosmological analogue of the quantum of action (the quantum of action of the universe) $\mathbf{M_U \bullet R_U \text{^} 2/T_U = \hbar \alpha D_0^3}$. The quantum of action of the universe is a scale-transformed Planck constant.

6. The product $\mathbf{A_0 \alpha^2 D_0}$ yields the value: $\mathbf{2.3274210 \times 10^{29}\ m/s^2}$**.** This is the Schwinger acceleration constant, known in physics.

7. The product $\mathbf{A_0 \alpha D_0}$ yields the value: $\mathbf{3.1894046 \times 10^{31}\ m/s^2}$**.** This is a well-known acceleration constant in physics: classical limiting acceleration amax = $\mathbf{3.1894046 \times 10^{31}}$ m/s².

8. The product $\mathbf{A_0\ \alpha D_0 \sqrt{(\alpha D_0)}}$ gives the value: $\mathbf{5.56073 \times 10^{51}\ m/s^2}$ This is the Planck acceleration: Planck acceleration a_P = $\mathbf{5.56073 \times 10^{51}}$ m/s².

9. The product $\mathbf{A_0 \bullet \alpha}$ yields the value: $\mathbf{7.65651 \times 10^{-12}\ m/s^2}$. This is well-known in physics gravitational acceleration created by the mass of an electron at a distance of its classical radius ag = 7.65651×10^{-12} m/s².

10. The new constant A_0 is related to other parameters of the Universe as follows:

$$A_0 = \frac{GM_U}{R_U^2} = \frac{R_U}{T_U^2} = c^2\sqrt{\Lambda} = \frac{c^4}{GM_U} = GM_U\Lambda = \frac{c}{T_U} = \frac{G\hbar}{cr^3} = \ldots =$$
$$= \frac{Gm_e}{\alpha\, r_e^2} = \frac{c^2}{r_e\, \alpha D_0} = 10.4922\ldots \bullet 10^{-10}\, m/s^2 \quad (8)$$

Where: G is the gravitational constant; Mu is the mass of the Universe; Ru is the radius of the Universe; Tu is time; c is the speed of light; Λ is the cosmological constant; m_e is the mass of the electron; r_e is the classical radius of the electron; α is the fine-structure constant; D_0 is the large Weyl number; ħ is Planck's constant.

Mathematical verification shows that the derived parameters of the universe ($\mathbf{M_U = 1.15348\ldots \cdot 10^{53}\ kg}$, $\mathbf{R_U = 0.856594\ldots \cdot 10^{26}\ m}$, $\mathbf{T_U = 2.85729\ldots \cdot 10^{17}\ s}$, $\mathbf{\Lambda = 1.36285\ldots \cdot 10^{-52}\ m^{-2}}$, $\mathbf{A_0 = 10.4922\ldots \cdot 10^{-10}\ m/s^2}$) are flawless. They have no internal contradictions and are completely consistent with fundamental physics.

7. Stages of the mathematical method for deriving the parameters of the observable Universe.

The initial data for the mathematical method for deriving the parameters of the Universe are experimental values of the Universe's parameters. This method is based on the results of modern observational cosmology and utilizes experimental data from the Planck and WMAP space observatories and the DESI survey. The experimental values of the Universe's parameters, known from astronomical observations, are not directly substituted into the equations. They serve as the basis for synthesizing cosmological equations. With their help, the relationship between the parameters of the Universe and fundamental physical constants is established.

The first cosmological equations were derived by Schrödinger, Blakesley, Milne, Tully, Fisher, and other scientists about 100 years ago. It is not difficult to derive other equations leading to the fine structure constant **"Alpha" ($\mathbf{m_e/M_U\Lambda r_e^2 = \alpha}$),** to Planck's constant **($\mathbf{M_U\Lambda c r_e^3 = \hbar}$)** or to a large Weyl number ($\mathbf{M_U R_U \Lambda r_e/m_e = D_0 = 4.1656 \cdot 10^{42}}$). Figure 3 shows the stages of the mathematical method for deriving the parameters of the observable Universe.

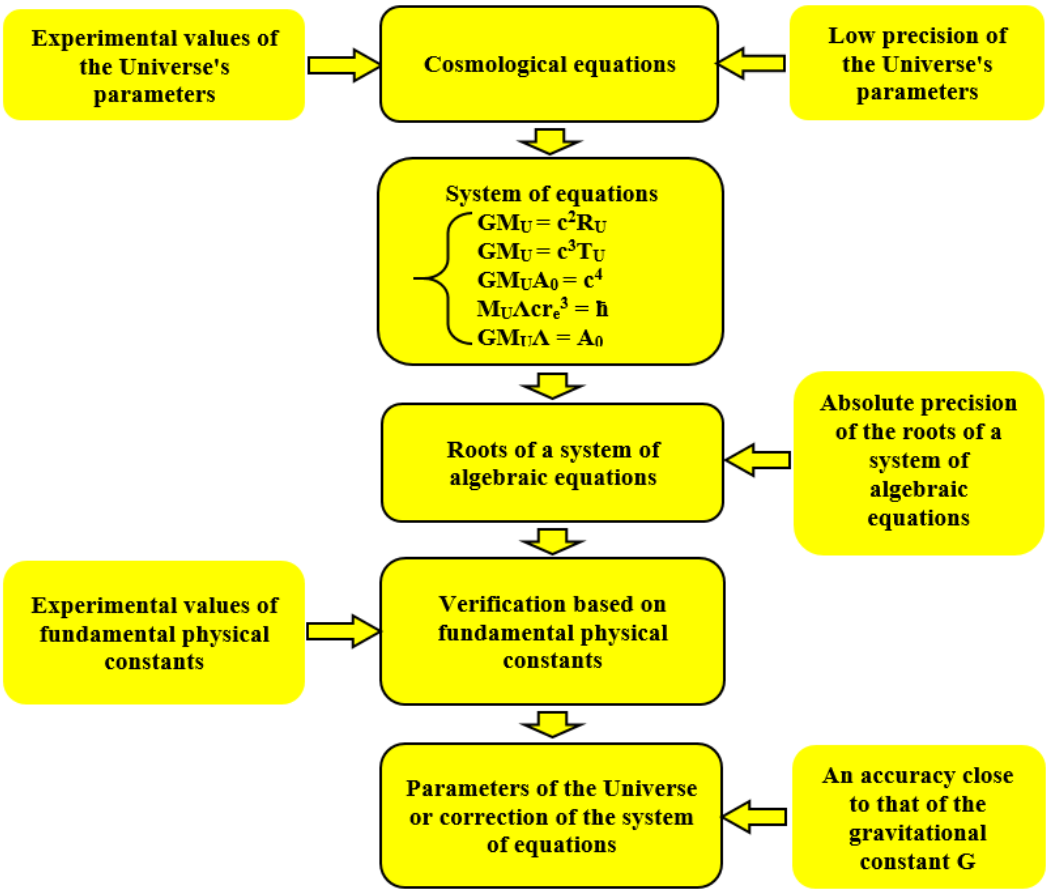


Figure 3. Stages of the mathematical method for deriving the parameters of the observable Universe.

When deriving the parameters of the Universe, an inverse problem is solved: the values of the parameters that satisfy the equations are determined. To do this, the disparate cosmological equations are combined into a system of cosmological equations (Fig. 2, Fig. 3). The roots of the system provide exact values of the parameters that satisfy the system of algebraic equations. However, this is not sufficient to identify the roots of the system of algebraic equations with the actual parameters of the Universe. A verification stage is necessary for the mathematically calculated parameters. During this verification stage, the roots of the system are used to perform control calculations of known physical quantities and physical constants. Here, the results of experiments measuring Planck's constant and the gravitational constant are used [11, 12]. The value of Planck's constant has been measured with the highest precision. The value of G is significantly inferior in accuracy to the constants of the microworld. However, for the parameters of the Universe, even such a "low" accuracy of G represents an unprecedentedly high precision in cosmology.

If verification using experimental values of fundamental physical constants yields a negative result, the erroneous equations are identified and a new system of algebraic equations is synthesized. Thus, during the verification stage, both the values of the roots and the correctness of the equations themselves are tested using experimental values of physical constants. If verification is positive, the values of the roots of the system of equations are considered parameters of the Universe. The accuracy of the calculated parameters of the Universe is limited only by the accuracy of the constant G.

Thus, two independent groups of experiments serve as the experimental basis for the mathematical method: experiments measuring the parameters of the Universe, based on data from the Planck and WMAP space observatories and the DES surveys, and experiments making high-precision measurements of fundamental physical constants.

8. Double experimental verification of the derived parameters of the observable Universe.

The very emergence of cosmological equations arose from the experimental values of the Universe's parameters obtained through their measurements. Experimental values of the Universe's parameters served as the basis for Schrödinger, Weyl, Dirac, Teller, Weinberg, and Hoyle to derive cosmological equations that mathematically unify the Universe's parameters and fundamental physical constants. These scientists laid the foundation for the development of a mathematical method for deriving the Universe's parameters.

During the verification stage, the results of the inverse problem solution are also subjected to experimental verification. In this case, precision values of fundamental physical constants are used.

The value of the proposed mathematical method is that it begins with experimental values of the Universe's parameters and concludes with comparisons with highly accurate physical constants measured experimentally.

First, the experimental values of the Universe's parameters allow the formulation of cosmological equations. At the final stage, high-precision experimental values of fundamental physical constants allow us to verify the correctness of cosmological equations and the correctness of the values of the parameters of the Universe with an accuracy close to the accuracy of the gravitational constant G. The derivation of cosmological equations from experimental values and their testing with

experimental values of fundamental physical constants constitute a double experimental verification of the derived parameters of the observable Universe.

9. Conclusion.

1. A system of algebraic equations for the Universe has been proposed that allows us to derive the parameters of the observable Universe with unprecedented accuracy, close to the accuracy of the gravitational constant.

2. An inverse problem has been solved: instead of substituting approximate experimental values of the Universe's parameters into the equations, the parameters are mathematically derived as the roots of a system of algebraic equations.

3. Two different approaches are commonly used to derive the parameters of the Universe. The "bottom-up" approach allows one to derive the parameters of the Universe from practical telescope observations, while the "top-down" approach allows one to calculate them from physical laws. The proposed mathematical method combines both approaches for the first time.

4. The proposed mathematical method begins with approximate experimental values of the parameters of the observable Universe at the stage of forming individual cosmological equations from the bottom up and concludes at the verification stage by comparing them with experimental values of fundamental physical constants.

5. The following high-values for the parameters of the observable Universe have been derived for the first time:

Mass $M_U = 1.15348\ldots \cdot 10^{53}$ kg,
radius $R_U = 0.856594\ldots \cdot 10^{26}$ m,
time $T_U = 2.85729\ldots \cdot 10^{17}$ s,
lambda $\Lambda = 1.36285\ldots \cdot 10^{-52}$ m^{-2},
acceleration $A_0 = 10.49220\ldots \cdot 10^{-10}$ m/s^2.

6. Verification of the derived parameters of the observable Universe, conducted by comparing the calculated values with known constants in physics, demonstrated their impeccability.

7. The parameters of the observable Universe are derived from two sets of experimental constants: experimental values of the Universe's parameters and experimental values of the fundamental physical constants. Cosmological equations follow from the experimental values of the Universe's parameters. The roots of the system of equations are verified using the experimental values of the fundamental physical constants. As a result, the derived parameters of the Universe are confirmed by two types of independent experiments: direct approximate measurements at the stage of forming the system of algebraic equations and direct, ultra-precise values of the fundamental physical constants at the verification stage.

8. The Universe is an absolutely deterministic, rigidly connected, and mathematically tuned structure. The parameters of the Universe are not arbitrarily selected values from an infinite number of possibilities or adjusted to match measured values, but the only possible roots of a system of algebraic equations.

10. Final Remarks.

The proposed mathematical method for deriving the parameters of the Universe does not use adjustable coefficients. The mathematical method for deriving values of the parameters of the Universe is based on the results of modern observational cosmology and utilizes experimental data from the Planck and WMAP space observatories and the DESI survey. Experimental values of the parameters of the Universe, known from astronomical observations, are not directly substituted into the equations. They are used to establish a relationship between the parameters of the Universe and fundamental physical constants. They serve as the basis for synthesizing cosmological equations that combine fundamental physical constants and the parameters of the Universe. Such equations were proposed by Schrödinger, Dirac, Hoyle, Milne, Blakesley, and other scientists. These equations are integrated into the structure of a system of algebraic equations. To eliminate the ambiguity of the parameters of the Universe, an inverse problem is solved using a deterministic system of algebraic equations. The roots of the system of algebraic equations are accepted as parameters of the Universe after their verification using fundamental physical constants and quantities known in QED, classical physics, and general relativity. Thus, the developed method for deriving the parameters of the observable Universe utilizes double experimental verification of the derived parameters.

We do not present here the system of algebraic equations with known equations containing the Hubble parameter. This is due to the unsolved problem of the Hubble Tension. However, not using equations containing the Hubble parameter has not prevented the derivation of other parameters of the Universe. At the same time, integrating the well-known Hoyle cosmological equation ($\mathbf{M_U = c^3/2HG}$) into the system of equations reveals another serious problem associated with the Hubble parameter. This problem can be formulated as the "FACTOR TWO PROBLEM" in equations containing the Hubble parameter. Both the Hoyle equation and the Friedmann equations imply the presence of a coefficient of "2" in front of the Hubble parameter. If this "TWO" is taken into account, then the system of cosmological equations yields an unexpected value for the Hubble parameter: $\mathbf{H_0 = 1.74991 \times 10^{-18}\ s^{-1}}$ **(53.9967 km/s/Mpc).** Perhaps modern experimental values of the Hubble parameter are overestimated? This makes the Universe much older than is commonly believed in the ΛCDM model (13.8 billion years). From the Hubble parameter: $\mathbf{H_0 = 1.74991 \times 10^{-18}\ s^{-1}}$, its real age follows: **18.1 billion years**. This unexpected value of the Hubble parameter $\mathbf{H_0 = 1.74991 \times 10^{-18}\ s^{-1}}$ requires in-depth research. The value $\mathbf{H_0 = 1.74991 \times 10^{-18}\ s^{-1}}$ **(53.9967 km/s/Mpc).** is surprisingly very close to the historical estimates of Allan Sandage **(50-55 km/s/Mpc**), which for a long time competed with the high values of Gerard de Vaucouleurs (100 km/s/Mpc) at the end of the 20th century.

This raises the question of how to interpret the TU. It's the time it takes for light to travel a distance equal to the radius of the observable universe. It's not the age of the universe "since birth," but a time scale strictly related to its geometric size.

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