MATHEMATICAL JUSTIFICATION OF THE MACH PRINCIPLE.

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Abstract. *As a mathematical justification of Mach's principle, we present a system of cosmological equations that combines the parameters of the Universe and fundamental physical constants. The equations included in the system of cosmological equations were derived independently and at different times by famous scientists: Schrödinger, Blackley, Milne, Hoyle and existed in a scattered form. The system of cosmological equations, formed on the basis of Mach's principle, allows us to derive mathematically the parameters of the observable Universe with an accuracy close to the accuracy of the gravitational constant G. This translates Mach's philosophical principle about the connection between the Universe and the microworld onto a rigorous mathematical basis. The system of cosmological equations gives the following roots (parameters of the observable Universe): mass:* ***Mu = 1.15348… •10^53 kg****; radius:* ***Ru = 0.856594…•10^26 m****; time:* ***Tu = 2.85729… •10^17 s****; acceleration:* ***Ao = 10.4922•10^-10 m/s^2****, Hubble parameter* ***H_0 = 1.74991x 10^-18 s-1 (53.9967 km/s/Mpc)****. The derived values of the parameters of the observable Universe confirm with high accuracy the connection between the Universe and the microworld formulated by Mach. The mathematical substantiation of Mach's principle showed that the parameters of the Universe are directly related to the parameters of the fundamental object of the microworld - the ELECTRON. Mach's principle turned out to be much deeper: not only are the inertial properties of any body determined by its interaction with the Universe, but the parameters of the Universe themselves are directly related to the fundamental constants of the microworld.*

Keywords: *cosmological equations, system of cosmological equations, Mach's principle, Hubble parameter, parameters of the observable Universe, fine-tuning of the Universe.*

1. Introduction

The inspiration for this article came from the insightful comment of the renowned German scientist, Hans Hermann Otto (Professor Emeritus, Clausthal University of Technology), on one of my previous papers: "...I'm missing Mach's principle in this article..." Indeed, Mach's principle is missing from many articles, and even from the entire field of astrophysics and cosmology. The reason is that this philosophical principle lacks a mathematical basis. Mach's principle was formulated in 1883 by the Austrian physicist and philosopher Ernst Mach [1]. The term "Mach's principle" was later coined by Albert Einstein in 1918.

The essence of the principle is that the inertial properties of any body are determined by its gravitational interaction with all other masses in the universe. Mach's principle became the impetus for Einstein to create the General Theory of Relativity (GTR). Albert Einstein openly acknowledged that it was Mach's principle that inspired him to search for a new theory of gravity. Mach forced physicists to view local phenomena through the prism of the universe. This led to the understanding that the local properties of the microworld are not isolated intrinsic properties, but are determined by the structure and properties of the universe. However, this fundamental principle lacks a mathematical basis. This hinders the development of astrophysics and cosmology.

2. The first attempts at a mathematical justification of Mach's principle.

Mach's principle is not represented by a quantitative measure. Mach expounded it as a philosophical principle. In 1925, Erwin Schrödinger attempted to provide a mathematical justification for Mach's principle. He set out to explain Mach's philosophical principle in mathematical terms and prove that the properties of the microworld are determined by the influence of the Universe.

To confirm that the local properties of the microworld are not isolated intrinsic properties but are determined by the structure and properties of the Universe, Schrödinger proposed an original approach. To explain the connection between the Universe and the microworld, he based his explanation on the relationship between the parameters of the Universe and the fundamental physical constants. He derived the equation $\mathbf{GM_U = c^2R_U}$. In this equation, Schrödinger combined the parameters of the Universe (mass and radius) and the fundamental physical constants (**c** and **G**) [2, 3]. The emergence of the Schrödinger equation was a revolutionary step, launching the process of translating Mach's philosophical principle into mathematical language. This was the first attempt to apply a quantitative estimate to Mach's philosophical principle.

The same equation $\mathbf{GM_U = c^2R_U}$ was independently derived by Bleksley in 1931 [4]. Schrödinger's approach was further developed. Milne proposed the equation $\mathbf{GM_U = c^3T_U}$ in 1936 [5]. Hoyle derived the equation $\mathbf{M_U = c^3/2H_0G}$ [6]. Cosmological equations linking other parameters of the Universe and the fundamental physical constants were proposed by Dirac, Rice, Weinberg, Teller, and Carvalho [7-12].

All these equations, in the spirit of Mach's principle, reflect the connection between the Universe and the microworld and are based on the unification of the parameters of the Universe and high-precision fundamental physical constants.

Disparate equations made it impossible to confirm the relationship between the parameters of the Universe and the FUNDAMENTAL PHYSICAL CONSTANTS in a strictly mathematical manner. Equations containing two or more parameters of the Universe do not provide an unambiguous solution. As a result, the task of translating Mach's philosophical principle into the language of mathematics, which was begun by Schrödinger, remained unfinished.

We took a different approach: to mathematically justify Mach's principle, instead of manually substituting imprecise experimental values or any fitting coefficients into the equations, we combined the disparate equations into a system of equations and derived the parameters of the universe strictly mathematically as the roots of a system of algebraic equations. The transition from disparate equations to a system of equations was a decisive step in the mathematical justification of Mach's principle. We solved the inverse mathematical problem: we determined the parameters of the universe that satisfy all the disparate equations and are the only solution.

3. Transition to a System of Cosmological Equations

Since the equations derived by Schrödinger, Blakeslee, Milne, and Hoyle pertain to a single physical object—the observable Universe—we grouped and combined them into a system of algebraic equations.

Using the relation $\mathbf{M_U/M = c^4/V^4}$ proposed in [17] and moving to the scale of the Universe, we obtain the Tully-Fisher relation applicable to the observable Universe in its two forms: $\mathbf{G^2M_U^2/R_U^2}$

$= c^4$, $GM_UA_0 = c^4$. Where A_0 is the acceleration caused by the mass of the observable Universe M_U at a distance of its radius R_U.

We added to the system the equation we had previously obtained: $\mathbf{m_eR_U^2/M_Ur_e^2 = \alpha}$, based on Weyl's discovery[18], which made the system definite. Weyl was the first to point out the relationship between the parameters of the observable Universe and the parameters of the electron [18] and even quantified this relationship: he indicated a scaling factor of $\mathbf{10^{40}}$. As a result, equations satisfying Mach's principle led to a system of equations based on Mach's principle. This eliminated the need for manually substituting inaccurate experimental values, as is typically done when using the Friedmann equations. Instead of substituting inaccurate experimental values, we seek a mathematical solution and obtain such values of the parameters of the Universe that approximate equations turn into exact equalities. The mathematical criterion becomes a selection factor for the unknown parameters of the Universe.

Transition to a deterministic system of algebraic equations for the observable Universe, where all parameters are calculated analytically, not only confirms Mach's principle but also creates a unique opportunity for a highly accurate derivation of the Universe's parameters. For the first time, the parameters of the Universe can be obtained as the roots of a system of algebraic equations. The high accuracy of the system's roots allows us to confirm the connection between the Universe and the microworld using the relationship between the parameters of the Universe and fundamental physical constants as an example.

4. A system of cosmological equations to substantiate Mach's principle.

We included the following individual equations in the system of cosmological equations:

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

$$\mathbf{GM_U = c^3T_U} \quad \mathbf{(2)}$$

$$\mathbf{GM_UA_0 = c^4} \quad \mathbf{(3)}$$

$$\mathbf{M_U = c^3/2H_0G} \quad \mathbf{(4)}$$

$$\mathbf{R_U^2m_e/M_Ur_e^2 = \alpha} \quad \mathbf{(5)}$$

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, m_e is the mass of the electron, re is the electron radius, α is the fine-structure constant; Ao is the constant of the Universe's acceleration, T_U is the time of the Universe, and H_0 is the Hubble parameter.

The result was a system of five algebraic equations containing the necessary parameters of the Universe. Since the equations include fundamental physical constants, without introducing any adjusting coefficients, the system of equations yields values of the Universe's parameters with an accuracy close to that of the gravitational constant. The parameters of the observable Universe are the roots of the system of algebraic equations.

The system of cosmological equations contains "a priori" parameters represented by the gravitational constant G and the fundamental physical constants. This leads to an unambiguous result for the entire set of parameters of the Universe.

“The mathematical basis for Mach's principle is a system of cosmological equations in which the equations contain the parameters of the Universe and the fundamental physical constants, and in which the number of unknown parameters coincides with the number of equations.”

5. Parameters of the Observable Universe as Roots of a System of Cosmological Equations.

The parameters of the observable Universe are solutions to a system of algebraic equations:

$$M_U = 1.15348\ldots \cdot 10^{53}\ \text{kg}, \quad (6)$$

$$R_U = 0.856594\ldots \cdot 10^{26}\ \text{m}, \quad (7)$$

$$T_U = 2.85729\ldots \cdot 10^{17}\ \text{s}, \quad (8)$$

$$H_0 = 1.74991\ldots \cdot 10^{-18}\ \text{s}^{-1}\ (53.9967\ \text{km/s/Mpc}) \quad (9)$$

$$A_0 = 10.4922\ldots \cdot 10^{-10}\ \text{m/s}^2) \quad (10)$$

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. All parameters of the observable Universe are derived with an accuracy of 5-6 decimal places. The system of algebraic equations of the Universe made it possible to completely eliminate the use of imprecise experimental values of the Universe's parameters, eliminating the need to adjust the parameters of the Universe to measured values and eliminating any numerology. As a result, the roots of the system of algebraic equations are not random physical quantities, but fundamental mathematical constants and parameters of the Universe.

"The parameters of the observable Universe are the roots of a system of algebraic equations that combine the fundamental physical constants of the microworld and the parameters of the Universe."

6. Verification of mathematically derived parameters of the observable Universe.

We will verify the derived parameters of the observable Universe using constants known in QED, GTR, and classical physics.

1. The combination of the parameters of the Universe $M_U c 2H_0$ allows us to determine the Planck force with high accuracy. $F_P = 1.21027\times10^{44}$ N:

$$F_P = 2H_0 M_U c = 1.21027\times10^{44}\ \text{N} \quad (11)$$

2. Dimensionless combinations of the parameters of the Universe ($M_U t_e 2H_0/m_e$) yield the famous large Weyl number: $D_0 = 4.1656 \cdot 10^{42}$:

$$2H_0 M_U t_e/m_e = D_0 = 4.1656 \cdot 10^{42} \quad (12)$$

3. The combination of the parameters of the Universe Ru, $2H_0$, Mu yields the cosmological analogue of the quantum of action (the quantum of action of the Universe): $(M_U \cdot R_U\text{^}2) \cdot 2H_0 = \hbar\alpha D_0^3$. The quantum of action of the Universe is the scale-transformed Planck constant.

4. Combinations of the Universe parameters $\mathbf{M_U R_U A_0 2H_0}$, $\mathbf{M_U/c \cdot 2H_0}$ yield the following well-known constants in physics: 3.62825•10^52 W, 1.34659•10^27 kg/m.

5. Combinations of the Hubble parameter and the speed of light yield the acceleration caused by the mass of the observable Universe at a distance equal to its radius:

$$\mathbf{2H_0 c = A_0 = 10.4922 \cdot 10^{-10}\ m/s^2} \quad \mathbf{(13)}$$

This acceleration has been stubbornly ignored by physicists and cosmologists. It exists and is generated by the mass of the observable Universe. It is responsible for the Pioneer anomaly. It must be taken into account in Newton's law of gravity. Failure to take it into account led to the dubious concept of dark matter and gave rise to the "big G" problem in measuring the gravitational constant [19]. The problems associated with not accounting for the cosmological acceleration A_0 don't end there.

We see that the value of H0 obtained by mathematical calculation differs significantly from the experimental one. At any other point in the universe, where the distance to the center of mass is not equal to the radius, the acceleration value will differ from A_0. This also applies to the solar system: the acceleration of the solar system caused by the mass of the universe will differ from A_0. Direct measurement of the cosmological acceleration for an object in free fall is impossible. However, measurement of H_0 is available. Accordingly, the measured value of H_0 also depends on the distance to the center of mass.

The mathematically derived value of H_0 differs significantly from the experimental value. The exact value of the ΔH_0 discrepancy will be known after solving the Hubble stress problem:

$$\mathbf{\Delta H_0 = 2H_{0\ theor} - H_{0\ exp} = ?} \quad \mathbf{(14)}$$

This discrepancy between the calculated H_0 and the measured H0 is of particular interest. Behind this discrepancy lies a monumental discovery in cosmology. Since the value 1.74991 x 10^{-18} s^{-1} (53.9967 km/s/Mpc) is calculated mathematically relative to a distance equal to the radius of the observable Universe, ΔH0 contains unique information about our location in the Universe.

> **“Dear astrophysicists and cosmologists! Solving the Hubble stress problem leads to a monumental discovery in cosmology: for the first time, it will be possible to indicate the location of the Earth and the Solar System in the Universe. Don't miss this discovery! The number of fundamental laws of nature is limited—there aren’t enough to go around!”**

7. Mach's Principle as a Fundamental Law of Nature.

In summary, the system of equations (15) below demonstrates that Mach's Principle is not simply a philosophical principle, but a fundamental law of nature, represented mathematically. In this system of equations, every parameter of the Universe is mathematically related to the constants of the microworld. With amazing accuracy, equations (15) confirm Weyl’s discovery made more than 100 years ago [18].

$$\begin{cases} M_U = m_e \alpha D_0^2 \\ R_U = r_e \alpha D_0 \\ T_U = t_e \alpha D_0 \\ A_0 = r_e / t_e^2 \alpha D_0 \\ \Lambda = 1 / r_e^2 \alpha^2 D_0^2 \\ H_0 = 1 / 2 t_e \alpha D_0 \\ G = r_e^3 / t_e^2 m_e D_0 \end{cases} \quad (15)$$

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, re is the electron radius, Ao is the constant of the Universe's acceleration, T_U is the time of the Universe, Λ is a cosmological constant and H_0 is the Hubble parameter, m_e is the mass of the electron; r_e is the classical radius of the electron; α is the fine-structure constant; t_e is the characteristic time of the electron; D_0 is the large Weyl number ($D_0 = \mathbf{4}.1\mathbf{656}1 \cdot \mathbf{10}^{\mathbf{42}}$).

The system of cosmological equations (15) is also a mathematical confirmation of Mach's principle. Equations (15) reveal the profound meaning of Mach's principle, namely: every parameter of the universe is directly related to the fundamental constants of the microworld. It is noteworthy that the parameters of the universe are directly related to the parameters of the fundamental object of the microworld – the electron! This means that the connection between the universe and the microworld, formulated by Mach, is more profound: the universe is linked with mathematical precision to local objects of the microworld.

Weyl was the first to point out the connection between the parameters of the Universe and the parameters of the electron more than 100 years ago [18]. His fundamental discovery was ahead of its time. At that time, the fine-structure constant **"alpha"** had only just been discovered, and Weyl did not have time to use it to derive the astonishing combination of constants $\boldsymbol{\alpha \cdot D_0 = 3.03979\ldots \times 10^{40}}$ as a connecting coefficient between the macrocosm and the microworld in the spirit of Mach. Nevertheless, he already indicated the order of this coefficient: $\mathbf{10^{40}}$.

Equations (15) complete the translation of Mach's philosophical principle into mathematical language, initiated by Schrödinger. The development of Schrödinger's approach convincingly demonstrates that the essence of Mach's principle is much deeper. Equations (15) demonstrate that not only are the inertial properties of any body determined by its interaction with the universe, but the parameters of the universe themselves are directly related to the fundamental constants of the microworld.

In mathematical terms, Mach's principle can be formulated as follows:

> **"The fundamental interconnection and interdependence of the Universe and the microworld is determined by the fact that the parameters of the Universe are directly related to the fundamental constants of the microworld and represent scaled parameters of a fundamental object of the microworld—the electron."**

The scaling of the parameters of the Universe and the microworld is based on a similar mathematical transformation of the electron's parameters using two dimensionless constants of electron: the fine structure constant "alpha" and the large Weyl number (D_0 = **4**.1**656**1 • **104**2).

The mass of the observable universe is the scaled mass of the electron: $\mathbf{M_U = m_e \alpha D_0^2}$

The radius of the observable universe is the scaled classical radius of the electron: $\mathbf{R_U = r_e \alpha D_0}$

The characteristic time of the observable universe is the scaled characteristic time of the electron: $\mathbf{T_U = t_e \alpha D_0}$

The cosmological acceleration is the scaled acceleration constant: $\mathbf{A_0 = r_e/t_e^2 \alpha D_0}$

The cosmological constant is the reciprocal of the square of the radius of the observable universe: $\mathbf{\Lambda = 1/r_e^2 \alpha^2 D_0^2}$

The Hubble parameter is the scaled characteristic frequency of the electron: $\mathbf{H_0 = 1/2 t_e \alpha D_0}$

The main discovery is that each parameter of the universe is mathematically represented by a combination of fundamental physical constants of the microworld. This confirms Schrödinger's conjecture that the mathematical justification for Mach's principle can be found in the relationship between the parameters of the universe and the constants of the microworld. Substitution of the derived parameters of the universe, represented by the constants of the microworld, into the Schrödinger equation $\mathbf{GM_U = c^2 R_U}$ confirms the validity of his equation with high accuracy.

Schrödinger's mathematical idea for confirming Mach's principle was adopted, developed, and popularized by Brans, Dicke, and Siama [13-16]. In the Brans-Dicke theory, $\mathbf{GM_u/R_u c\text{^}2 \approx 1}$. This equation implies that the total gravitational potential energy of the Universe is of the order of its rest energy. Siama showed [16] that if the inertia of a body is completely induced by the gravitational field of the Universe, then the ratio $\mathbf{GM_u/R_u c\text{^}2}$ must be exactly equal to unity. We confirmed above that this relation holds not approximately, but as a strict algebraic equality.

8. Examples of other systems of cosmological equations.

The system of cosmological equations represented by equations (1) – (5) is not unique. Below is a system of cosmological equations in which we have included the well-known Stewart cosmological equation [20, 21]:

$$\mathbf{Gm_e^2/r_e = \alpha^2 \hbar/T_U} \quad \mathbf{(16)}$$

$$\mathbf{GM_U = c^2 R_U} \quad \mathbf{(17)}$$

$$\mathbf{GM_U = c^3 T_U} \quad \mathbf{(18)}$$

$$\mathbf{GM_U A_0 = c^4} \quad \mathbf{(19)}$$

$$\mathbf{M_U = c^3/2 H_0 G} \quad \mathbf{(20)}$$

The roots of the given system exactly repeat the derived values of the parameters of the Universe (M_U = 1.15348 •10^{53} kg, R_U = 0.856594 •10^{26} m, T_U = 2.85729 •10^{17} s, H_0 = 1.74991x10^{-18} s^{-1} (53.9967 km/s/Mpc), A_0 = 10.4922 •10^{-10} m/s^2).

To derive the value of the cosmological constant Λ, we formed the following system of cosmological equations:

$$\mathbf{R_U/T_U^3 \Lambda = c^3} \quad \mathbf{(21)}$$

$$\mathbf{Gm_e^2/r_e = \alpha^2 \hbar/T_U} \quad \mathbf{(22)}$$

$$\mathbf{GM_U = c^2 R_U} \quad \mathbf{(23)}$$

$$\mathbf{GM_U = c^3T_U} \quad \textbf{(24)}$$
$$\mathbf{GM_UA_0 = c^4} \quad \textbf{(25)}$$
$$\mathbf{M_U = c^3/2H_0G} \quad \textbf{(26)}$$

We included in this system the cosmological equation $R_U/T_U{}^3\Lambda = c^3$ obtained earlier. The roots of the reduced system exactly repeat the derived values of the parameters of the Universe (M_U = 1.15348 •10^{53} kg, R_U = 0.856594 •10^{26} m, T_U = 2.85729 •10^{17} s, H_0 = 1.74991x10^{-18} s^{-1} (53.9967 km/s/Mpc), A_0 = 10.4922 •10^{-10} m/s^2) and additionally give the value of the cosmological constant Λ = 1.36285•10^{-52} m^{-2}. All the systems of cosmological equations are easily reduced to the system of equations (15). The proof is very simple, even a schoolchild can do it, so we do not present it.

9. The Hubble parameter as a root of the system of cosmological equations.

One of the roots of the system of algebraic equations of the Universe is the Hubble parameter. Its value is **H_0 = 1.74991… x 10^{-18} s^{-1} (53.9967 km/s/Mpc)**. The derived value of H_0 turned out to be much smaller than in the ΛCDM model. The Hoyle and Friedmann equations imply the presence of a coefficient of "2" in front of the Hubble parameter. As a result, the system of cosmological equations yields an unexpectedly low value for the Hubble parameter: **H_0 = 1.74991… x 10^{-18} s^{-1} (53.9967 km/s/Mpc)**.This indicates that the Universe is much older than is commonly believed in the ΛCDM model. From the Hubble parameter: **H_0 = 1.74991… x 10^{-18} s^{-1} (53.9967 km/s/Mpc)**, its real age follows: 18.1 billion years. The value **H_0 = 1.74991… x 10^{-18} s^{-1} (53.9967 km/s/Mpc)** is surprisingly very close to Allan Sandage's historical estimates (**50-55 km/s/Mpc**), which for a long time competed with Gérard de Vaucouleurs's high values (**100 km/s/Mpc**) at the end of the 20th century.

This raises the question of how to interpret the T_U time. This is the time it takes light to travel a distance equal to the radius of the observable Universe. This is not an age "from birth," but a characteristic time scale that is rigidly tied to its geometric size.

The Hubble parameter, derived from the system of cosmological equations, is related to other parameters of the Universe as follows:

$$H_0 = \frac{GM_U}{2cR_U^2} = \frac{c\sqrt{\Lambda}}{2} = \frac{c^3}{2GM_U} = \frac{1}{2T_U} = \frac{G\hbar}{2c^2r^3} = ... = \frac{Gm_e}{2c\alpha\, r_e^2} = \frac{c}{2r_e\,\alpha D_0} = 1.74991...\bullet 10^{-18} s^{-1} (53.9967...km/s/MPs) \quad (27)$$

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 ligh; H_0 is the Hubble parameter; 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.

Verification of the derived parameters of the Universe (**M_U = 1.15348… •10^{53} kg, R_U = 0.856594…•10^{26} m, T_U = 2.85729… •10^{17} s, H0 = 1.74991…x 10^{-18} s^{-1} (53.9967 km/s/Mpc), A0 = 10.4922…•10-10 m/s^2, Λ = 1.36285…•10^{-52} m^{-2}**) using the well-known constants of QED, GTR, and classical physics showed their impeccability. They have no internal contradictions and are completely consistent with fundamental physics.

10. Conclusion.

1. No special theories are needed to mathematically justify Mach's principle. It turns out that it's sufficient to formulate a system of cosmological equations that combines the parameters of the Universe and the parameters of the microworld, and to derive the parameters of the Universe as the roots of the system of equations.

2. In 1925, Schrödinger first proposed an equation $\mathbf{GM_U = c^2R_U}$ for the mathematical justification of Mach's principle, in which the parameters of the universe are combined with the fundamental physical constants of the microworld. Other equations, in which the parameters of the universe are combined with the fundamental physical constants of the microworld, were proposed by Dirac, Blakesley, Milne, Weyl, Stewart and Hoyle.

3. Disparate equations did not allow for a mathematical justification of Mach's principle. Since all the disparate cosmological equations relate to one single physical object – the Universe, this allows them to be combined into a system of equations.

4. Developing Schrödinger's approach to the mathematical justification of Mach's principle, we combined the disparate equations into a system of cosmological equations.

5. The proposed system of algebraic equations of the Universe allows us to derive the values of the parameters of the observable Universe with unprecedented accuracy, close to the accuracy of the gravitational constant: Mass $\mathbf{M_U = 1.15348\ldots \cdot 10^{53}\ kg,}$ radius $\mathbf{R_U = 0.856594\ldots \cdot 10^{26}\ m,}$ time $\mathbf{T_U = 2.85729\ldots \cdot 10^{17}\ s,}$ Hubble parameter $\mathbf{H_0 = 1.74991\ldots x\ 10^{-18}\ s^{-1}\ (53.9967\ km/s/Mpc),}$ acceleration $\mathbf{A_0 = 10.4922\ldots \cdot 10\text{-}10\ m/s^2,}$ $\mathbf{\Lambda = 1.36285\ldots \cdot 10^{-52}\ m^{-2}}$.

6. The value of the Hubble parameter is derived theoretically for the first time. The derived value of the Hubble parameter shows that the Universe is much older than is commonly believed in the ΛCDM model. From the Hubble parameter: $H_0 = 1.74991\ldots \text{ x } 10^{-18}\ s^{-1}$ follows that its real age is **18.1** billion. years.

7. The values of the parameters of the observable Universe, derived from the system of cosmological equations, confirm with high accuracy the connection between the Universe and the microworld formulated by Mach.

8. The mathematical justification of Mach's principle showed that the parameters of the Universe are directly related to the parameters of the fundamental object of the microworld – the ELECTRON. Weyl was the first to point out the connection between the parameters of the Universe and the parameters of the electron more than 100 years ago [18].

9. Mach's principle turned out to be much deeper: not only are the inertial properties of any body determined by its interaction with the Universe, but the parameters of the Universe themselves are directly related to the fundamental constants of the microworld.

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