

A new mathematical method for deriving the parameters of the observable Universe.

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Abstract. *We propose a new mathematical method for deriving the parameters of the Universe. The method is based on the discovered relationship between the parameters of the Universe and the fundamental physical constants of the microcosm. To solve this problem, large numbers were derived on previously unknown scales of 10^{140} , 10^{160} , and 10^{180} . These large numbers made it possible to obtain cosmological equations linking the parameters of the Universe to the fundamental physical constants. The number of cosmological equations and parameters of the Universe turned out to be sufficient to combine the equations into a system of algebraic equations. The values of the parameters of the Universe are the roots of the system of algebraic equations. This is a mathematical method for directly calculating the parameters of the Universe, bypassing the Friedmann equations. For the first time, the values of the fundamental parameters of the observable Universe were calculated with an accuracy close to the accuracy of Newton's gravitational constant G . No other theoretical approach has ever yielded the parameters of the observable Universe with such high accuracy. The obtained results show that the architecture of the Universe is "tuned" with filigree mathematical precision.*

Keywords: *large numbers, cosmological equations, parameters of the observable Universe, fine-tuning of the Universe.*

1. Introduction

Large numbers in physics and cosmology and their multiple coincidences have attracted the attention of many scientists for more than 100 years. For more than 100 years the problem of coincidence of large numbers has not found a solution. The coincidence of large numbers was first noticed by H. Weyl. He also obtained large numbers as the ratio of the electric force to the gravitational force for the electron ($\approx 10^{42}$) and the ratio of the radius of the Universe to the radius of the electron ($\approx 10^{40}$) [1]. In attempts to explain the coincidences of large numbers, well-known scientists have proposed cosmological equations that include the parameters of the observable Universe. These include the Dirac equation [2, 3], Stewart equation [4, 5], Eddington-Weinberg equation [6, 7], Teller equation [8, 9], Rice equation [10], Nottale equation [11, 12], Milne equation [13, 14], Bleksley equation [15], Hoyle equation [16], Carvalho equation [17]. Some equations are approximate and the coincidences in them are evaluated only by order of magnitude. In [18], the approximate equations are refined to exact equations. The table in Fig. 1 summarizes the known cosmological equations obtained in different years.

Name	Parameters Universe	Formula	Note
Weyl's equations	G, R_U	$\mathbf{e}^2/\mathbf{Gm}_e^2 = 4.17 \times 10^{42}$ $\mathbf{R}_U/\mathbf{r}_e \approx 10^{40}$	1918, [1]
Approximate equation Rice	G, R_U	$\frac{4\pi}{\alpha} \approx \frac{r_e^2 c^2}{6R_U G m_e}$	1925, [10]
Exact equation		$\frac{R_U G m_e}{r_e^2 c^2} = \alpha$	
Stewart's equation	G, H	$G m_e^2 / r_e = \alpha^2 \hbar H$	1931, [4]
Milne equation	G, M_U, T	$\mathbf{M}_U = \mathbf{c}^3 \mathbf{T}_U / \mathbf{G}$	1936, [13]
Approximate Dirac equation	G, H	$m_e c^3 / (H e^2) \approx e^2 / (G m_e^2)$	1937, [2,3]
Exact equation		$\mathbf{m}_e \mathbf{c}^3 / (\mathbf{H} \mathbf{e}^2) = \alpha \mathbf{e}^2 / (\mathbf{G} \mathbf{m}_e^2)$	[18]
Bleksley equation	G, M_U, R_U	$\mathbf{M}_U = \mathbf{c}^2 \mathbf{R}_U / \mathbf{G}$	1951, [15]
Approximate Eddington- Weinberg equation	G, H	$\hbar^2 H \approx G c m_p^3$	1972, [6]
Exact equation		$\hbar^2 H \alpha^3 = G c m_e^3$	[18,19] [20]
Approximate Teller's equation	G, H	$2 \frac{G \hbar H}{c^4 l_{Pl}} = 2 t_{Pl} H = 2 \frac{G m_{Pl} H}{c^3} \equiv \exp(-1/\alpha)$	1948 [8]
Exact equation		$\frac{G \hbar H}{c^4 l_{Pl}} = t_{Pl} H = \frac{G m_{Pl} H}{c^3} = (\sqrt{\alpha D_0})^{-3}$	[18]
Approximate Nottale equation	G, Λ	$c^3 / G \hbar \Lambda \approx 10^{120}$	1993 [11,12]
Exact equation		$c^3 / G \hbar \Lambda = \alpha^3 D_0^3$	[18]
Carvalho equation	G, M_U, H	$\mathbf{M}_U = \mathbf{c}^3 / \mathbf{G} \mathbf{H}$	1995, [22]

Fig. 1. Cosmological equations containing the parameters of the Universe. **M_U** is the mass of the observable Universe, **α** is the fine structure constant, **$\hbar$** is Planck's constant, **G** is the Newtonian gravitational constant, **Λ** is the cosmological constant, **R_U** is the radius of the observable Universe, **T_U** is the time of the Universe, **H** is the Hubble constant (**H=2 H₀**), **r_e** is the classical radius of the electron; **c** - speed of light in vacuum; **m_e** - electron mass, **D₀** - large Weyl number, **t_{Pl}** - Planck time, **l_{Pl}** - Planck length, **m_{Pl}** - Planck mass.

The known cosmological equations contain a limited number of parameters of the Universe. Equations link 2 and 3 parameters of the Universe. Equations linking more than 3 parameters of the Universe are unknown. The limited number of parameters of the Universe in equations did not allow us to obtain the values of the parameters of the Universe. The same reason did not give an opportunity to reveal the possible relationship between the parameters of the Universe. An even greater unsolved mystery remains the relationship between the parameters of the Universe and the fundamental physical constants.

New large numbers, obtained from the law of scaling of large numbers [21], lead to new cosmological equations linking more than 3 parameters of the Universe. These results open new possibilities for astrophysics and cosmology.

The fundamental parameters of the Universe, such as mass, radius, and the cosmological constant, are known with low accuracy—1-3 percent. Here we propose a mathematical method for determining the parameters of the Universe that allows us to derive them with unprecedented precision.

2. The law of scaling of large numbers as a function of the fine structure constant “alpha”

The values of large numbers that follow from the relations of the dimensional parameters of the Universe allowed us to derive the law of scaling of large numbers [21]. The law of scaling of large numbers is represented by the degree dependence of the combination of two dimensionless constants: fine structure constant alpha and the Weyl number.

The law of scaling of large numbers has the form (Fig. 2).

$$D_i = (\sqrt{\alpha D_0})^i$$

$$i = 0, \pm 1, \pm 2, \pm 3, \pm 4, \pm 5, \pm 6, \pm 7, \pm 8, \pm 9.$$

Fig. 2: Fine structure constant alpha in the scaling law of large numbers. D_0 is a large Weyl number ($D_0 = 4.16561... \times 10^{42}$), α is the fine structure constant.

The scaling law gives a new method of calculating the values of large numbers. Its peculiarity is that the large numbers are obtained from the dimensionless fine structure constants alpha and Weyl number. The scaling law generates large numbers up to scale 10^{180} with high accuracy. The large numbers obtained from the scaling law are close to the accuracy of the Newtonian constant of gravitation G. This opens the possibility to obtain by mathematical method the parameters of the Universe with accuracy close to the accuracy of the Newtonian constant of gravitation G. The values of the large numbers and the formulas for their calculation are given in Fig. 3.

$$(\sqrt{\alpha D_0})^0 = 1$$

$$D_{20} = (\sqrt{\alpha D_0})^1 = 1.74349... \bullet 10^{20}$$

$$D_{40} = (\sqrt{\alpha D_0})^2 = 3.03979... \bullet 10^{40}$$

$$D_{60} = (\sqrt{\alpha D_0})^3 = 5.29987... \bullet 10^{60}$$

$$D_{80} = (\sqrt{\alpha D_0})^4 = 9.24033... \bullet 10^{80}$$

$$D_{100} = (\sqrt{\alpha D_0})^5 = 16.1105... \bullet 10^{100}$$

$$D_{120} = (\sqrt{\alpha D_0})^6 = 28.088... \bullet 10^{120}$$

$$D_{140} = (\sqrt{\alpha D_0})^7 = 48.972... \bullet 10^{140}$$

$$D_{160} = (\sqrt{\alpha D_0})^8 = 85.383... \bullet 10^{160}$$

$$D_{180} = (\sqrt{\alpha D_0})^9 = 148.86... \bullet 10^{180}$$

Fig. 3. Family of large numbers and formulas for their computation from the law of scaling large numbers.

3. Extension of the family of large numbers to scales 10^{140} , 10^{160} and 10^{180} .

Studies of large numbers usually end with the scale 10^{120} . At the same time, it is well known that the ratio of the volume of the Universe to the Planck volume gives a large number of scale 10^{180} . The law of scaling of large numbers showed that the large number of scale 10^{120} is not the maximum number in the family of large numbers. The law of scaling has led to new large numbers on scales 10^{140} , 10^{160} and 10^{180} . The values of the large numbers ($D_{140} = 48.972 \dots \times 10^{140}$, $D_{160} = 85.383 \dots \times 10^{160}$, $D_{180} = 148.86 \dots \times 10^{180}$) were confirmed by dimensional relationships. The relations of dimensional quantities coincided with the large numbers obtained from the mesoscaling law with high accuracy. As a result, new cosmological equations are obtained on scales 10^{140} , 10^{160} and 10^{180} , which demonstrate a fundamental relationship between the parameters of the Universe [21, 22, 23].

4. Ten scales and ten large numbers from the law of scaling of large numbers

The table in Fig. 4 summarizes the dimensional relations that lead to large numbers at 10 scales. The many coincidences of large numbers make it possible to derive cosmological equations for various combinations of cosmological parameters and fundamental physical constants.

Ratios of dimensional constants	Scale
$\frac{Gm_e^2}{r_e \alpha^2 \hbar H} = \frac{G\hbar}{r_e^3 H c^2} = \frac{Gm_e}{r_e^2 \alpha H c} = \frac{Gm_e^3 c}{\alpha^3 \hbar^2 H} = \frac{c^2}{M_U R_U G \Lambda} = \frac{c^3}{M_U G H} = \frac{c^2 R_U}{M_U G} = \frac{l_{Pl}^4}{\Lambda r_e^6} =$ $= \frac{c^3 T_U}{M_U G} = \frac{\Lambda c^2}{H^2} = \frac{c^3 T_U^3}{R_U^3} = \frac{H^2}{M_U R_U G \Lambda^2} = \frac{c r_e^3 A_0}{G \hbar} = \frac{c^4}{M_U R_U H^2 G} = \frac{M_U R_U H A_0 G}{c^5} = 1$	10^0
$D_{20} = \frac{r_e}{l_{Pl}} = \frac{t_0}{t_{Pl}} = \frac{\alpha m_{Pl}}{m_e} = \frac{c l_{Pl}}{r_e^2 H} = \frac{l_{Pl} R_U}{r_e^2} = \frac{c^2 l_{Pl}}{r_e^2 A_0} = \sqrt{\alpha D_0}$	10^{20}
$D_{40} = \frac{T_U}{t_0} = \frac{R_U}{r_e} = \frac{m_e c^2}{\alpha \hbar H} = \frac{1}{t_0 H} = \frac{r_e^2}{l_{Pl}^2} = \frac{t_0^2}{t_{Pl}^2} = \frac{\alpha^2 m_{Pl}^2}{m_e^2} = \frac{c^2}{r_e A_0} = (\sqrt{\alpha D_0})^2$	10^{40}
$D_{60} = \frac{T_U}{t_{Pl}} = \frac{R_U}{l_{Pl}} = \frac{M_U}{m_{Pl}} = \frac{c}{l_{Pl} H} = \frac{r_e^3}{l_{Pl}^3} = \frac{t_0^3}{t_{Pl}^3} = \frac{c^3}{G m_{Pl} H} = \frac{c^2}{l_{Pl} A_0} = (\sqrt{\alpha D_0})^3$	10^{60}
$D_{80} = \frac{R_U^2}{r_e^2} = \frac{H M_U^2 \alpha G}{c^3 m_e} = \frac{c^2}{r_e^2 H^2} = \frac{c r_e}{H l_{Pl}^2} = \frac{1}{r_e^2 \Lambda} = (\sqrt{\alpha D_0})^4$	10^{80}
$D_{100} = \frac{m_e c^3}{l_{Pl} \alpha \hbar H^2} = \frac{r_e \alpha M_U}{l_{Pl} m_e} = \frac{H M_U^2 \alpha G r_e}{c^3 m_e l_{Pl}} = \frac{R_U^2}{r_e l_{Pl}} = \frac{1}{r_e l_{Pl} \Lambda} = (\sqrt{\alpha D_0})^5$	10^{100}
$D_{120} = \frac{T_U^2}{t_{Pl}^2} = \frac{R_U^2}{l_{Pl}^2} = \frac{M_U^2}{m_{Pl}^2} = \frac{c^2}{l_{Pl}^2 H^2} = \frac{R_U^3}{r_e^3} = \frac{M_U c^2}{\hbar H} = \frac{G M_U^2}{\hbar c} = \frac{c^5}{G \hbar H^2} = \frac{c^3}{G \hbar \Lambda} = \frac{1}{l_{Pl}^2 \Lambda} = (\sqrt{\alpha D_0})^6$	10^{120}
$D_{140} = \frac{r_e^2 m_e c^3}{l_{Pl}^3 \alpha \hbar H^2} = \frac{r_e^3 \alpha M_U}{l_{Pl}^3 m_e} = \frac{R_U^3}{l_{Pl}^3 r_e^2} = \frac{1}{t_{Pl} t_0^2 H^3} = \frac{c}{l_{Pl} r_e^2 H \Lambda} = \frac{c^2}{l_{Pl} r_e^2 A_0 \Lambda} = (\sqrt{\alpha D_0})^7$	10^{140}
$D_{160} = \frac{M_U R_U c^2 \alpha^2}{G m_e^2} = \frac{M_U^2 R_U G \alpha}{c^2 r_e^2 m_e} = \frac{1}{r_e^4 \Lambda^2} = (\sqrt{\alpha D_0})^8$	10^{160}
$D_{180} = \frac{r_e^4 m_e c^3}{l_{Pl}^5 \alpha \hbar H^2} = \frac{r_e^5 \alpha M_U}{l_{Pl}^5 m_e} = \frac{R_U^3}{l_{Pl}^3} = \frac{c^3}{l_{Pl}^3 H^3} = \frac{c}{l_{Pl}^3 H \Lambda} = \frac{c^2}{l_{Pl}^3 A_0 \Lambda} = \frac{G M_U T_U^2 l_{Pl}}{\Lambda r_e^6} = (\sqrt{\alpha D_0})^9$	10^{180}

Fig. 4. Relationships of dimensional constants at 10 scales giving 10 large numbers. M_U - mass of the observable Universe, α - fine-structure constant, $\hbar$ - Planck constant, G - Newtonian constant

of gravitation, Λ - cosmological constant, R_U - radius of the observable Universe, T_U - time of Universe, H - Hubble constant, A_0 - cosmological acceleration, r_e - classical electron radius; c - speed of light in vacuum; $t_0 = r_e/c$, m_e - electron mass, D_0 is a large Weyl number, t_{pl} - Planck time, l_{pl} - Planck length, m_{pl} - Planck mass.

5. The scale is 10^0 , which gives the most important cosmological equations.

From the scaling law of large numbers, the number $(\sqrt{\alpha D_0})^0$. This is the lower limit of the family of large numbers:

$$(\sqrt{\alpha D_0})^0 = 1 \quad (1)$$

The scale 10^0 (Fig. 4) is represented by the largest number of coincidences of dimensional magnitude relations. From the relations of dimensional quantities on the scale 10^0 , the most important cosmological equations follow. Among them are Stewart's equation, Carvalho equation, Eddington-Weinberg equation, Milne equation, Bleksley equation.

6. New cosmological equations

Below are new cosmological equations, which contain the parameters of the Universe in different combinations - 2 parameters, 3 parameters, 4 parameters, 5 parameters, 6 parameters.

The table in Fig. 5 shows cosmological equations, which include 2 parameters of the Universe:

Name	Parameters Universe	Cosmological equations	Note
GR-equations	G, R_U	$\frac{c^3 r_e^3}{G R_U} = \hbar$ $\frac{R_U G m_e}{r_e^2 c^2} = \alpha$ $G R_U \hbar / r_e^3 = c^3$	[22], [23]
GT-equations	G, T_U	$G \hbar \alpha^3 D_0^3 / T_U^2 = c^5$ $\frac{T_U G m_e}{r_e^2 c} = \alpha$	[23]
GA-equations	G, Λ	$G^2 m_e^2 = \Lambda c^4 r_e^4 \alpha^2$ $\frac{G m_e}{r_e^2 c^2 \sqrt{\Lambda}} = \alpha$ $G \hbar \Lambda \alpha^3 D_0^3 = c^3$	[23]
GA ₀ -equations	G, A_0	$\frac{c r_e^3 A}{G} = \hbar$ $\frac{G m_e}{r_e^2 A_0} = \alpha$	[22], [23]
GM-equations	G, M_U	$M_U G^2 m_e = \alpha c^4 r_e^2$ $\frac{c^5 r_e^3}{M_U G^2} = \hbar$ $M_U G^2 m_e / \alpha r_e^2 = c^4$	[22]
MA-equations	M_U , Λ	$M_U \Lambda c r_e^3 = \hbar$ $\frac{m_e}{M_U \Lambda r_e^2} = \alpha$	[23]
M R -equations	M_U , R_U	$M_U c r_e^3 = \hbar R_U^2$ $\frac{m_e R_U^2}{M_U r_e^2} = \alpha$	[22], [23]
M T-equations	M_U , T_U	$M \alpha r_e^2 = T_U^2 m_e c^2$ $M r_e^3 = T_U^2 \hbar c$ $M r_e^3 / \hbar T_U^2 = c$	
MA ₀ -equations	M_U , A_0	$\frac{m_e c^4}{M_U A_0^2 r_e^2} = \alpha$ $M A_0^2 r_e^3 = \hbar c^3$	[23]
TA-equation	T_U , Λ	$\Lambda T_U^2 c^2 = 1$	
A ₀ Λ-equation	A_0 , Λ	$A_0^2 = \Lambda c^4$	

FIG. 5. Cosmological equations that contain 2 parameters of the Universe each.

The table in Fig. 6 shows cosmological equations that contain 3 parameters of the Universe each:

Name	Parameters Universe	Cosmological equations	Note
MA₀G-equation	M_U, A₀, G	M_UA₀G = c⁴	
MGT-equation	M_U, G, T_U	M_UG = c³T_U	Milne equation
MGR	M_U, G, R_U	M_UG = c²R_U	Bleksley equation
G, A₀, Λ-equations	G, A₀, Λ	$\frac{c^5 r_e^3 \Lambda}{GA_0} = \hbar$ $\frac{Gm_e A_0}{\Lambda c^4 r_e^2} = \alpha$	[22], [23]
G, R_U, Λ-equations	G, R_U, Λ	$\frac{R_U \Lambda c^3 r_e^3}{G} = \hbar$ $\frac{Gm_e}{R_U \Lambda c^2 r_e^2} = \alpha$	[22], [23]
RTΛ-equation	R_U, T_U, Λ	R_U/T_U³Λ = c³	

FIG. 6. Cosmological equations that contain 3 parameters of the Universe each.

The table in Fig. 7 shows cosmological equations that contain 4 parameters of the Universe each:

Name	Parameters Universe	Cosmological equations	Note
MGRT-equation	M_U, G, R_U, T_U	M_UG = R_U³/T_U²	Kepler's law [28]
MΛGA₀-equation	M_U, Λ, G, A₀	M_UΛG = A₀	
MTAG-equation	M_U, T_U, Λ, G	M_UT_UΛG = c	
MRAG-equation	M_U, R_U, Λ, G	M_UR_UΛG = c²	[23]
MRA₀G-equation	M_U, R_U, A₀, G	M_UR_UA₀²G = c⁶	

FIG. 7. Cosmological equations that contain 4 parameters of the Universe each.

The table in Fig. 8 shows cosmological equations that contain 5 parameters of the Universe each:

Name	Parameters Universe	Cosmological equations	Note
MRAGA₀-equation	M_U, R_U, Λ, G, A₀	M_UR_UΛ²Gc² = A₀²	
MRAGT-equation	M_U, R_U, Λ, G, T	M_UR_UΛ²GT² = 1	

FIG. 8. Cosmological equations that contain 5 parameters of the Universe each.

The table in Fig. 9 shows cosmological equations that contain 6 parameters of the Universe each:

Name	Parameters Universe	Cosmological equations	Note
MRAGA₀T-equations	M_U, R_U, Λ, G, A₀, T_U	M_UR_UΛ²GA₀T_U³ = c M_UR_UΛGA₀T_U = c³	

FIG. 9. Cosmological equations that contain 6 parameters of the universe each.

7. Mathematical method for obtaining the parameters of the observed Universe.

The new cosmological equations (Fig. 5 - Fig. 9), combined in a system of algebraic equations, provide a new method for obtaining the values of the parameters of the Universe. For the first time it was possible to obtain the parameters of the Universe as a result of solving a system of algebraic equations. The solution of systems of algebraic equations gives the parameters of the Universe with an accuracy close to the accuracy of the Newtonian constant of gravitation G

From cosmological equations it is possible to compose various blocks of algebraic equations in which combinations of the parameters of the Universe are equal to the speed of light.

$$\left\{ \begin{array}{l} M_U R_U \Lambda^2 G T_U^2 = c^0 \\ G \hbar / r_e^3 A_0 = c^1 \\ 1/T_U^2 \Lambda = c^2 \\ M_U R_U \Lambda G A_0 T_U = c^3 \\ M_U A_0 G = c^4 \\ M_U R_U A_0 G / T_U = c^5 \\ M_U R_U A_0^2 G = c^6 \end{array} \right.$$

Fig. 10. Block of algebraic equations of the Universe

This attractive system of equations (Fig. 10) is redundant, so we can restrict ourselves to the following systems of algebraic equations:

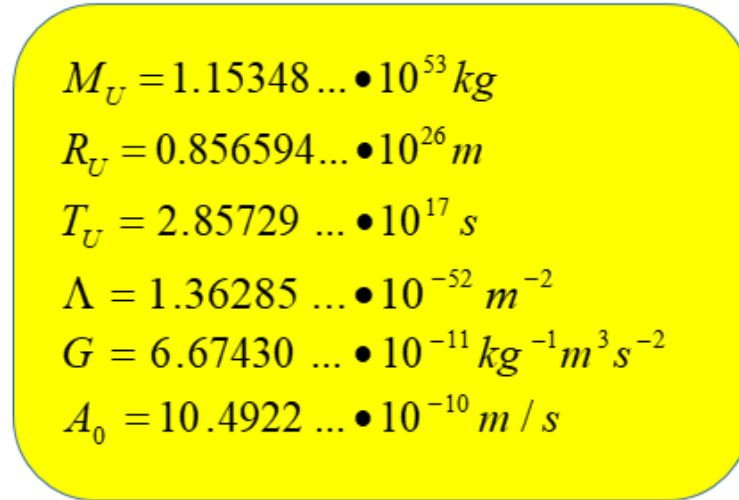
$$\left\{ \begin{array}{l} \frac{M_U G^2 m_e}{c^4 r_e^2} = \alpha \\ \frac{m_e}{M_U \Lambda r_e^2} = \alpha \\ \frac{G m_e}{R_U \Lambda c^2 r_e^3} = \alpha \\ \frac{G m_e A_0}{\Lambda c^4 r_e^2} = \alpha \end{array} \right. \quad \left\{ \begin{array}{l} \frac{c^5 r_e^3}{M_U G^2} = \hbar \\ M_U \Lambda c r_e^3 = \hbar \\ \frac{R_U \Lambda c^3 r_e^3}{G} = \hbar \end{array} \right. \quad \left\{ \begin{array}{l} G \hbar / r_e^3 A_0 = c \\ 1/T_U^2 \Lambda = c^2 \\ G R_U \hbar / r_e^3 = c^3 \\ M_U A_0 G = c^4 \\ M_U R_U A_0 G / T_U = c^5 \end{array} \right. \quad \left\{ \begin{array}{l} G M_U = c^3 T_U \\ G M_U = c^2 R_U \\ R_U G m_e = \alpha c^2 r_e^2 \\ c^4 = G M_U A_0 \end{array} \right.$$

Fig. 11. Examples of various Systems of cosmological equations of the Universe.

In this system of cosmological equations (Fig. 11), the known quantities are the fundamental physical constants **G**, **h**, **r_e**, **c**. The unknown cosmological parameters **M_U**, **R_U**, **Λ**, **A₀**, **T_U** are easily obtained by solving the system of algebraic equations.

8. Parameters of the Universe as roots of a system of algebraic equations.

The solution of the system of algebraic equations (Fig. 11) gives the following values of the parameters of the Universe (Fig. 12).



$$\begin{aligned}
 M_U &= 1.15348 \dots \cdot 10^{53} \text{ kg} \\
 R_U &= 0.856594 \dots \cdot 10^{26} \text{ m} \\
 T_U &= 2.85729 \dots \cdot 10^{17} \text{ s} \\
 \Lambda &= 1.36285 \dots \cdot 10^{-52} \text{ m}^{-2} \\
 G &= 6.67430 \dots \cdot 10^{-11} \text{ kg}^{-1} \text{ m}^3 \text{ s}^{-2} \\
 A_0 &= 10.4922 \dots \cdot 10^{-10} \text{ m} / \text{ s}
 \end{aligned}$$

Fig. 12. Parameters of the Universe and their values.

The precision of the derived parameters of the Universe is close to that of the gravitational constant. This is an unprecedented leap in precision for cosmology throughout its history. A new parameter has emerged among the known parameters of the Universe: the cosmological acceleration **A₀**. Below, we provide a detailed description of this new parameter of the Universe.

9. The new acceleration constant **A₀ = 10.4922... × 10⁻¹⁰ m/s²**.

An approximate value of the additional acceleration **A₀** can be obtained using the approximate value of the mass of the observable Universe (**M_U ≈ 1.45 • 10⁵³ kg**) and the limiting value of the force – the Planck force (**F_P = 1.210²⁷ × 10⁴⁴ N**). The resulting acceleration value is: **a_{MU} ≈ F_P/M_U ≈ 8.347 • 10⁻¹⁰ m/s²**. The calculated acceleration is approximately 7 times greater than the MOND threshold.

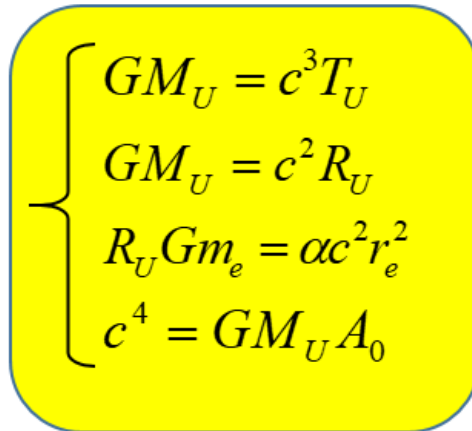
Using the cosmological constant measured by the Planck space telescope, **Λ ≈ 1.1 • 10⁻⁵² m⁻²**, and calculating the acceleration using the formula **c²√Λ**, we obtain: **a_Λ ≈ c²√Λ ≈ 9.426 • 10⁻¹⁰ m/s²**, which is approximately 8 times greater than the MOND threshold. Solving the inverse problem also yields an acceleration several times greater than the MOND threshold.

As a result, we have three independent calculations that lead us to the same conclusion: for precision physics and metrology, a discrepancy of almost 6-8 times is a huge gap that cannot be called a "coincidence." The MOND acceleration is just the tip of the iceberg. But the given acceleration values of **8.347 • 10⁻¹⁰ m/s²**, **9.426 • 10⁻¹⁰ m/s²** and **5.8834 • 10⁻¹⁰ m/s²**, obtained by three independent calculations, these are still approximate values. They still cannot claim to be a constant of the

Universe. But even these approximate values indicate that the actual value of the additional acceleration must be higher than the MOND threshold.

For precision physics and metrology, a more accurate value of the additional acceleration is needed. In this case, the additional acceleration must be calculated, not entered manually. Below, we propose a unique method for calculating additional acceleration A_0 .

At various times, equations —linking the parameters of the observable Universe with fundamental physical constants—were discovered by prominent scientists (Schrödinger, Bleksley, Milne, Rice, Tully, Fisher). To calculate a more accurate value of the acceleration A_0 , we combined the disparate cosmological equations of Schrödinger, Milne, Rice, and Tully–Fisher into a single system of cosmological equations. As a result, we have obtained a system of algebraic equations (Fig. 13) which has a solution. The additional acceleration A_0 is calculated from a system of cosmological equations. Additional acceleration A_0 is one of the roots of the system of algebraic equations (Fig. 13). The system of cosmological equations includes the Milne equation ($GM_U = c^3 T_U$), the Schrödinger equation ($GM_U = c^2 R_U$), the Rice equation ($R_U Gm_e = \alpha c^2 r_e^2$) and the Tully–Fisher equation for the universe ($c^4 = GM_U A_0$) (Fig. 13).



$$\left\{ \begin{array}{l} GM_U = c^3 T_U \\ GM_U = c^2 R_U \\ R_U Gm_e = \alpha c^2 r_e^2 \\ c^4 = GM_U A_0 \end{array} \right.$$

Fig. 13. A system of cosmological equations, used to calculate the additional acceleration A_0 .

We use the system of cosmological equations of the Universe to eliminate human-invented units of measurement, since the Universe "knows nothing" about them. The cosmological equations (Fig. 13) are reduced to pure, "absolute" numbers ($\dots = \alpha$ or $\dots = 1$), which are the same at any point in the Universe and for any civilization. As a result, the roots of the system of algebraic equations turn out to be not random physical quantities, but fundamental mathematical constants and codes of the Universe. We will further demonstrate that it is precisely "alpha" and its combinations that suddenly begin to play the role of the main mathematical key to the values of the Universe's parameters. This is the key to the direct mathematical connection between the parameters of the Metagalaxy and the constants of the microcosm.

“The roots of the system of cosmological equations (Fig. 13), in which the constants of the microcosm and the parameters of the Universe are related by

dimensionless numbers (...= α or ...= 1), are the exact values of the fundamental parameters of the Universe."

In addition to the acceleration A_0 , the system of cosmological equations of the Universe allows all the parameters of the observable Universe to be determined with a high degree of accuracy. Solving the system of equations yields the following values for the parameters of the Universe (Fig. 14):

$$\begin{aligned} G &= 6.67430 \dots \bullet 10^{-11} \text{ kg}^{-1} \text{ m}^3 \text{ s}^{-2} \\ M_U &= 1.15348 \dots \bullet 10^{53} \text{ kg} \\ R_U &= 0.856594 \dots \bullet 10^{26} \text{ m} \\ T_U &= 2.85729 \dots \bullet 10^{17} \text{ s} \\ A_0 &= 10.4922 \bullet 10^{-10} \text{ m} / \text{ s}^2 \end{aligned}$$

Fig. 14. Values of the parameters of the Universe derived from the system of cosmological equations.

The acceleration A_0 and other parameters of the Universe are the mathematical roots of a system of algebraic equations. All the calculated values of the parameters of the Universe have a precision close to that of the gravitational constant. This represents an unprecedented level of precision 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 of the mass of the observable Universe ($M_U \approx 1.45 \bullet 10^{53} \text{ kg}$), we obtained its exact value ($M_U = 1.15348 \bullet 10^{53} \text{ kg}$). Precise values of R_U and T_U were also obtained. The first test of them ($F = GM_U^2/R_U^2 = 1.210^{27} \times 10^{44} \text{ N} = F_P$) gives the exact value of the Planck force.

The acceleration caused by the mass of the Universe is of the same order of magnitude as the critical acceleration of the MOND model, but exceeds it in absolute value (Fig. 15).

$$\mathbf{A_0 = 10.4922... \bullet 10^{-10} \text{ m/s}^2}$$

Fig. 15. New acceleration constant.

Based on the foregoing, I draw the following conclusions:

"The obtained value $A_0 = 10.4922... \bullet 10^{-10} \text{ m/s}^2$ is a new acceleration constant, previously unknown in physics and cosmology. This is the acceleration caused by the mass of the universe. This acceleration is ubiquitous. The new acceleration constant A_0 leads to a new law of gravitation. In terms of Einstein's General Theory of Relativity (GTR), the acceleration

$A_0 = 10.4922... \cdot 10^{-10} \text{ m/s}^2$ is a direct physical embodiment of the geometric background curvature of spacetime of the Universe. This is a local physical manifestation of the geometric curvature of spacetime, given by the cosmological constant Λ .

Acceleration $A_0 = 10.4922... \cdot 10^{-10} \text{ m/s}^2$ is a fundamental integral parameter of the Universe. The acceleration (A_0) caused by the mass of the universe is an additional acceleration to the local Newtonian acceleration. When the local Newtonian acceleration is significant, the contribution of A_0 to the resultant acceleration is negligible. When local accelerations are small, the contribution of A_0 to the resultant acceleration is substantial. Since, in experiments to measure the gravitational constant G , the local acceleration is of the order of $\sim 10^{-7}$, the acceleration A_0 cannot be neglected. Dependent on the angle between the vector of the Newtonian force and the vector of the cosmological constant, the contribution A_0 can alter the value of G to the fourth or fifth decimal place.

10. The new acceleration constant $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$ complements the family of known acceleration constants.

The constant $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$, which is needed to calculate the value of "Big G," is not among the known acceleration constants in physics. This is a new constant. In physics, there are several important fixed values of acceleration that are used in science as acceleration constants:

- Planck acceleration $a_p = 5,56073 \times 10^{51} \text{ m/s}^2$; Calculated from Planck units.
- classical limiting acceleration $a_{\max} = 3,1894046 \times 10^{31} \text{ m/s}^2$. Calculated from the formula: $a_{\max} = c^2/r_e$.
- critical Schwinger acceleration $a_s = 2,3274210 \times 10^{29} \text{ m/s}^2$. Calculated from the formula: $a_s = m_e c^3/\hbar$.
- gravitational acceleration created by the mass of an electron at a distance of its classical radius $a_g = 7.65651 \times 10^{-12} \text{ m/s}^2$, derived from Newton's law.
- MOND critical acceleration: $a_0 \approx 1.2 \times 10^{-10} \text{ m/s}^2$. This is an empirical constant and is not derived from the fundamental laws of physics.

All of the listed acceleration constants (except MOND critical acceleration) are related to each other through fundamental physical constants. Let's demonstrate this relationship. The ratio of the classical limiting acceleration $3,1894046 \times 10^{31} \text{ m/s}^2$ to the gravitational acceleration of the electron $7.65651 \times 10^{-12} \text{ m/s}^2$ yields a large number well known in physics:

$$a_{\max}/a_g = 4.1656 \cdot 10^{42} = D_0 \quad (2)$$

This is the famous large Weyl number, which was originally obtained as the ratio of the Coulomb repulsion force to the gravitational attraction force between two electrons.

Large Weyl numbers are frequently encountered in physics. This is the ratio of the electrostatic force of an electron (**29,05351 N**) to the force of gravitational attraction of two electrons (**$6.9746 \cdot 10^{-42} \text{ N}$**), and the ratio of the Planck force (**$1.21027 \times 10^{44} \text{ N}$**) to the electrostatic force (29.0535 N), and the ratio of the square root of the Planck force (**$\sqrt{1.21027 \times 10^{44}}$**) to the square root of the force of gravitational attraction of two electrons (**$\sqrt{6.9746 \times 10^{-42}}$**).

Let's look at how the other acceleration constants are related to each other in pairs. The ratio of the critical Schwinger acceleration **$2,3274210 \times 10^{29}$** m/s² to the gravitational acceleration of the electron 7.65651×10^{-12} m/s² yields a large number equal to the product of the Weyl number and the fine structure constant "alpha":

$$a_s/a_g = 3.03979 \times 10^{40} = \alpha \cdot D_0 \quad (3).$$

The ratio of the square of the Planck acceleration **$5,56073 \times 10^{51}$** m/s² to the square of the classical limiting acceleration 3.1894046×10^{31} m/s² also gives the number $\alpha \cdot D_0$:

$$(a_p/a_{\max})^2 = 3.03979 \times 10^{40} = \alpha \cdot D_0 \quad (4).$$

The same number $\alpha \cdot D_0 = 3.03979 \times 10^{40}$ is also obtained from the ratio of the fundamental electric force of the electron (29.05351 N) to the gravitational force of interaction of the electron with the mass of the Universe (9.5577×10^{-40} N) and the ratio of the square of the classical radius of the electron to the square of the Planck length: $(r_e/t_p)^2 = 3.03979 \cdot 10^{40}$; and the ratio of the square of the characteristic time of the electron ($t_e=r_e/c$) to the square of the Planck time: $(t_e/t_p)^2 = 3.03979 \cdot 10^{40}$.

The ratio of the critical Schwinger acceleration **$2,3274210 \times 10^{29}$** m/s² to the classical limiting acceleration **$3,1894046 \times 10^{31}$** m/s² yields the fine-structure constant α :

$$a_s/a_{\max} = 7.297353 \dots \times 10^{-3} = \alpha \quad (5).$$

The ratio of the square of the Planck acceleration **$5,56073 \times 10^{51}$** m/s² to The square of the critical Schwinger acceleration **$2,3274210 \times 10^{29}$** m/s² yields the number D_0/α :

$$(a_p/a_s)^2 = 5.70839 \times 10^{44} = D_0/\alpha \quad (6)$$

As we can see, the numbers $\alpha = 7.297353 \cdot 10^{-3}$ $D_0 = 4.1656 \cdot 10^{42}$ and $\alpha \cdot D_0 = 3.03979 \times 10^{40}$ are mathematical standards linking acceleration constants of different scales. Below it is shown how these same numbers $\alpha = 7.297353 \cdot 10^{-3}$ $D_0 = 4.1656 \cdot 10^{42}$ and $\alpha \cdot D_0 = 3.03979 \cdot 10^{40}$ connect the new constant $A_0 = 10.4922 \cdot 10^{-10}$ m/s² with the known acceleration constants.

11. The relationship of the acceleration constant $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ with known acceleration constants.

The new constant A_0 is harmoniously related to all known acceleration constants in physics. This striking relationship is mediated by the fundamental constant $\alpha = 7.297353 \cdot 10^{-3}$ and the large Weyl number $D_0 = 4.1656 \cdot 10^{42}$ (Fig. 16).

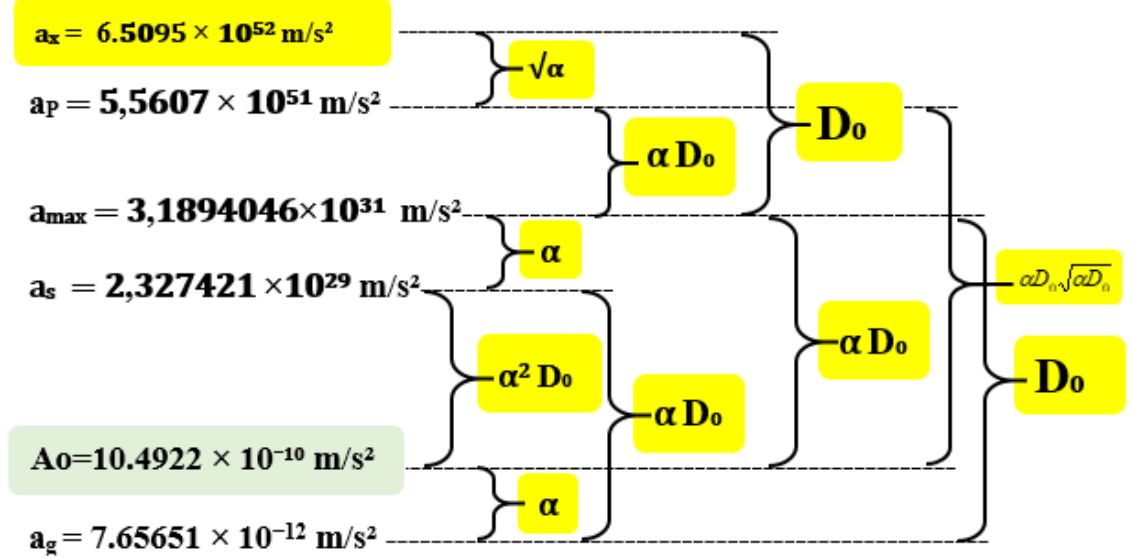


Fig. 16. Harmony of acceleration constants: the relationship of constants through the numbers “Alpha” and $D_0 = 4.1656 \cdot 10^{42}$

The ratio of the classical limiting acceleration $3,1894046 \times 10^{31} \text{ m/s}^2$ to the acceleration $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ gives the number $3.03979 \times 10^{40} = \alpha D_0$:

$$a_{\text{max}}/A_0 = 3.03979 \times 10^{40} = \alpha D_0 \quad (7)$$

The ratio of the gravitational acceleration of the electron $7.65651 \times 10^{-12} \text{ m/s}^2$ to the acceleration $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ gives the fine structure constant α :

$$a_g/A_0 = 7.297353 \dots \times 10^{-3} = \alpha \quad (8)$$

The ratio of the critical Schwinger acceleration $2,3274210 \times 10^{29} \text{ m/s}^2$ to the acceleration $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ yields the number $\alpha^2 D_0$:

$$a_s/A_0 = \alpha^2 \cdot D_0 \quad (9)$$

The ratio of the Planck acceleration $5,56073 \times 10^{51} \text{ m/s}^2$ to the acceleration $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ yields the number:

$$a_p/A_0 = \alpha D_0 \sqrt{\alpha D_0} \quad (10)$$

The identified patterns in the scaling of the acceleration constants have predictive power. The patterns predict the existence of another acceleration constant (a_x), the value of which is GREATER than the Planck acceleration (Fig. 16). The value of this constant is easily calculated using the large Weyl number $D_0 = 4.1656 \cdot 10^{42}$ and the classical limiting acceleration $3,1894046 \times 10^{31} \text{ m/s}^2$:

$$a_x = \sqrt{((a_{\text{max}})^2 \cdot D_0)} = 6.5095 \cdot 10^{52} \text{ m/s}^2 \quad (11).$$

The number $6.5095 \cdot 10^{52} \text{ m/s}^2$ is none other than George Stoney's acceleration constant. Stoney acceleration is acceleration in the Stoney system of units. This system of natural units was proposed by the Irish physicist George Stoney in 1881, long before Max Planck proposed his famous Planck system of units. In modern physics, Stoney acceleration (and the entire Stoney system of units) is extremely rare. Preference is given to Planck units. Our rediscovery of the Stoney acceleration constant $a_x = 6.5095 \cdot 10^{52} \text{ m/s}^2$ confirms the deep connection between acceleration constants. Stoney acceleration is also related to other acceleration constants by the scaling factors "ALPHA" and the Weyl number $D_0 = 4.16561 \cdot 10^{42}$.

The ratio of the square of the Stoney acceleration ($6.5095 \cdot 10^{52} \text{ m/s}^2$) to the square of the number $3.1894046 \cdot 10^{31} \text{ m/s}^2$ is equal to the large Weyl number $D_0 = 4.16561 \cdot 10^{42}$:

$$(a_x/a_{\max})^2 = 4.1656 \cdot 10^{42} = D_0 \quad (12)$$

The ratio of the square of the number $6.5095 \cdot 10^{52} \text{ m/s}^2$ to the square of the Schwinger acceleration $2,3274210 \cdot 10^{29} \text{ m/s}^2$ gives the number: D_0/α .

$$(a_x/a_s)^2 = 7.8225 \cdot 10^{46} = D_0/\alpha^2 \quad (13).$$

The ratio of the Stoney acceleration of $6.5095 \cdot 10^{52} \text{ m/s}^2$ to the acceleration $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ yields the number: :

$$a_x/A_0 = 6.20415 \cdot 10^{61} = \alpha D_0 \sqrt{D} \quad (14).$$

The new constant $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ fits perfectly into the family of acceleration constants and complements it. All known acceleration constants in physics can be easily reduced to the new constant $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ using the numbers "alpha" and $D_0 = 4.1656 \cdot 10^{42}$:

$$a_g/\alpha = 7.65651 \cdot 10^{-12} \text{ m/s}^2 / 7.297353 \cdot 10^{-3} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (15)$$

$$a_s/\alpha^2 D_0 = 2.327421 \cdot 10^{29} \text{ m/s}^2 / 2.21824 \cdot 10^{38} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (16)$$

$$a_{\max}/\alpha D_0 = 3.18940 \cdot 10^{31} \text{ m/s}^2 / 3.03979 \cdot 10^{40} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (17)$$

$$a_p/\alpha D_0 \sqrt{(\alpha D_0)} = 5.5607 \cdot 10^{51} \text{ m/s}^2 / 5.29987 \cdot 10^{60} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (18).$$

$$a_x/\alpha D_0 \sqrt{D} = 6,5095 \cdot 10^{52} \text{ m/s}^2 / 6.20415 \cdot 10^{61} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (19).$$

12. The absolute upper limit of the gravitational force, calculated using the constant $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$.

The constant A_0 allows us to calculate the absolute upper theoretical limit of the gravitational force that is, in principle, possible between two objects:

$$\begin{aligned} F_{\max} &= M_U A_0 = \frac{GM_U^2}{R_U^2} = \frac{M_U R_U}{T_U^2} = M_U c^2 \sqrt{\Lambda} = \frac{c^4}{G} = GM_U^2 \Lambda = \frac{M_U c}{T_U} = \\ &= \frac{M_U G \hbar}{c r^3} = \dots = \frac{M_U G m_e}{\alpha r_e^2} = \frac{M_U c^2}{r_e \alpha D_0} = 1.21027 \cdot 10^{44} \text{ N} \end{aligned} \quad (20)$$

All the equivalent formulae yield the value: $1.21027 \times 10^{44} \text{ N}$. This is none other than the Planck force, well known in general relativity and quantum gravity. For a century, the Planck force

was regarded as a purely abstract mathematical limit of the microworld. The absolute upper limit of the gravitational force in the Universe also turned out to be the Planck force. Newton's law underlies all the equivalent formulas (20), while the values of the Universe's parameters were derived as the mathematical roots of a system of algebraic equations. It is noteworthy that the Planck force formulae include Planck's constant h , the speed of light and the parameters of the Universe, but do not include Planck units. Moreover, neither the Friedmann equations nor the equations describing black holes were required to derive the Planck force.

These are new formulae for calculating the Planck force, derived from the acceleration $A_0 = 10.4922... \times 10^{-10} \text{ m/s}^2$. The speed of light, which features in both the force formulas and the formula for acceleration A_0 , is the speed at which gravity propagates.

An important conclusion follows from formula (20):

“Of all the acceleration constants known in physics, only one constant $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$ directly connects the mass of the Universe M_U with the Planck force ($1.21027 \times 10^{44} \text{ N}$).”

If we consider a hypothetical gravitational attraction between an electron and the Universe, the equivalent equations allow us to determine the value of the force.

$$F_{e-U} = m_e A_0 = \frac{m_e G M_U}{R_U^2} = \frac{m_e R_U}{T_U^2} = m_e c^2 \sqrt{\Lambda} = \frac{m_e c^4}{G M_U} = m_e G M_U \Lambda = \frac{m_e c}{T_U} = \frac{m_e G \hbar}{c r^3} = \dots = \frac{G m_e^2}{\alpha r_e^2} = 9.5577 \cdot 10^{-40} \text{ N} \quad (21)$$

This is a new constant. It represents the gravitational interaction between a single electron and the entire Universe. The physical significance of this constant is that it shows the total gravitational influence of the Universe on a single electron is comparable to the quantum forces of the microcosm. For example, the gravitational force constant between two electrons at a distance equal to the classical electron radius is: $6.9746 \times 10^{-42} \text{ Newtons}$. This is 137 (!) times smaller than the new force constant.

The constant of the gravitational force between an electron and the entire mass of the Universe is $9.5577 \times 10^{-40} \text{ N}$. The formulas for the gravitational constant between an electron and the Universe includes Planck's constant h , the speed of light and the parameters of the Universe.

The ratio of the Planck force to the gravitational force of attraction of an electron to the Universe demonstrates a surprising mathematical coincidence. This ratio yields, with high precision, a number represented by a combination of the fine-structure constant α and the Weyl number $D_0 = 4.1656 \cdot 10^{42}$.

$$\frac{F_{MAX}}{F_{e-U}} = \frac{F_P}{F_{e-U}} = 1.26626 \cdot 10^{83} = \alpha D_0^2 \quad (22)$$

Where: α is the fine-structure constant; D_0 is the large Weyl number ($D_0 = 4.1656 \cdot 10^{42}$).

13. The Tully–Fisher relation in the cosmological limit.

The ratio of the Planck force F_P to the mass of the Universe M_U yields the constant $A_0 = 10.4922 \cdot 10^{-10} \text{ m/s}^2$:

$$F_P/M_U = 1.21027 \times 10^{44} \text{ N} / 1/15348 \cdot 10^{53} \text{ kg} = 10.4922 \cdot 10^{-10} \text{ m/s}^2 = A_0 \quad (23).$$

Formula (23) directly implies the Tully–Fisher relation for the Universe. In this extreme theoretical limit, relation (23) takes the following form:

$$F_p/M_U = c^4/GM_U = A_0 \quad (24).$$

From this it follows:

$$c^4 = GM_U A_0 \quad (25).$$

This is the result of the limiting transition of the local Tully–Fisher relation to the cosmological scale, when the velocity tends to the maximum possible physical limit—the speed of light ($v_{\max} \rightarrow c$). In this case, the local equation for an individual object inevitably develops into an equation for the entire Universe, linking its total mass M_U to fundamental constants. We regard formula (25) as the "Tully–Fisher limit for the Universe." At the level of the Universe, the local variable ($v_{\max}$) reaches its absolute limit (c), the local mass tends to the limiting mass—the mass of the Universe M_U —and the Tully–Fisher relation turns into an exact equation that includes the parameters of the Universe: G , c , M_U , A_0 .

14. An algebraic equation for the dimensionless mass of the Universe.

Dimensionless constants are needed in physics because they express true properties of our Universe, independent of the choice of unit system. To eliminate man-made units of measurement, we can use dimensionless constants to describe the Universe: the fine structure constant (α) and the large Weyl number ($D_0 = 4.1656 \times 10^{42}$) in various combinations. We will demonstrate this using the example of the dimensionless mass of the Universe.

Let us represent the dimensionless mass of the Universe $\mathcal{M}$ as the ratio of the mass of the Universe M_U to the mass of the electron m_e :

$$\mathcal{M} = \alpha \cdot D_0^2 = 1.26626 \cdot 10^{83} = M_U/m_e \quad (26).$$

The dimensionless mass of the Universe $\mathcal{M}$ is uniquely characterized by the number $\alpha \cdot D_0^2$. The number $\alpha \cdot D_0^2 = 1.26626 \cdot 10^{83}$ shows how many electron masses are contained in the entire observable Universe. This is its physical meaning. It turns out that the macrocosm and the microcosm are connected by such a rigid mathematical harmony that all information about the Universe is already "sewn" into quantum constants. This mathematical magic leads to the fact that it is enough to take the mass of a tiny electron m_e and multiply it by the dimensionless constant $\alpha \cdot D_0^2$ to obtain the exact value of the mass of the Universe: **$1.15348 \cdot 10^{53}$ kg**. This means that the macrocosm is a mirror image of the microcosm. The obtained theoretical value of the mass of the Universe (**$1.15348 \cdot 10^{53}$ kg**) is in full agreement with modern experimental estimates of astrophysics (range from 10^{52} to 10^{54} kg), calculated on the basis of the critical density of the Universe and the Hubble radius.

15. Conclusion

In addition to the known cosmological equations of Stewart, Dirac, Eddington-Weinberg, Teller, Rice, Nottale, Milne, Bleksley, Hoyle, Carvalho, new cosmological equations are derived which reveal the fundamental relationship between the parameters of the Universe and physical constants. New cosmological equations are derived using previously unknown large numbers on scales 10^{140} , 10^{160} , and 10^{180} . The key to unlocking the mystery of large numbers is provided by new cosmological equations demonstrating the relationship between the parameters of the Universe and the fine structure constant α . Based on the revealed connection between the parameters of the Universe and fundamental physical constants, a mathematical method for obtaining the parameters of

the Universe is developed. The mathematical method gives values of the parameters of the Universe with an accuracy close to the accuracy of the Newtonian constant of gravitation G . This is an unprecedented precision for the parameters of the Universe.

The parameters of the Universe are the roots of the system of algebraic equations. It strikes the imagination how mathematically fine-tuned the Universe is. The main discovery was the following: the values of the Universe parameters are scale-transformed electron constants; the scale factors are large numbers; the large numbers come from the fine structure constant "alpha". The relationship between the parameters of the Universe and the fundamental constants indicates that the architecture of the Universe is "tuned" with exquisite mathematical precision, with cosmological scales rigidly predetermined by the constants of the microworld. To explain the observable Universe, the fundamental laws of physics alone are sufficient.

References

1. H.Weyl, *Raum-Zeit-Materie* (Berlin,1918).
2. Dirac, P. A. M., *Nature*, 139, 323 (1937).
3. Dirac, P. A. M., *Proc. R. Soc., A* **165**, 199 (1938)
4. Stewart J. O. "Phys. Rev.", 1931, v. 38, p. 2071.
5. Muradyan, R. M. Universal constants. Physical and astrophysical constants and their dimensional and dimensionless combinations. *Fiz. ehlementar. chastits i atom. yadra*, Vol. 8, No. 1, p. 175 - 192. 1977.
6. S. Weinberg, "Gravitation and Cosmology," Wiley, New York, 1972.
7. S. Eddington, *Fundamental Theory* (Cambridge University Press, 1946).
8. E. Teller, *Phys. Rev.* 73, 801(1948) E. Teller (1948). On the change of physical constants. *Physical Review*, vol.73 pp. 801—802. DOI:10.1103/PhysRev.73.801
9. Kuhne, Rainer W.. "TIME-VARYING FINE-STRUCTURE CONSTANT REQUIRES COSMOLOGICAL CONSTANT." *Modern Physics Letters A* 14 (1999): 1917-1922.
10. Rice J. On Eddington's natural unit of the field // *Philosophical Magazine Series 6*. — 1925. — Vol. 49. — P. 1056—1057.
11. Nottale, L. (1993) Mach's Principle, Dirac's Large Numbers and the Cosmological Constant Problem. <http://www.luth.obspm.fr/%7Eluthier/nottale/arlambda.pdf>
12. Laurent Nottale. Solution to the cosmological constant problem from dark energy of the quark vacuum. 2019. (hal-02133255).
13. Milne, E. A. On the foundations of dynamics. *Proc. R. Soc. A* **1936**, 154, 22–52.
14. Espen Gaarder Haug. Progress in the Composite View of the Newton Gravitational Constant and Its Link to the Planck Scale. *Universe* 2022, 8(9), 454; <https://doi.org/10.3390/universe8090454>
15. A. E. H. Bleksley. A new approach to cosmology: Iii. *South African Journal of Science*, 48 (1), 1951. https://hdl.handle.net/10520/AJA00382353_3467
16. F. Hoyle, in *Proc. 11th Solvay Conference in Physics*, Ed. R. Stoops, Brussels, Belgium (1958).
17. Carvalho, J.C. Derivation of the mass of the observable universe. *Int J Theor Phys* 34, 2507–2509 (1995). <https://doi.org/10.1007/BF00670782>
18. Mykola Kosinov. Reducing approximate cosmological equations to exact equations. February 2024. DOI: [10.13140/RG.2.2.12475.59689](https://doi.org/10.13140/RG.2.2.12475.59689)
19. L. Nottale, *Fractal Space-Time and Microphysics* (World Scientific, London, (1993) pp. 283-307. (misprints corrected and notes added, 27 March 2006.)

20. P. H. Chavanis, *Phys. Dark Univ.* 24, 100271 (2019). (A.S. Eddington *Proc. R. Soc. A* 133 (1931) 605
21. Mykola Kosinov. THE LAW OF SCALING FOR LARGE NUMBERS: origin of large numbers from the primary large number $D_{20} = 1.74349... \times 10^{20}$. January 2024. DOI: 10.13140/RG.2.2.33664.20480
22. Mykola Kosinov. PARAMETERS OF THE OBSERVABLE UNIVERSE AND PLANCK'S CONSTANT IN ONE EQUATION: a the strange and useful unity of the constants of the microcosm and the universe. January 2024. DOI: [10.13140/RG.2.2.16290.61128](https://doi.org/10.13140/RG.2.2.16290.61128)
23. Mykola Kosinov. Unexpected connection of the parameters of the observed Universe with the fine structure constant alpha. February 2024. DOI: [10.13140/RG.2.2.24039.42408](https://doi.org/10.13140/RG.2.2.24039.42408)