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SYSTEMS OF COSMOLOGICAL EQUATIONS OF THE UNIVERSE. THE FINE STRUCTURE CONSTANT "ALPHA" IN A NEW CAPACITY AS THE MAIN CONSTANT OF COSMOLOGY.

Abstract: *A mathematical method for obtaining the parameters of the Universe is found. New cosmological equations linking the parameters of the Universe with the fine structure constant "alpha" are derived. The appearance of the constant "alpha" in cosmological equations opens new possibilities in cosmology. In this paper, we investigate the phenomenon of the appearance of the microcosm constant "alpha" in cosmological equations. Cosmological equations are combined into systems of cosmological equations. This makes it possible to obtain the parameters of the universe as the solution of the system of algebraic equations of the universe. The theory based on the law of scaling of large numbers allows us to obtain the parameters of the observed Universe with an accuracy close to the accuracy of the Newtonian constant of gravitation G. It is shown that all the main parameters of the Universe and large numbers of scales 10^20 - 10^180 are composite quantities and include the fine structure constant "alpha". The fine structure constant "alpha" shows itself not only as a fundamental constant of the microworld, but also as the main constant of cosmology. The "alpha" constant makes it possible to obtain the values of the parameters of the Universe by a mathematical method from the electron constants. The fundamental connection between the parameters of the Universe and electron constants is revealed.*

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

1. Introduction

At different times, cosmological equations including 2 and 3 parameters of the Universe and fundamental physical constants have been proposed by famous scientists. These cosmological equations indicate that there is a relationship between the parameters of the universe and the fundamental physical constants. They include the Dirac equation [1, 2], Stewart equation [3, 4], Eddington-Weinberg equation [5, 6], Teller equation [7, 8], Rice equation [90] Nottale equation [10, 11], Milne equation [12, 13], Bleksley equation [14], Hoyle equation [15], Carvalho equation [16]. The known cosmological equations contain a limited number of parameters of the universe. The approximate equations and the limited number of parameters of the Universe in the equations did not allow us to obtain from them the values of the parameters of the Universe with accuracy better than on the order of magnitude. In [17] these equations were supplemented with new cosmological equations including more than three parameters of the Universe. This allowed us to form systems of cosmological equations containing all the main parameters of the Universe.

As a result, it was possible to reduce the problem of determining the parameters of the universe to solving a system of algebraic equations. This is a new mathematical method for obtaining the parameters of the Universe. Among the derived cosmological equations there are those that demonstrate an unexpected connection between the parameters of the Universe and the fine structure constant "alpha"[19]. The appearance of the fine structure constant "alpha" in the cosmological equations is a significant event in cosmology. In this paper, we investigate the phenomenon of the appearance of the microcosm constant "alpha" in cosmological equations.

2. The fine structure constant "alpha" in the law of scaling of large numbers.

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 [18]. The law of scaling of large numbers includes two dimensionless constants: fine structure constant "alpha" and Weyl number.

The law of scaling of large numbers has the form (Fig. 1):

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

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

Fig. 1. The scaling law of large numbers. D_0 is a large Weyl number (D_0 = 4.16561...x 10^{42}), α - fine structure constant.

The scaling law provides a new method for calculating the values of large numbers from dimensionless constants. The scaling law generates large numbers up to the 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. The values of the large numbers and the formulas for their calculation are given in Fig. 2.

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

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

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

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

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

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

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

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

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

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

Fig. 2. Fine structure constant "alpha" in large number formulas.

3. Coincidences of large numbers as a basis for deriving cosmological equations

The table in Fig. 3 summarizes the relationships of dimensional quantities that lead to large numbers. 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
$\frac{Gm_e^2}{r_e\alpha^2\hbar H}=\frac{G\hbar}{r_e^3Hc^2}=\frac{Gm_e}{r_e^2\alpha Hc}=\frac{Gm_e^3c}{\alpha^3\hbar^2H}=\frac{c^2}{M_UR_UG\Lambda}=\frac{c^3}{M_UGH}=\frac{c^2R_U}{M_UG}=\frac{l_{Pl}^4}{\Lambda r_e^6}=$ $=\frac{c^3T_U}{M_UG}=\frac{\Lambda c^2}{H^2}=\frac{c^3T_U^3}{R_U^3}=\frac{H^2}{M_UR_UG\Lambda^2}=\frac{cr_e^3A_0}{G\hbar}=\frac{c^4}{M_UR_UH^2G}=\frac{M_UR_UHA_0G}{c^5}=1$	10^0
$D_{20}=\frac{r_e}{l_{Pl}}=\frac{t_0}{t_{Pl}}=\frac{\alpha\, m_{Pl}}{m_e}=\frac{cl_{Pl}}{r_e^2H}=\frac{l_{Pl}R_U}{r_e^2}=\frac{c^2l_{Pl}}{r_e^2A_0}=\sqrt{\alpha D_0}$	10^{20}
$D_{40}=\frac{T_U}{t_0}=\frac{R_U}{r_e}=\frac{m_ec^2}{\alpha\hbar H}=\frac{1}{t_0H}=\frac{r_e^2}{l_{Pl}^2}=\frac{t_0^2}{t_{Pl}^2}=\frac{\alpha^2m_{Pl}^2}{m_e^2}=\frac{c^2}{r_eA_0}=(\sqrt{\alpha D_0})^2$	10^{40}
$D_{60}=\frac{T_U}{t_{Pl}}=\frac{R_U}{l_{Pl}}=\frac{M_U}{m_{Pl}}=\frac{c}{l_{Pl}H}=\frac{r_e^3}{l_{Pl}^3}=\frac{t_0^3}{t_{Pl}^3}=\frac{c^3}{Gm_{Pl}H}=\frac{c^2}{l_{Pl}A_0}=(\sqrt{\alpha D_0})^3$	10^{60}
$D_{80}=\frac{R_U^2}{r_e^2}=\frac{HM_U^2\alpha G}{c^3m_e}=\frac{c^2}{r_e^2H^2}=\frac{cr_e}{Hl_{Pl}^2}=\frac{1}{r_e^2\Lambda}=(\sqrt{\alpha D_0})^4$	10^{80}
$D_{100}=\frac{m_ec^3}{l_{Pl}\alpha\hbar H^2}=\frac{r_e\alpha M_U}{l_{Pl}m_e}=\frac{HM_U^2\alpha Gr_e}{c^3m_el_{Pl}}=\frac{R_U^2}{r_el_{Pl}}=\frac{1}{r_el_{Pl}\Lambda}=(\sqrt{\alpha D_0})^5$	10^{100}
$D_{120}=\frac{T_U^2}{t_{Pl}^2}=\frac{R_U^2}{l_{Pl}^2}=\frac{M_U^2}{m_{Pl}^2}=\frac{c^2}{l_{Pl}^2H^2}=\frac{R_U^3}{r_e^3}=\frac{M_Uc^2}{\hbar H}=\frac{GM_U^2}{\hbar c}=\frac{c^5}{G\hbar H^2}=\frac{c^3}{G\hbar\Lambda}=\frac{1}{l_{Pl}^2\Lambda}=(\sqrt{\alpha D_0})^6$	10^{120}
$D_{140}=\frac{r_e^2m_ec^3}{l_{Pl}^3\alpha\hbar H^2}=\frac{r_e^3\alpha M_U}{l_{Pl}^3m_e}=\frac{R_U^3}{l_{Pl}r_e^2}=\frac{1}{t_{Pl}t_0^2H^3}=\frac{c}{l_{Pl}r_e^2H\Lambda}=\frac{c^2}{l_{Pl}r_e^2A_0\Lambda}=(\sqrt{\alpha D_0})^7$	10^{140}
$D_{160}=\frac{M_UR_Uc^2\alpha^2}{Gm_e^2}=\frac{M_U^2R_UG\alpha}{c^2r_e^2m_e}=\frac{1}{r_e^4\Lambda^2}=(\sqrt{\alpha D_0})^8$	10^{160}
$D_{180}=\frac{r_e^4m_ec^3}{l_{Pl}^5\alpha\hbar H^2}=\frac{r_e^5\alpha M_U}{l_{Pl}^5m_e}=\frac{R_U^3}{l_{Pl}^3}=\frac{c^3}{l_{Pl}^3H^3}=\frac{c}{l_{Pl}^3H\Lambda}=\frac{c^2}{l_{Pl}^3A_0\Lambda}=\frac{GM_UT_U^2l_{Pl}}{\Lambda r_e^6}=(\sqrt{\alpha D_0})^9$	10^{180}

Fig. 3. Relationships of dimensional constants yielding large numbers. M_U is the mass of the observable Universe, α is the fine structure constant, ħ 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, A_0 is the cosmological acceleration, r_e is the classical radius of the electron; c - speed of light in vacuum; $t_0 = r_e/c$, m_e - electron mass, D_0 - large Weyl number, t_{pl} - Planck time, l_{pl} - Planck length, m_{pl} - Planck mass.

4. New cosmological equations

In [17] new cosmological equations are given, which include more than three parameters of the Universe. The number of new cosmological equations was sufficient to form systems of cosmological equations containing all the main parameters of the Universe. It became possible to reduce the problem of calculating the parameters of the Universe to solving a system of algebraic equations. This is a new mathematical method of obtaining the parameters of the Universe. It is a good complement to the experimental method, since measuring the parameters of the observed Universe is a very difficult task and does not give the necessary accuracy.

5. Systems of cosmological equations and mathematical method for obtaining the parameters of the Universe.

New cosmological equations combined in a system of equations make it possible to obtain the parameters of the Universe as a result of solving a system of algebraic equations. The solution of the system of algebraic equations gives the parameters of the Universe with an accuracy close to the accuracy of the Newtonian constant of gravitation G.

From the cosmological equations obtained in [17] it is possible to compose various systems of algebraic equations. The large number of new cosmological equations gives a wide choice of different systems of equations. In [17] the following system of algebraic equations of the Universe is presented:

$$\begin{cases} G\hbar/r_e^{3}A_0 = c \\ 1/T_U^{2}\Lambda = c^2 \\ GR_U\hbar/r_e^{3} = c^3 \\ M_UA_0G = c^4 \\ M_UR_UA_0G/T_U = c^5 \end{cases}$$

FIG. 4. System of algebraic equations of the Universe

In this system of cosmological equations (Fig. 4), the known quantities are the fundamental physical constants **G, ħ,** $\mathbf{r_e}$**, c**. The unknown cosmological parameters $\mathbf{M_U}$**,** $\mathbf{R_U}$**, Λ,** $\mathbf{A_0}$**,** $\mathbf{T_U}$ are easily obtained by solving the system of algebraic equations.

The solution of the system of algebraic equations gives the following values of the Universe parameters (Fig. 5).

$$M_U = 1.15348... \bullet 10^{53} kg$$
$$R_U = 0.856594... \bullet 10^{26} m$$
$$T_U = 2.85729... \bullet 10^{17} s$$
$$\Lambda = 1.36285 ... \bullet 10^{-52} m^{-2}$$
$$G = 6.67430 ... \bullet 10^{-11} kg^{-1} m^3 s^{-2}$$
$$A_0 = 10.4922 ... \bullet 10^{-10} m / s$$

Fig. 5. Values of the Universe parameters obtained from the system (Fig. 5) of algebraic equations.

Among the new cosmological equations there are those that contain Planck's constant.

$$M_U \Lambda c r_e^3 = \hbar, \quad \frac{c^5 r_e^3}{M_U G^2} = \hbar, \quad \frac{R_U \Lambda c^3 r_e^3}{G} = \hbar, \quad \frac{c r_e^3 A_0}{G} = \hbar,$$
$$m_e c r_e^2 \sqrt{\Lambda D_0^2} = \hbar, \quad \frac{c^5 r_e^3 \Lambda}{G A_0} = \hbar, \quad \frac{c^3 t_e^3}{G R_U} = \hbar, \quad \frac{M_U r_e^3}{R_U T_U} = \hbar.$$

Fig. 6. Planck constant in cosmological equations. Where : ħ - Planck constant, M_U - mass of the observable Universe, G - Newtonian constant of gravitation, Λ - cosmological constant, R_U - radius of the observable Universe, A_0 - cosmological acceleration, r_e - classical electron radius; c - speed of light in vacuum; m_e - electron mass, D_0 - large number.

From the cosmological equations containing Planck's constant (Fig. 6) the system of algebraic equations (Fig. 7) is composed, where the fundamental physical constants **m_e, G, ħ, r_e, c** are known, and the unknown parameters are mass **M_U**, lambda **Λ**, radius **R_U**, time **T_U**, acceleration **A_0**.

$$\begin{cases} \frac{c^5 r_e^3}{M_U G^2} = \hbar \\ M_U \Lambda c r_e^3 = \hbar \\ \frac{R_U \Lambda c^3 r_e^3}{G} = \hbar \\ \frac{c r_e^3 A_0}{G} = \hbar \\ \frac{M_U r_e^3}{R_U T_U} = \hbar \end{cases}$$

Fig. 7. System of cosmological equations of the Universe with Planck's constant.

The solution of the system of algebraic equations (Fig. 7) gives the following values of the parameters of the Universe (Fig. 8).

$$M_U = 1.15348... \bullet 10^{53}\, kg$$
$$R_U = 0.856594... \bullet 10^{26} m$$
$$T_U = 2.85729... \bullet 10^{17}\, s$$
$$\Lambda = 1.36285\ ... \bullet 10^{-52}\, m^{-2}$$
$$G = 6.67430\ ... \bullet 10^{-11}\, kg^{-1} m^3 s^{-2}$$
$$A_0 = 10.4922\ ... \bullet 10^{-10}\, m / s$$

Fig. 8. Values of the parameters of the Universe from the system (Fig. 7) of algebraic equations.

From the new cosmological equations can be composed of other systems of algebraic equations (Fig. 9) and (Fig. 10):

$$\mathbf{M_U \Lambda G = A_0}$$
$$\mathbf{M_U R_U \Lambda^2 G T_U^2 = 1}$$
$$\mathbf{M_U R_U^3 \Lambda^2 G = A_0^2 T_u^2}$$
$$\mathbf{M_U G T_u^2 = R_u^3}$$
$$\mathbf{R_u^3 \Lambda = A_0 T_u^2}$$

Fig. 9. System of cosmological equations consisting directly of the parameters of the Universe.

$$M_U A_0 G = c^4$$
$$M_U \Lambda c r_e^3 = \hbar$$
$$\frac{M_U G^2 m_e}{c^4 r_e^2} = \alpha$$
$$\mathbf{M_U G T_u^2 = R_u^3}$$
$$\mathbf{M_U \Lambda G T_u^2 = R_U}$$

FIG. 10. Mixed system of cosmological equations of the Universe.

Both systems of equations (Fig. 9) and (Fig. 10) give the same values of the parameters of the Universe:

$$M_U = 1.15348... \bullet 10^{53}\, kg$$
$$R_U = 0.856594... \bullet 10^{26}\, m$$
$$T_U = 2.85729... \bullet 10^{17}\, s$$
$$\Lambda = 1.36285\ ... \bullet 10^{-52}\, m^{-2}$$
$$G = 6.67430\ ... \bullet 10^{-11}\, kg^{-1} m^3 s^{-2}$$
$$A_0 = 10.4922\ ... \bullet 10^{-10}\, m/s$$

Fig. 11. Values of the parameters of the Universe.

6. Relation of the parameters of the Universe with the fine structure constant "alpha"

The system of cosmological equations of the Universe containing the fine structure constant "alpha" is of greatest interest [19]. Fig. 12 shows the cosmological equations that give the fine structure constant "alpha" .

$$\frac{M_U G^2 m_e}{c^4 r_e^2} = \alpha, \quad \frac{m_e}{M_U \Lambda r_e^2} = \alpha, \quad \frac{G m_e}{R_U \Lambda c^2 r_e^2} = \alpha, \quad \frac{G m_e}{r_e^2 A_0} = \alpha,$$

$$\sqrt{\frac{1}{r_e^2 \Lambda D_0^2}} = \alpha, \quad \sqrt[3]{\frac{c^3}{G\hbar \Lambda D_0^3}} = \alpha, \quad \frac{G m_e A_0}{\Lambda c^4 r_e^2} = \alpha, \quad \frac{R_U G m_e}{r_e^2 c^2} = \alpha,$$

$$\frac{G m_e}{r_e^2 c^2 \sqrt{\Lambda}} = \alpha, \quad \frac{m_e c^4}{M_U A_0^2 r_e^2} = \alpha. \quad \frac{T_U G m_e}{r_e^2 c} = \alpha \quad \frac{m_e R_U^2}{M_U r_e^2} = \alpha$$

Fig. 12. Fine-structure constant "alpha" in the cosmological equations. Where: α - fine-structure constant, ħ - Planck constant, M_U - mass of the observable Universe, G - Newtonian constant of gravitation, Λ - cosmological constant, R_U - radius of the observable Universe, A_0 - cosmological acceleration, r_e - classical electron radius; c - speed of light in vacuum; m_e - electron mass, D_0 - large number.

Fig. 13 shows the system of cosmological equations with the fine structure constant "alpha".

$$
\begin{cases}
\dfrac{M_U G^2 m_e}{c^4 r_e^2} = \alpha ; \\[2ex]
\dfrac{m_e}{M_U \Lambda r_e^2} = \alpha ; \\[2ex]
\dfrac{G m_e}{R_U \Lambda c^2 r_e^2} = \alpha ; \\[2ex]
\dfrac{G m_e}{r_e^2 A_0} = \alpha ; \\[2ex]
\dfrac{G m_e T_U}{r_e^2 c} = \alpha .
\end{cases}
$$

Fig. 13: System of cosmological equations of the Universe with a constant fine structure "alpha".

In this system of cosmological equations, only the fundamental physical constants **G, α, m_e, r_e, c,** are known quantities. The unknown cosmological parameters **M_U, R_U, Λ, A_0, T_U** are easily obtained by solving the system of algebraic equations.

7. The fine structure constant "alpha" is the main constant of cosmology.

The new cosmological equations containing the fine structure constant "alpha" reveal the fundamental relationship between the parameters of the Universe and the electron constants. Fig. 14 shows the values of the parameters of the Universe obtained from the system of cosmological equations containing the "alpha" constant. New formulas for calculating the parameters of the Universe using the fine structure constant "alpha" and the electron constants are also given there.

$$M_U = m_e \alpha D_0^2 = 1.15348 \ldots \bullet 10^{53} \, kg$$

$$R_U = r_e \alpha D_0 = 0.856594 \ldots \bullet 10^{26} \, m$$

$$T_U = \frac{r_e \alpha D_0}{c} = 2.85729 \ldots \bullet 10^{17} \, s$$

$$\Lambda = \frac{1}{r_e^2 \alpha^2 D_0^2} = 1.36285 \ldots \bullet 10^{-52} \, m^{-2}$$

$$G = \frac{r_e^3}{t_0^2 m_e D_0} = 6.67430 \ldots \bullet 10^{-11} \, kg^{-1} m^3 s^{-2}$$

$$A_0 = \frac{c^2}{r_e \alpha D_0} = 10.4922 \ldots \bullet 10^{-10} \, m / s$$

Fig. 14. Values of the Universe parameters and formulas for their calculation.

All formulas for calculating the parameters of the Universe contain the fine structure constant "alpha". The parameters of the Universe and large numbers are composite quantities and include the fine structure constant "alpha" .

8. Conclusion

Measuring the parameters of the observable Universe is a very difficult task and does not give the necessary accuracy. A mathematical method for obtaining the parameters of the Universe has been found. The method is based on new cosmological equations linking the parameters of the Universe with fundamental physical constants. The cosmological equations are combined into a system of algebraic equations consisting of the parameters of the Universe. As a result, the possibility of obtaining the parameters of the Universe by mathematical method opened up. The parameters of the Universe are the roots of the system of algebraic equations of the Universe. The theory based on the law of scaling of large numbers allows us to obtain the parameters of the observable Universe with an accuracy close to the accuracy of the Newtonian constant of gravitation G. The equations in which the parameters of the Universe are represented by the fine structure constant "alpha" and electron constants are obtained. The obtained results show mathematically accurate tuning of the Universe with respect to the electron constants.

The phenomenon of the appearance of the microcosm constant "alpha" in the cosmological equations requires deep research. The systems of cosmological equations of the Universe have revealed the special role of the fine structure constant "alpha" in cosmology. The appearance of the fine structure constant "alpha" in the cosmological equations calls into question the independent status of many constants of cosmology. At the same time, it became possible to reveal the connection between the parameters of the Universe and fundamental physical constants.

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