Coincidence of large numbers, exact value of cosmological parameters and their analytical representation

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Abstract

A new approach to the phenomenon of large numbers coincidence leads to unexpected results. No matter how strange it might sound, the exact value of cosmological parameters and their analytical expression through fundamental constants have been founded. The basis for obtaining these unusual results is the equality of the fundamental Large Number to the exponent of the inverse value of the fine structure constant.

1. INTRODUCTION

It should be mentioned at the very beginning, that the work under consideration is unusual in form, content and results. Without making up any theoretical constructions, this research only compares and analyses figure value of observed data: fundamental constants and cosmological parameters. The work is the generalization and continuation of the problem of large numbers coincidence. From the point of view of microphysics and cosmology, the research is simple and illustrative, and could even be carried out by a student, at least by an interested one, who has some idea about Plank numbers, cosmological parameters and natural logarithms. Popularizing the methodological essence of the work, one can say that the research concerns physical numerology, and certain manipulations of physical numbers. In this respect, we found it appropriate to touch upon one number phenomenon which we called the Piazzi Smyth Effect and which is directly connected with the methodology of the present work.

Charles Piazzi Smyth is a well-known English astronomer, who, after visiting Egypt in the middle of the 19th century, took the most detailed measurements of the Great Egyptian Pyramids. Having a great set of figures at his disposal and considering their different

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arithmetic combinations, he achieved extraordinary results: with a very high level of proximity he, for example, obtained the number $\pi$, calculated the average distance between the Earth and the Moon, and got the parameters of other astronomic concepts. Piazzi Smyth came to a definite conclusion: the builders of the Pyramids possessed knowledge unknown to the inhabitants of the Earth at that period of time, they were extremely technically skilled and consequently were the representatives of non-Earth civilization. But the real explanation of the effect is rather simple: if one has a complete set of numbers and a certain freedom to manipulate them, one can achieve any result wanted.

2. THE PHENOMENON OF LARGE NUMBERS COINCIDENCE

According to the common view, this phenomenon proves the existence of some deep connection between submicro- and mega-physics. Large numbers and the phenomenon of their coincidence were first mentioned in H.Weyl’s works [1,2]. Later, this problem was thoroughly tackled by A.Eddington [3-5], and in the 30’s of the last century it was P.A.M.Dirack who turned to the topic in connection with his hypothesis of the changeability of fundamental constants [6]. The essence of the phenomenon is simple.

The relation between the intensity of electromagnetic and gravitation interactions of elementary particles (of an electron, for example) is a first illustration of a large number.

$$N_1 = \frac{e^2/\hbar c}{Gm_e^2/\hbar c} \approx 10^{40}.\quad (2.1)$$

Another large number appears in a different, metagalactical context as the ratio of ”the Universe radius” (the Hubble radius) $R_{Hb} = c/H_0$ to the electron radius $r_e = e^2/m_e c^2$:

$$N_2 = m_e c^3/H_0 e^2 \approx 10^{40},\quad (2.2)$$

where $H_0$ - is the Hubble constant.

As P.Jordan first discovered [7], the ratio of the mass of a typical star $M_\ast$ to the electron mass is also connected with large numbers:

$$M_\ast/m_e \approx 10^{60} \approx N_1^{3/2}.\quad (2.3)$$

Jordan was too emotional about these figures since he thought them to be the precursor of cardinal revolutionary changes in cosmology.

Estimating the average matter density in the Universe $\rho \approx 10^{-30} g/cm^3$, we might consider the ratio of ”the mass of the Universe” $M_0$ to the proton mass which gives the square of the large number:

$$M_\nu/m_p \approx 10^{80} \approx N_1^2.\quad (2.4)$$

Transforming this formula regarding $m_p$, we might obtain an approximate formula which derive mass through the Hubble constant and fundamental constants. In this context, S.Weinberg [8] gives the empirical formula for the pion mass:

$$m_\pi = \left(\frac{\hbar^2 H_0}{Gc}\right)^{1/3} - \quad (2.5)$$
as possessing a real though enigmatic sense. No matter how strange it might seem to seriously speak about the formulas which reveal the mass of elementary particles through cosmological parameters, such relations, as we will see later, are fairly real.

3. A NEW APPROACH TO THE LARGE NUMBERS COINCIDENCE

Our approach to the phenomenon of large numbers is simple and natural. We will discuss the ratio of cosmological parameters to the corresponding microscopic parameters: for example, the ratio of the largest parameter of length, the Hubble radius, to the smallest one - the Plank length. We will later give a few examples of large numbers coincidence. For estimation, we will use the value of the Hubble constant $H_0 = 75 km/Mps \ldots$. So, the ratio of the Hubble radius $R_{Hb} = c/H_0$ to the Plank length $l_P = (\hbar G/c^3)^{1/2} = 1.6 \cdot 10^{-33} cm$ is

$$R_{Hb}/l_P \approx 10^{60}. \quad (3.1)$$

The ratio of the "Universe mass" to the Plank mass produces a figure of the same order

$$M_{Hb}/m_P \approx 10^{61}. \quad (3.2)$$

From this relation follows for the ratio of the Plank mass density to the observed matter density of the Universe

$$\rho_P/\rho \approx 10^{120}. \quad (3.3)$$

The square of the ratio of the Plank energy to the background microwave radiation temperature $T_\gamma = 2.726^\circ$ is

$$(E_P/T_\gamma)^2 \approx 10^{60}. \quad (3.4)$$

Estimating the neutrino mass $m_\nu \approx 10^{-3} - 10^{-4} eV$, we will obtain the following for the square of the ratio of the Plank mass to the neutrino mass:

$$(m_P/m_\nu)^2 \approx 10^{61}. \quad (3.5)$$

The cube of the ratio of the Plank mass to the mass of elementary particles is

$$(m_P/m_e)^3 \approx 10^{62}, (m_P/m_\pi)^3 \approx 10^{63}, (m_P/m_p)^3 \approx 10^{58}. \quad (3.6)$$

Let us adduce here the ratio of the typical star mass (the limit of Chandrasekhar-Landau) to the electron mass

$$M_*/m_e \approx 10^{60}. \quad (3.7)$$

The list of coincidences is rather long, as you can see, and this list might be prolonged but we will turn to the further discussion of this problem after we have analyzed the Hubble and Plank scales.

4. THE PLANK SCALES
Let us give the value of the fundamental constants which are necessary for the future.

\[ h = 1.05457 \cdot 10^{-27} \text{erg} \cdot \text{s}, \quad G = 6.673 \cdot 10^{-8} \text{sm}^3/\text{g} \cdot \text{s}^2 \]

\[ c = 2.99792 \cdot 10^{10} \text{sm} / \text{s}, \quad \alpha = e^2/hc = 1/137.035999. \]

We use two Plank scales. The first Plank scale of quantity is somehow different from the traditional one.

\[ m_{\text{Pl}} = \frac{1}{2} \left( \frac{hc}{G} \right)^{1/2} = 1.0884 \cdot 10^{-5} \text{g}, \]
\[ l_{\text{Pl}} = 2 \left( \frac{hG}{c^3} \right)^{1/2} = 3.232 \cdot 10^{-33} \text{cm}, \]
\[ t_{\text{Pl}} = 2 \left( \frac{hG}{c^5} \right)^{1/2} = 1.078 \cdot 10^{-43} \text{s}, \]
\[ E_{\text{Pl}} = \frac{1}{2} \left( \frac{hc^5}{G} \right)^{1/2} = 6.11 \cdot 10^{18} \text{GeV}, \]
\[ \omega_{\text{Pl}} = 1/t_{\text{Pl}} = 0.928 \cdot 10^{43} \text{s}^{-1}. \]  \hspace{2cm} (4.1)

The second (reduced) Plank scale differs from the first one by the factor \( \alpha^{-1/2} = 11.706237 \), i.e.

\[ m_0 = \alpha^{1/2} m_{\text{Pl}} = 0.9298 \cdot 10^{-6} \text{g}, \]
\[ r_0 = \alpha^{-1/2} l_{\text{Pl}} = 3.7835 \cdot 10^{-32} \text{cm}, \]
\[ t_0 = \alpha^{-1/2} t_{\text{Pl}} = 1.262 \cdot 10^{-42} \text{s}, \]
\[ E_0 = \alpha^{1/2} E_{\text{Pl}} = 0.523 \cdot 10^{18} \text{GeV}, \]
\[ \omega_0 = 1/t_0 = 0.792 \cdot 10^{42} \text{s}^{-1}. \]  \hspace{2cm} (4.2)

Besides these two scales, we will need to introduce the mass with the value

\[ m_* = 2 \alpha^{-1/2} m_{\text{Pl}} = 2.548 \cdot 10^{-4} \text{g}. \]  \hspace{2cm} (4.3)

The main characteristic of the mass \( m_* \) is the equality of its gravitation radius to the reduced Plank length \( r_0 \) from (4.2).

5. THE HUBBLE SCALE AND COSMOLOGICAL PARAMETERS

For the last few years, radical changes in observed cosmology and astrophysics have taken place thanks to the realization of the more than 50 projects dealing with research of background microwave radiation (see their description in \[12\]). The results of that research (primarily of the projects COBE, BOOMERANG, MAXIMA) provided very important information about cosmological parameters and made their value more precise.
Below, basing oneself on the analysis of those data [10-14], we present the magnitudes of the Hubble scale parameters. The Hubble constant in the traditional units is

\[67 < H_0 < 77 \text{ (km/Mps \cdot s)}\]  \hspace{1cm} (5.1)

and in Hertz

\[2.17 \cdot 10^{-18} \text{s}^{-1} < H_0 < 2.5 \cdot 10^{-18} \text{s}^{-1}.\]  \hspace{1cm} (5.2)

The time parameter of the scale (the Hubble time) \(t_{Hb} = 1/H_0\)

\[4 \cdot 10^{18} < t_{Hb} < 4.6 \cdot 10^{18} \text{ s}.\]  \hspace{1cm} (5.3)

The parameter of the length (the Hubble radius) is defined as

\[1.2 \cdot 10^{28} \text{cm} < R_{Hb} < 1.4 \cdot 10^{28} \text{cm}.\]  \hspace{1cm} (5.4)

The parameter of the mass (the Hubble mass) is defined as

\[M_{Hb} = c^3/2H_0G.\]  \hspace{1cm} (5.5)

The value is within the limits

\[0.81 \cdot 10^{56} \text{g} < M_{Hb} < 0.93 \cdot 10^{56} \text{g}.\]  \hspace{1cm} (5.6)

The Hubble mass density presented as the ratio of \(M_{Hb}\) to the Hubble volume \(V_{Hb} = \frac{4}{3} \pi R_{Hb}^3\)

\[\rho_{Hb} = \frac{3H_0^2}{8\pi G}\]  \hspace{1cm} (5.7)

coincides with the well-known parameter - the critical density of the matter \(\rho_{cr}\).

The value of the critical density:

\[0.843 \cdot 10^{-29} \text{g/cm}^3 < \rho_{cr} < 1.12 \cdot 10^{-29} \text{g/cm}^3.\]  \hspace{1cm} (5.8)

The energy density (the mass density), bound to \(\Lambda\), of the gravitational field, equation is among other very important cosmological parameters. In relative figures -\(\Omega_\Lambda = \rho_\Lambda/\rho_{cr}\), where the mass density

\[\rho_\Lambda = \frac{\Lambda c^2}{8\pi G}.\]

The measurements localized \(\Omega_\Lambda\) within the limits [16] :

\[0.5 < \Omega_\Lambda < 0.8.\]  \hspace{1cm} (5.9)

The corresponding value \(\Lambda\) is

\[0.99 \cdot 10^{-56} \text{cm}^{-2} < \Lambda < 1.6 \cdot 10^{-56} \text{cm}^{-2}.\]  \hspace{1cm} (5.10)

The next parameter ”the dark mass density”, \(\Omega_\Delta\) is usually bound to the nonbarionic matter forms, which are considered to be distributed throughout the Universe. We will consider the parameter \(\Omega_\Delta\) in analogy with \(\Omega_\Lambda\), introducing \(\Delta\) close to \(\Lambda\). Thus,

\[\rho_\Delta = \frac{\Delta c^2}{8\pi G}.\]  \hspace{1cm} (5.11)
The value $\Omega_\Delta$ is localized within

$$0.25 < \Omega_\Delta < 0.45.$$  \hfill (5.12)

Correspondingly the value of the parameter $\Delta$:

$$0.5 \cdot 10^{-56} \text{cm}^{-2} < \Delta < 0.9 \cdot 10^{-56} \text{cm}^{-2}.$$  \hfill (5.13)

Mutual densities $\Omega_\Lambda + \Omega_\Delta \approx 1$ significantly exceed the density of the usual barionic matter $\Omega_b$, the value of which is

$$0.03 < \Omega_b < 0.06.$$  \hfill (5.14)

In conclusion, we present the value of the cosmological parameter, whose measurements are known best of all - background microwave radiation temperature

$$T_\gamma = 2.726^\circ K \approx 2.349 \cdot 10^{-4} eV.$$  \hfill (5.15)

6. THE HUBBLE CONSTANT: ONE CAN HARDLY BELIEVE IN IT

Let us discuss the ratio of the Hubble and Plank values in a more detailed and thorough way. We take the Plank value from the reduced scale (4.2). It is obvious $R_{Hb}/r_0 = t_{Hb}/\tau_0 = \omega_0/H_0$. For the last ratio of the Plank frequency to the Hubble constant we have

$$3.17 \cdot 10^{59} < \omega_0/H_0 < 3.65 \cdot 10^{59}.$$  

The natural logarithm of the ratio

$$137.006 < \log(\omega_0/H_0) < 137.147.$$  \hfill (6.1)

It is extremely surprising! The inverse value of the fine structure constant $1/\alpha = 137.035999$ can fit this narrow interval! What is it? An extraordinary coincidence or fact which has some deep physical sense? Taking into consideration the numerous examples of the large numbers coincidence (3.1) - (3.7), we tend towards the favouring of the latter and we make the following

**SUPPOSITION A.**

*The logarithm of the ratio of the Plank frequency $\omega_0$ to the Hubble constant is equal to the inverse value of the fine structure constant:*

$$\log(\omega_0/H_0) = 1/\alpha.$$  \hfill (6.2)

From this immediately follows

$$H_0 = \omega_0 e^{-1/\alpha},$$  \hfill (6.3)
which looks to be too fascinating in its full form

\[ H_0 = \frac{ec^2}{2h\sqrt{G}}e^{-hc/e^2}. \] (6.4)

All this is definitely very strange and not quite understandable. Why should the Hubble constant which characterizes the speed of the Universe expanding be connected with the fundamental constants? By analogy, we have

\[ R_{Hb} = r_0e^{1/\alpha}, \quad t_{Hb} = \tau_0e^{1/\alpha}. \] (6.5)

We can also write down the value of the Large Number \( B_0 = e^{1/\alpha} \):

\[ B_0 = 0.326572 \cdot 10^{60} \] (6.6)

and for the reference some values

\[ B_0^{-1} = 3.062115 \cdot 10^{-60}, \]
\[ B_0^{1/2} = 0.57146 \cdot 10^{30}, \]
\[ B_0^{-1/2} = 1.74989 \cdot 10^{-30}, \]
\[ B_0^{1/3} = 0.688641 \cdot 10^{20}, \]
\[ B_0^{-1/3} = 1.452136 \cdot 10^{-20}. \] (6.7)

From the formula (6.3), we can define the ”exact” value of the Hubble constant:

\[ H_0 = 2.425 \cdot 10^{-18}c^{-1} = 74.85 \text{km/Mps} \cdot \text{s}. \] (6.8)

If we can not be absolutely sure of the exactness of the formula (6.4), then at least, we will not have any doubts as to the fact that (6.4) gives the main value of the Hubble constant and the only problem is in the possibility of slight corrections. Thus, strictly speaking, the inequality might be written as the more general expression than (6.2)

\[ \log(\omega_0/H_0) = \frac{1}{\alpha} + O(\alpha). \] (6.9)

In this connection, we will make the following

**SUPPOSITION A’**

The logarithm of the ratio of the Plank frequency \( \omega_0 \) to the Hubble constant equals the inverse value of the fine structure constant with slight corrections \( \alpha \)

\[ \log(\omega_0/H_0) = \frac{1}{\alpha} + a_1\alpha + a_2\alpha^2 + \ldots \] . (6.10)

The more general supposition introduces some uncertainty in the value \( H_0 \). But this uncertainty is not very big and is less than one per cent. The following numerological experiment is a kind of proof and an illustration to the pertinence of the specifying
supposition made above. For the experiment, we will use the parameter $T_\gamma$, supposing that it is known approximately

$$2.7K < T_\gamma < 2.75K$$  \hspace{1cm} (6.11)

and we will try to numerologically reconstruct its exact value. Let us form the expression

$$A = 9\beta_0^{-1}(E_0/T_\gamma)^2$$  \hspace{1cm} (6.12)

and define the interval of its localization.

$$134.6 < A < 138.3.$$

Hence, supposing that $A = 1/\alpha$, we will obtain

$$T_\gamma = 3\alpha^{1/2}E_0e^{-1/2\alpha} \approx 2.722^0K.$$  

It is very close to but not the exact value. Now, in conformity with Supposition A’ we will present

$$A = \frac{1}{\alpha} + a_1\alpha + O(\alpha^2).$$

Then

$$T_\gamma = 3\alpha^{1/2}E_0(1 + a_1\alpha)e^{-1/2\alpha},$$

where the unknown coefficient $a_1$ is defined by comparison with the exact value $T_\gamma = 2.726$. And then

$$T_\gamma = 3\alpha^{1/2}E_0(1 + \frac{1}{5}\alpha)e^{-1/2\alpha}.$$

7. PRECISE DEFINITION OF THE PARAMETERS

$\Omega_\Lambda$ AND $\Omega_\Delta$

We proceed from the estimations

$$0.5 < \Omega_\Lambda < 0.8$$  \hspace{1cm} (7.1)

and

$$0.25 < \Omega_\Delta < 0.45.$$  \hspace{1cm} (7.2)

For the parameters $\Lambda$ and $\Delta$ we correspondingly have

$$0.99 \cdot 10^{-56}cm^{-2} < \Lambda < 1.6 \cdot 10^{-56}cm^{-2}$$

and

$$0.5 \cdot 10^{-56}cm^{-2} < \Delta < 0.9 \cdot 10^{-56}cm^{-2}.$$  

Let us construct the expression $(2/\Lambda r_0^2)^{1/2}$ and find the localization of its logarithm.

$$136.96 < \log(2/\Lambda r_0^2)^{1/2} < 137.20$$  \hspace{1cm} (7.3)

and make the next
SUPPOSITION B

The logarithm \((2/\Lambda r_0^2)^{1/2}\) is equal to the inverse value of fine structure constant.

\[
\log(2/\Lambda r_0^2)^{1/2} = 1/\alpha.
\]

From this it can be concluded that

\[
\Lambda = \frac{2}{r_0^2} e^{-2/\alpha}
\]

or

\[
\Lambda = \frac{2}{R_{Hb}^2}.
\]

That gives for \(\Lambda\)-energy density

\[
\Omega_{\Lambda} = 2/3. \quad (7.4)
\]

Having repeated the procedure the same way for \(\Omega_\Delta\) and \(\Delta\), one can get

\[
136.9 < \log\left(\frac{1}{\Delta r_0^2}\right)^{1/2} < 137.21.
\]

hence, making

SUPPOSITION C

The logarithm \((1/\Delta r_0^2)^{1/2}\) is equal to the inverse value of the fine structure constant

\[
\log(1/\Delta r_0^2)^{1/2} = 1/\alpha.
\]

Hence

\[
\Delta = \frac{1}{r_0^2} e^{-2/\alpha} = 1/R_{Hb}^2.
\]

Accordingly relative energy (mass) density \(\Delta\)

\[
\Omega_\Delta = 1/3. \quad (7.5)
\]

Traditionally, the density \(\Omega_\Delta\) is connected with the large quantity of non-barionic matter existing in the Universe in the form of weakly interacting mass particles (WIMP), supersymmetrical partners of various particles etc. This non-barionic matter is regarded as "responsible" for "dark mass" concentrated in galaxies and their groups. But our numerical results, though, make the aforementioned sound doubtful. One cannot but feel that \(\Lambda\) and \(\Delta\) matters are related. They might be regarded as the two sides of the coin. For example, \(\Omega_\Delta\) is two times smaller than \(\Omega_\Lambda\). If one sum them up, he will get a one, i.e. \(\rho_\Lambda + \rho_\Delta = \rho_{cr}\). The \(\Lambda\)-matter has the equation of state

\[
P_\Lambda = -\varepsilon_\Lambda. \quad (7.6)
\]

where \(P_\Lambda\) is the pressure, \(\varepsilon_\Lambda\) is the density of energy.

Concerning the equation of the \(\Delta\)-matter state and status equation the following radical

SUPPOSITION D

can be made:
Δ-matter as well as Λ-matter is of exotic nature and can be described with the help of the equation of state

\[ P_\Delta = \varepsilon_\Delta, \quad (7.7) \]

where \( P_\Delta \) is pressure, \( \varepsilon_\Delta = \rho_\Delta c^2 \) is the density of energy.

Considering \( \Delta \) and \( \Lambda \) matters altogether, one can write down the combined equation of state:

\[ P_\Delta + P_\Lambda = \varepsilon_\Delta - \varepsilon_\Lambda \]

or

\[ P = -\frac{1}{3} \varepsilon, \quad (7.8) \]

where

\[ P = P_\Lambda + P_\Delta, \]

\[ \varepsilon = \varepsilon_\Delta + \varepsilon_\Lambda. \]

If one considers \( \Lambda \) and \( \Delta \) matters as the two sides of the coin, the latter, in this context, might be regarded as some united exotic environment, which will be further called the "cosmological vacuum" (C-vacuum, quintessence). Let’s think of the evolution of the Universe in which there is no matter of any kind and which is filled only with the C-vacuum. Within the framework of the Standard cosmological model the equations of the gravitation field look like the following (Fridman equations):

\[ \frac{1}{2} \left( \frac{da}{dt} \right)^2 = \frac{4\pi G}{3c^2} a^2 (\varepsilon_\Lambda + \varepsilon_\Delta), \quad (7.9) \]

\[ \frac{d^2 a}{dt^2} = -\frac{4\pi G}{3c^2} (\varepsilon_\Lambda + 3P_\Lambda + \varepsilon_\Delta + 3P_\Delta) \quad (7.10) \]

As the C-vacuum density is equal to the critical one it can be concluded that the Universe is flat. And according to the equations of state (7.6), (7.7), and \( \varepsilon_\Delta = \varepsilon_\Lambda / 2 \) the right-hand expression in brackets (7.10) becomes equal to zero, and instead of (7.9) and (7.10) we have

\[ \dot{a}/a = H_0, \]
\[ \ddot{a}/a = 0, \]

i.e., as it should be expected, the "empty" flat Universe expands uniformly and with steady speed on the condition that real substance is absent.

The C-vacuum can be perfectly described in terms of a real scalar field. Let us briefly consider this point as well:

Scalar field Lagrangian looks as follows [15]:

\[ \mathcal{L} = \frac{1}{2} \partial_\mu \phi \partial^\mu \phi - V(\phi), \]

Where the first term of the equation is the density of the field kinetic energy, the second term is the density of the field potential energy.
Stress-energy tensor of the scalar field is
\[ T^{\mu\nu} = \partial^\mu \phi \partial^\nu \phi - g^{\mu\nu} \mathcal{L} \]  

(7.11)

Within the framework of the Standard cosmological model a supposition can be made where the components of the tensor are regarded in a perfect fluid approximation, for which in terms of energy density and pressure
\[ T^{\mu\nu} = (\varepsilon + P)u^\mu u^\nu - Pg^{\mu\nu} \]  

(7.12)

Therefore,
\[ T^{00} = \varepsilon, \quad T^{11} = T^{22} = T^{33} = -P \]  

(7.13)

Taking into consideration the cosmological principal, the scalar field is regarded as being homogenous, i.e. gradients \( \nabla \phi \) are equal to zero. Owing to this fact the stress-energy tensor components are:
\[ T^{00} = \frac{1}{2} \dot{\phi}^2 + V(\phi), \quad T^{11} = (\partial^1 \phi)^2 - V(\phi), \]
\[ T^{22} = (\partial^2 \phi)^2 - V(\phi), \quad T^{33} = (\partial^3 \phi)^2 - V(\phi). \]

Hence, the pressure is
\[ P = \frac{1}{3} (T^{11} + T^{22} + T^{33}) = \frac{1}{2} \dot{\phi}^2 - V(\phi) \]  

(7.14)

and energy density is
\[ \varepsilon = T^{00} = \frac{1}{2} \dot{\phi}^2 + V(\phi). \]  

(7.15)

This coincides with (7.8) for the C-vacuum components. Thus one can write
\[ \varepsilon_\Delta = \frac{1}{2} \dot{\phi}^2, \]
\[ \varepsilon_\Lambda = V(\phi), \]
\[ P_\Delta = \frac{1}{2} \dot{\phi}^2, \]
\[ P_\Lambda = -V(\phi). \]

i.e. \( \varepsilon_\Delta \) is the density of the C-vacuum kinetic energy, \( \varepsilon_\Lambda \) is the density of potential energy. Without going into details, it should be mentioned in conclusion that cosmological vacuum is not in any regard to be equated with that one of quantum field theory, the density of which is \( B_0^2 = 10^{419} \) times higher, i.e. \( \rho_{QFT} = \rho_{crit} e^{2/\alpha} \).

8. BARIONIC MATTER DENSITY

Due to the newest measurements it is known that the barionic matter density is within
\[ 0.03 < \Omega_b < 0.06. \]
The barionic mass of the Universe (the mass of barions inside Hubble sphere)

\[ 2.3 \cdot 10^{59} < M_b < 4.6 \cdot 10^{59}. \]

The logarithm

\[ 136.7 < \log(M_b/m_{Pl}) < 137.4, \]

One make the aforementioned SUPPOSITION E

The logarithm \( M_b/m_{Pl} \) is equal to the inverse value of the fine structure constant.

\[ \log(M_b/m_{Pl}) = \frac{1}{\alpha} + O(\alpha). \]

Following the supposition and taking into consideration that \( M_b = m_{Pl} \cdot B_0 \) and \( M_{Hb} = m_\star B_0 \) a simple analytic expression is available for barionic matter density of the Universe

\[ \Omega_b = M_b/M_{Hb} = \frac{1}{2} \alpha^{1/2}. \]

Numerical value of barionic density is

\[ \Omega_b \approx 0.047. \]

Total density of the matter of the Universe is

\[ \Omega_{tot} = 1 + \Omega_b + \Omega_\nu + \Omega_\gamma + \Omega_G + \ldots. \]

C-vacuum density (\( \Omega_\Lambda + \Omega_\Delta = 1 \)), as well as barionic, \( \Omega_b = 0.047 \) predominate in total density. Further, one will think that

\[ \Omega_{tot} \approx 1 + \frac{1}{2} \alpha^{1/2}. \]

As the density of the other forms of matter is to be less than \( \Omega_b \), otherwise it would contradict the observation data. But here one can face a problem of ”dark mass” in galaxies and galaxies groups. Not to go into details two ways of solving the problem should be mentioned here:

1. The dark mass effect being observed in galaxies and theirs groups is a mirage. The cause for the mirage is the changing of the form of the gravitation interaction at great distances \( R >> R_0 \approx 10kps \). For example, gravitation potential

\[ V(r) = -\frac{GM}{r} + \frac{GM}{R_0} \log \frac{r}{R_0} \]

may be used to describe the effect in the proper way.

2. Dark matter is connected with C-vacuum desity increas it the vicinity of heavily gravitating objects.
9. THE AGE OF THE UNIVERSE AND THE PARAMETER OF RETARDATION

The Age of the Universe
\[ t_U = \frac{b}{H_0}, \quad (9.1) \]

Here the parameter \( b \) is depend on a concrete type of the cosmological model under consideration. It can be concluded from (9.1) that
\[ \dot{H}_0 = -\frac{1}{b}H_0^2. \quad (9.2) \]

According to definition the retardation parameter is \( q_0 = -\ddot{a}/aH_0^2 \). On the one hand, from the Hubble formula \( \dot{a} = H_0a \) one can get
\[ q_0 = \frac{1}{b} - 1, \]

On the other hand, from the second Fridman equation one can get
\[ -\frac{\ddot{a}}{aH_0^2} = \frac{4\pi G}{3c^2H_0^2} \frac{\rho_b c^2}{2}, \]
or
\[ q_0 = -\frac{\ddot{a}}{aH_0^2} = \frac{1}{2}\Omega_b. \]

Finally, for the retardation parameter and parameter \( b \)
\[ q_0 = \frac{1}{4}\alpha^{1/2}, \]
\[ b \approx 1 - \frac{1}{4}\alpha^{1/2}. \]

Thus, the age of the Universe is
\[ t_U = \frac{1 - \alpha^{1/2}/4}{H_0} \approx 0.4 \cdot 10^{18}c \approx 12.8 \cdot 10^9 \text{ years} \]

10. CHANGEABILITY OF FUNDAMENTAL CONSTANTS

P.A.M. Dirac was the first to suggest the idea of changeability of fundamental constants in the context of the large numbers coincidence phenomenon. On the whole the idea was perceived with a slight doubt. Nevertheless, the results of this research which have revealed the analytic interconnections between fundamental constants and the changing-in-time cosmological parameters do leave no room for the doubt about the changeability of fundamental constants. From the author’s point of view, it should be noticed that, even without taking into consideration the aforementioned, in the non-stationary Universe all physical quantities, including fundamental constants, are bound to change.
It is the speed of fundamental constant changeability which is of interest. The general rate of the Universe changeability, the speed of its expanding is determined with the Hubble constant value. Therefore, the following plausible

**SUPPOSITION F** can be made:

*Fundamental constants change in time with the relative speed which is proportional to the Hubble constant.*

\[
\frac{\dot{F}}{F} \sim H_0.
\]

How can this supposition be supported? First, it should be noticed (as we can see from (9.2)) that the Hubble constant itself changes in time with speed which is

\[
\frac{\dot{H}_0}{H_0} = -\frac{1}{b} H_0
\]

Further, from the expression (6.3), as well as from many others analogous ones one can find directly

\[
\frac{\dot{\omega}_0}{\omega_0} = \frac{\dot{H}_0}{H_0} - \frac{\dot{\alpha}}{\alpha^2} \sim H_0
\]

which, on the whole, is for the mentioned supposition.

### 11. MASS OF ELEMENTARY PARTICLES

To draw the line let us consider the point which, on the one hand, seems to be far from cosmology,

But on the other hand it deals with large numbers and numerology directly. As it was above mentioned, the relation between the Plank mass and the mass of elementary particles has the large number order

For example, let us consider the mass of an electron. In order to do this we are to evaluate the expression

\[
\frac{\alpha^3}{2} B_0^{-1} \left(\frac{m_0}{m_e}\right)^3 = 2.0464 \approx 2.
\]

Therefore for the electron mass one can get the simple formula

\[
m_e = \frac{1}{2^{1/3}} \alpha^{1/2} m_0 e^{-1/3} \approx 0.515 MeV.
\]

Or it may be represented in detail

\[
m_e = \frac{1}{2^{4/3}} \frac{e^2}{\sqrt{\hbar c}} e^{-\hbar c/e^2}. \tag{11.1}
\]

The formula cannot be regarded as a banal approximation, from the author’s viewpoint. One would think that one day the formula with correction terms will be obtained from first principles. Within the framework of a some high theory.
Let us consider what we have for the mass of the pion. The following expression is to be calculated by analogy

\[ \alpha^{-1/2} B_0^{-1} \left( \frac{m_{Pl}}{m_{\pi^+}} \right)^3 \approx 3. \]

Therefore

\[ m_{\pi^+} = \frac{1}{3^{1/3}} \alpha^{-1/6} m_{Pl} e^{-1/3 \alpha}. \tag{11.2} \]

Let us use the aforementioned Weinberg empiric formula for the mass of a pion

\[ m_\pi \approx \left( \frac{\hbar^2 H_0}{Gc} \right)^{1/3}. \]

After non-complicated transformation we get

\[ m_\pi = \left( \frac{hc \cdot \omega_0 H_0}{Gc^2 \omega_0} \right). \]

Taking into consideration that \( hc/G = 4 \alpha^{-1} m_0^2 \), \( \hbar \omega_0 = m_0 e^2 \), \( H_0/\omega_0 = B_0^{-1} \), one can get the formula which is similar to that one (11.2)

\[ m_\pi \approx 2^{2/3} \alpha^{-1/3} m_0 e^{-1/3 \alpha} \]

12. CONCLUSIONS

So, unusual results have been achieved out of practically nothing. It is evident that numerical analysis made by the author has revealed the elements of a very deep interconnection between micro- and megauniverse. One would hope that the revealed phenomenon encourages investigations and the creation of proper models. The author does not comment on the results obtained. But it does not mean, though, that he has no ideas concerning them. One should notice, without going into details, that further work on creating adequate physical models is very likely to be connected with the modern Brane world models.

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