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5D World-Universe Model. Neutrinos. The World

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Abstract

In this manuscript we discuss mass-varying neutrinos and propose their energy density to exceed that of baryonic and dark matter. We introduce cosmic Large Grains whose mass is about Planck mass, and their temperature is around 29 K. Large Grains are in fact Bose-Einstein condensates of proposed dineutrinos, and are responsible for the cosmic Far-Infrared Background (FIRB) radiation. The distribution of the energy density of all components of the World (protons, electrons, photons, neutrinos, and dark matter particles) is considered. We present an overview of the World-Universe Model (WUM) and pay particular attention to the self-consistent set of time-varying values of basic parameters of the World: the age and critical energy density; Newtonian parameter of gravitation and Hubble's parameter; temperatures of the cosmic Microwave Background radiation and the peak of the cosmic FIRB radiation; Fermi coupling parameter and coupling parameters of the proposed Super-Weak and Extremely-Weak interactions. Additionally, WUM forecasts the masses of dark matter particles, axions, and neutrinos; proposes two fundamental parameters of the World: fine-structure constant α and the quantity Q which is the dimensionless value of the fifth coordinate, and three fundamental physical units: basic unit of momentum, energy density, and energy flux density. WUM suggests that all time-dependent parameters of the World are interconnected and in fact dependent on Q. We recommend adding the quantity Q to the list of the CODATA-recommended values.

Keywords

5D World-Universe Model, Medium of the World, Mass-Varying Neutrinos, Dineutrinos, Bose-Einstein Condensates, Far-Infrared Background Radiation, Time-Varying Parameters of the World

1. Introduction

We can't solve problems by using the same kind of thinking we used when we created them.
—Albert Einstein

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The role of the Intergalactic plasma consisting of protons, electrons, and photons as part of the Medium of the World is analyzed in [1]. The Multicomponent Dark Matter and its decisive role in the Medium and Macroobjects of the World are discussed in [2].

Mass-varying neutrinos as part of the Medium of the World are analyzed in Section 2.1. The distribution of the energy density of all components of the World (protons, electrons, photons, neutrinos, and dark matter particles) is considered in Section 2.2. In Section 3 we propose a new physical model for the cosmic Far-Infrared Background (FIRB) radiation based on Bose-Einstein condensates of cosmic dineutrinos. In Section 4 we present an overview of World-Universe Model (WUM) and pay particular attention to time-varying values of the basic parameters of the World.

In 5D WUM [1] [2] we introduced

- a basic unit of mass m_0 that equals to

$$m_0 = \frac{h}{ac} = 70.025267 \text{ MeV/c}^2 \tag{1.1}$$

where h is Planck constant, c is the electrodynamic constant, $a = 2\pi a_0$, and a_0 is the classical electron radius;

- a dimensionless time-varying quantity Q which equals to the ratio of the size of the World R at cosmological time τ to the Worlds' size a at the Beginning:

$$Q = \frac{R}{a} \tag{1.2}$$

In WUM, neutrino masses are related to and proportional to m_0 multiplied by fundamental parameter $Q^{-1/4}$ and different coefficients that will be discussed in Section 2.1.

2. Components of the World

2.1. Mass-Varying Neutrinos

It is now established that there are three different types of neutrino: electronic ν_e, muonic ν_μ, and tauonic ν_τ, and their antiparticles. B. Pontecorvo and Y. Smorodinsky discussed the possibility of energy density of neutrinos exceeding that of baryonic matter [3]. Neutrino oscillations imply that neutrinos have non-zero masses [4] [74].

Let's take neutrino masses $m_{\nu_e}, m_{\nu_\mu}, m_{\nu_\tau}$ that are near

$$m_\nu = m_0 \times Q^{-1/4} \tag{2.1}$$

Their concentrations n_ν are then proportional to

$$n_\nu \propto \frac{1}{a^3} \times Q^{-3/4} = \frac{1}{L_F^3} \tag{2.2}$$

where L_F is the Fermi length parameter:

$$L_F = a \times Q^{1/4} \tag{2.3}$$

L_F is a characteristic of neutrino density (2.2), and also of critical energy density of the World [1]:

$$\rho_{cr} = 3\rho_0 \times Q^{-1} = \frac{3hc}{L_F^4} \tag{2.4}$$

$$\rho_0 = \frac{hc}{a^4} \tag{2.5}$$

where ρ_0 is a basic unit of energy density. Energy densities of neutrinos are proportional to Q^{-1}, and consequently to $\frac{1}{R}$, since critical energy density ρ_{cr} is proportional to $\frac{1}{R}$ [1].

Experimental results obtained by M. Sanchez [5] show $\nu_e \to \nu_{\mu,\tau}$ neutrino oscillations with parameter Δm^2_{sol} given by

$$2.3\times10^{-5}\ \text{eV}^2/\text{c}^4 \le \Delta m_{sol}^2 \le 9.3\times10^{-5}\ \text{eV}^2/\text{c}^4 \tag{2.6}$$

and $\nu_\mu \to \nu_\tau$ neutrino oscillations with parameter Δm_{atm}^2:

$$1.6\times10^{-3}\ \text{eV}^2/\text{c}^4 \le \Delta m_{atm}^2 \le 3.9\times10^{-3}\ \text{eV}^2/\text{c}^4 \tag{2.7}$$

where Δm_{sol}^2 and Δm_{atm}^2 are mass splitting for solar and atmospheric neutrinos respectively.

Significantly more accurate result was obtained by P. Kaus, *et al*. [6] for the ratio of the mass splitting:

$$\sqrt{\frac{\Delta m_{sol}^2}{\Delta m_{atm}^2}} \cong 0.16 \approx \frac{1}{6} \tag{2.8}$$

Let's assume that muonic neutrino's mass indeed equals to

$$m_{\nu_\mu} = m_\nu = m_0 \times Q^{-1/4} \cong 7.5\times10^{-3}\ \text{eV}/\text{c}^2 \tag{2.9}$$

From equation (2.8) it then follows that

$$m_{\nu_\tau} = 6m_\nu \cong 4.5\times10^{-2}\ \text{eV}/\text{c}^2 \tag{2.10}$$

Then the squared values of the muonic and tauonic neutrino masses fall into ranges (2.6) and (2.7):

$$m_{\nu_\mu}^2 \cong 5.6\times10^{-5}\ \text{eV}^2/\text{c}^4$$

$$m_{\nu_\tau}^2 \cong 2\times10^{-3}\ \text{eV}^2/\text{c}^4 \tag{2.11}$$

Let's assume that electronic neutrino mass equals to

$$m_{\nu_e} = \frac{1}{24} m_\nu \cong 3.1\times10^{-4}\ \text{eV}/\text{c}^2 \tag{2.12}$$

The assumptions made in (2.9) and (2.12) are further supported by the excellent numerical agreement of calculated and measured value of fine-structure constant α discussed in Section 2.2.

The calculated neutrino masses are in a good agreement with masses found in [7]:

$$\begin{aligned} m_{\nu_\tau} &\cong 4.9\times10^{-2}\ \text{eV}/\text{c}^2 \\ m_{\nu_\mu} &\cong 7.8\times10^{-3}\ \text{eV}/\text{c}^2 \\ m_{\nu_e} &\cong 2.5\times10^{-4}\ \text{eV}/\text{c}^2 \end{aligned} \tag{2.13}$$

and with experimental values obtained in [8] [9]. The sum of the calculated neutrino masses

$$\Sigma m_\nu \cong 0.053\ \text{eV}/\text{c}^2 \tag{2.14}$$

is also in a good agreement with the value of $0.06\ \text{eV}/\text{c}^2$ discussed in literature [10].

Considering that all elementary particles, including neutrinos, are fully characterized by their four-momentum $\left(\frac{E_{\nu i}}{c}, \boldsymbol{p}_{\nu i}\right)$:

$$\left(\frac{E_{\nu i}}{c}\right)^2 - \boldsymbol{p}_{\nu i}^2 = \left(m_{\nu i} c\right)^2, \quad i = e, \mu, \tau \tag{2.15}$$

we obtain the following neutrino energy densities $\rho_{\nu i}$ in accordance with theoretical calculations made by L. D. Landau and E. M. Lifshitz [11]:

$$\rho_{\nu i} = \frac{8\pi c}{h^3}\int_0^{p_F} p^2\sqrt{p^2 + m_{\nu i}^2 c^2}\,\mathrm{d}p = \frac{2\pi\left(p_F c\right)^4}{\left(hc\right)^3} \times F\left(x_{\nu i}\right) \tag{2.16}$$

where p_F is Fermi momentum,

$$F(x_{vi}) = \frac{x_{vi}^{1/2}(2x_{vi}+1)(x_{vi}+1/2)^{1/2} - \ln\left[x_{vi}^{1/2} + (x_{vi}+1)^{1/2}\right]}{2x_{vi}^2} \tag{2.17}$$

$$x_{vi} = \left(\frac{p_F}{m_{vi}c}\right)^2 \tag{2.18}$$

$$m_{vi} = A_i m_0 \times Q^{-1/4} \tag{2.19}$$

$$A_i = \frac{1}{24}; 1; 6 \tag{2.20}$$

Let's take the following value for Fermi momentum p_F:

$$p_F^2 = \frac{h^2}{2\pi^2 L_F^2} = \frac{h^2}{2\pi^2 a^2} \times Q^{-1/2} = p_{F0}^2 \times Q^{-1/2} \tag{2.21}$$

where $p_{F0}^2 = \frac{h^2}{2\pi^2 a^2}$ is the extrapolated value of p_F at the Beginning when $Q = 1$. Using (2.16), we obtain neutrinos relative energy densities Ω_{vi} in the Medium in terms of the critical energy density ρ_{cr}:

$$\Omega_{vi} = \frac{\rho_{vi}}{\rho_{cr}} = \frac{1}{6\pi^3} F(y_{vi}) \tag{2.22}$$

where

$$y_{vi} = \left(2\pi^2 A_i^2\right)^{-1} \tag{2.23}$$

It's commonly accepted that concentrations of all types of neutrinos are equal. This assumption allows us to calculate the total neutrinos relative energy density in the Medium:

$$\Omega_v = \frac{\rho_v}{\rho_{cr}} = \frac{\rho_{ve} + \rho_{v\mu} + \rho_{v\tau}}{\rho_{cr}} = 0.45801647 \tag{2.24}$$

One of the principal ideas of WUM holds that energy densities of Medium particles are proportional to proton energy density in the World's Medium [1]:

$$\Omega_p = \frac{2\pi^2\alpha}{3} = 0.048014655 \tag{2.25}$$

which depends on the fundamental parameter α. We take the value of Ω_v to equal

$$\Omega_v = \frac{30}{\pi}\Omega_p = 20\pi\alpha = 0.45850618 \tag{2.26}$$

which is remarkably close to its value calculated in (2.24).

2.2. Distribution of the World's Energy Density

According to WUM energy density of all Macroobjects of the World ρ_{MO} equals to 1/3 of the total energy density ρ_{cr} and energy density of the Medium ρ_M equals to $2/3\,\rho_{cr}$ [1]. Therefore the total neutrinos relative energy density Ω_{vtot} (in the Medium and in Macroobjects) in terms of the critical energy density ρ_{cr} equals to

$$\Omega_{vtot} = \frac{45}{\pi}\Omega_p = 30\pi\alpha = 0.68775927 \tag{2.27}$$

Our Model holds that the energy density of all types of Dark Matter Particles (DMP) is proportional to the proton energy density ρ_p in the World's Medium:

$$\rho_p = \frac{2\pi^2\alpha}{3}\rho_{cr} \tag{2.28}$$

In all, there are 5 different types of DMP: Neutralinos, WIMPs, DIRACs, ELOPs, and Sterile Neutrinos with the anticipating masses of 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV [2]. Then the total energy density of DM ρ_{DM} is

$$\rho_{DM} = 5\rho_p = 0.24007327\rho_{cr} \tag{2.29}$$

which is close to the DM energy density measured in literature [12]: $\rho_{DM} \cong 0.268\rho_{cr}$.

An alternative interesting approach to Dark Matter is given by extended theories of gravity, as it has been shown by Prof. Christian Corda in [36].

The total baryonic energy density ρ_B is:

$$\rho_B = 1.5\rho_p \tag{2.30}$$

The sum of electron and Microwave Background Radiation (MBR) energy densities ρ_{eMBR} equals to [1]

$$\rho_{eMBR} = \rho_e + \rho_{MBR} = 1.5\frac{m_e}{m_p}\rho_p + 2\frac{m_e}{m_p}\rho_p = 3.5\frac{m_e}{m_p}\rho_p \tag{2.31}$$

We took additional energy density ρ_{ADD}

$$\rho_{ADD} = \left(2 + \frac{1}{5\pi}\right)\frac{m_e}{m_p}\rho_p \tag{2.32}$$

so that the energy density of the World ρ_W equals to the theoretical critical energy density ρ_{cr}

$$\rho_W = \left[\frac{45}{\pi} + 6.5 + \left(5.5 + \frac{1}{5\pi}\right)\frac{m_e}{m_p}\right]\frac{2\pi^2\alpha}{3}\rho_{cr} = \rho_{cr} \tag{2.33}$$

We will connect the chosen value of ρ_{ADD} with energy density of dineutrinos and Far-Infrared Background radiation in Section 3.

From (2.33) we can calculate the value of α, using electron-to-proton mass ratio $\frac{m_e}{m_p}$

$$\frac{1}{\alpha} = \frac{\pi}{15}\left[450 + 65\pi + (55\pi + 2)\frac{m_e}{m_p}\right] = 137.03600 \tag{2.34}$$

which is in excellent agreement with the commonly adopted value of 137.035999074 (44) and proves our assumptions about electronic neutrino mass (2.12), neutrinos energy density of the Medium (2.26), and additional energy density (2.32) that is discussed in Section 3.

It follows that there is a direct correlation between constants α and $\frac{m_e}{m_p}$ expressed by equation of the total energy density of the World (2.33). As shown above, $\frac{m_e}{m_p}$ is not an independent constant, but is instead derived from α.

To summarize:

- The World's energy density is proportional to the Fundamental parameter Q^{-1};
- The particles relative energy densities are proportional to Fundamental constant α;
- The total neutrinos energy density is almost 10 times greater than baryonic energy density, and about 3 times

greater than Dark Matter energy density.

3. Cosmic Far-Infrared Background

The cosmic Far-Infrared Background (FIRB), which was announced in January 1998, is part of the Cosmic Infrared Background (CIB), with wavelengths near 100 microns that is the peak power wavelength of the black body radiation at temperature 29 K. In this Section we introduce Bose-Einstein Condensate (BEC) drops of dineutrinos whose mass is about Planck mass, and their temperature is around 29 K. These drops are responsible for the FIRB.

3.1. Observations

Infrared Astronomical Satellite (IRAS) mission was the first all-sky survey which used far-infrared wavelengths in 1983. Using IRAS, scientists were able to determine the luminosity of the galactic objects discovered. Over 250,000 infrared sources were observed during the 10 month mission.

The FIRB radiation was observed for different galaxies in [13]-[32]. M. G. Hauser, *et al.* revealed bright emission from interplanetary dust at 100 microns [13]. F. J. Low, *et al.* pointed out that the 100 micrometer cirrus may represent cold material in the outer solar system or a new component of the interstellar medium [14].

B. Wang in 1991 found that the integrated FIRB from galaxies peaks at around 100 - 130 microns, with total radiation density from 0.5% to 6% of the cosmic MBR [15]. E. L. Wright in 1999 recomputed of FIRB and found its total intensity to be about 3.4% of the MBR intensity [16].

In 1999, G. Lagache, *et al.* described the cosmic FIRB and announced that *for the first time the far-IR emission of dust associated with the Warm Ionized Medium* (*WIM*) *is evidenced. The best representation of the WIM dust spectrum is obtained for a temperature of 29.1 K* [21]. D. P. Finkbeiner, *et al.* have detected substantial flux in the 100 micron channel in excess of expected zodiacal and Galactic emission. They concluded that there is currently no satisfactory explanation for the 100 micron excess [22].

M. J. Devlin, *et al.* have this to say about a population of luminous, high-redshift, dusty starburst galaxies: *In the* redshift *range* $1 \le z \le 4$, *these massive submillimetre galaxies go through a phase characterized by optically obscured star formation at rates several hundred times that in the local Universe. Half of the starlight from this highly energetic process is absorbed and thermally reradiated by clouds of dust at temperatures near* 30 K *with spectral energy distributions peaking at* 100 μm [29].

3.2. Model

According to [33]-[35], the size of large cosmic grains D_G is roughly equal to the Fermi length L_F:

$$D_G \sim L_F = a \times Q^{1/4} = 1.6532 \times 10^{-4} \text{ m} \tag{3.1}$$

and their mass m_G is close to the Planck mass $M_P = 2.17647 \times 10^{-8}$ kg:

$$m_G \sim \left(10^{-9} \Leftrightarrow 10^{-7}\right) \text{kg} \tag{3.2}$$

The density of grains ρ_G is about:

$$\rho_G \sim \frac{6}{\pi} \frac{M_P}{L_F^3} \approx 9.2 \times 10^3 \frac{\text{kg}}{\text{m}^3} \tag{3.3}$$

According to WUM, Planck mass M_P equals to (see equation (4.7))

$$M_P = 2m_0 \times Q^{1/2} \tag{3.4}$$

Note that the value of M_P is increasing with cosmological time, and is proportional to $\tau^{1/2}$. Then,

$$\frac{\mathrm{d}}{\mathrm{d}\tau} M_P = \frac{M_P}{2\tau} \tag{3.5}$$

A grain of mass $B_1 M_P$ and radius $B_2 L_F$ is receiving energy from the Medium of the World (see Section

3.5) at the following rate:

$$\frac{\mathrm{d}}{\mathrm{d}\tau}\left(B_1 M_P c^2\right) = \frac{B_1 M_P c^2}{2\tau} \tag{3.6}$$

where B_1 and B_2 are parameters.

The received energy will increase the grain's temperature T_G, until equilibrium is achieved: power received equals to the power irradiated by the surface of a grain in accordance with the Stefan-Boltzmann law

$$\frac{B_1 M_P c^2}{2\tau} = \sigma_{SB} T_G^4 \times 4\pi B_2^2 L_F^2 \tag{3.7}$$

where σ_{SB} is Stefan-Boltzmann constant:

$$\sigma_{SB} = \frac{2\pi^5 k_B^4}{15 h^3 c^3} \tag{3.8}$$

and k_B is the Boltzmann constant.

With Nikola Tesla's principle at heart—*There is no energy in matter other than that received from the environment*—we apply the World equation [2] to a grain:

$$B_1 M_P c^2 = 4\pi B_2^2 L_F^2 \sigma_0 \tag{3.9}$$

where σ_0 is a basic unit of surface energy density:

$$\sigma_0 = \rho_0 a \tag{3.10}$$

We then calculate the grain's stationary temperature T_G to be

$$T_G = \left(\frac{15}{4\pi^5}\right)^{1/4} \frac{hc}{k_B L_F} = 28.955\ \mathrm{K} \tag{3.11}$$

This result is in an excellent agreement with experimentally measured value of 29 K [21]-[32].

Cosmic FIRB radiation is not a black body radiation. Otherwise, its energy density ρ_{FIRB} at temperature T_G would be too high and equal to the energy density of the Medium of the World:

$$\rho_{FIRB} = \frac{8\pi^5}{15}\frac{k_B^4}{(hc)^3} T_G^4 = \frac{2}{3}\rho_{cr} = \rho_M \tag{3.12}$$

The total flux of the FIRB radiation is the sum of the contributions of all individual grains.

WUM calculates the value of the MBR temperature T_{MBR} to be (see equation (4.8)):

$$T_{MBR} = \left(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p}\right)^{1/4} \frac{hc}{k_B L_F} = 2.72518\ \mathrm{K} \tag{3.13}$$

Comparing Equations (3.11) and (3.13), we can find the relation between the grains' temperature and the temperature of the MBR:

$$T_G = \left(3\Omega_e\right)^{-1/4} \times T_{MBR} \tag{3.14}$$

where electron relative energy density Ω_e in terms of the critical energy density ρ_{cr} equals to

$$\Omega_e = \frac{m_e}{m_p}\Omega_p \tag{3.15}$$

3.3. Planck Mass

The developed FIRB model introduces Large Grains whose mass is about Planck mass M_P. Recall Dirac's

quantization condition:

$$\frac{e\mu}{4\pi\varepsilon_0} = n\frac{hc}{4\pi} \tag{3.16}$$

where n is an integer, ε_0 is the electric parameter, e and μ are electron and Dirac's monopole charges respectively.

Taking into account the analogy between electromagnetic and gravitoelectromagnetic fields, we can rewrite the same equation for masses of a gravitoelectromagnetic field:

$$\frac{mM}{4\pi\varepsilon_g} = GmM = \frac{hc}{2\pi}\frac{mM}{M_P^2} = n\frac{hc}{4\pi} \tag{3.17}$$

where $\varepsilon_g = \frac{1}{4\pi G}$ is the gravitoelectric parameter and G is the gravitational parameter. Taking $n = 1$ we obtain the minimum product of masses

$$mM = \frac{1}{2}M_P^2 = 2m_0^2 \times Q = 2.36851\times10^{-16}\ \text{kg}^2 \tag{3.18}$$

Two particles or microobjects will not exert gravity on one another when both of their masses are smaller than the Planck mass. Planck mass can then be viewed as the mass of the smallest macroobject capable of generating the gravitoelectromagnetic field.

3.4. Mass-Varying Quants: Axions and Dineutrinos

According to WUM, all "elementary" particles of the World are fermions and they possess masses. Bosons such as photons, X-rays, and gamma rays are composite particles and consist of an even numbers of fermions. An axion is a boson possessing the lowest rest mass m_a [1]:

$$m_a = \left(\frac{m_e}{m_p}\right)^{1/2} \times m_0 \times Q^{-1/2} = 1.8743\times10^{-14}\ \text{eV}/\text{c}^2 \tag{3.19}$$

which is decreasing in time: $m_a \propto \tau^{-1/2}$. Super soft X-rays have energies in the 0.09 to 2.5 keV range. We assume that X-quants are dineutrinos $\nu\bar{\nu}$ with the rest mass m_X:

$$m_X \propto m_0 \times Q^{-1/4} \sim 10^{-4}\ \text{eV}/\text{c}^2 \tag{3.20}$$

which is about 10 orders of magnitude larger than the axion mass and is decreasing in time: $m_X \propto \tau^{-1/4}$. We will name these dineutrinos "Xions". New physics utilizing dineutrinos has been actively discussed in literature in recent years (see, for example [37]-[48]).

According to WUM, the total neutrinos energy density in the World is almost 10 times greater than baryonic energy density, and about 3 times greater than Dark Matter energy density (Section 2.2). At high neutrinos concentration, we can expect "neutrino pairs" $\nu\bar{\nu}$ (Xions) to be created. The concentration of Xions may indeed be sufficient to undergo Bose-Einstein condensation (BEC), and as a result create BEC drops (Large Grains), possessing masses roughly equal to Planck mass.

3.5. Bose-Einstein Condensate

New cosmological models employing the Bose-Einstein Condensates (BEC) have been actively discussed in literature in recent years [49]-[63]. The transition to BEC occurs below a critical temperature T_c, which for a uniform three-dimensional gas consisting of non-interacting particles with no apparent internal degrees of freedom is given by

$$T_c = \left[\zeta(3/2)\right]^{-2/3}\frac{h^2 n_X^{2/3}}{2\pi m_X k_B} \approx \frac{h^2 n_X^{2/3}}{11.918 m_X k_B} \tag{3.21}$$

where n_X is the particle density, m_X is the mass per boson, ζ is the Riemann zeta function:

$$\zeta(3/2) \approx 2.6124 \tag{3.22}$$

According to our Model, we can take the value of the critical temperature T_c to equal the stationary temperature T_G of Large Grains (see equation (3.11)). Let's assume that the energy density of boson particles ρ_X equals to the MBR energy density (see equation (2.31)):

$$\rho_X = n_X m_X = 2\frac{m_e}{m_p}\rho_p = 4\pi^2\alpha\frac{m_e}{m_p}\frac{hc}{L_F^4} = 1.5690\times10^{-4}\times\frac{hc}{L_F^4} \tag{3.23}$$

Taking into account equations (3.11), (3.21) and (3.23), we can calculate the value of n_X:

$$n_X = \left[47.672\pi^2\alpha\frac{m_e}{m_p}\left(\frac{15}{4\pi^5}\right)^{1/4}\right]^{3/5}\times L_F^{-3} = 0.011922\times L_F^{-3} = 2.6386\times10^9\ \mathrm{m}^{-3} \tag{3.24}$$

and the value of the mass m_X:

$$m_X = \frac{\rho_X}{n_X c^2} = 0.013161\times m_0\times Q^{-1/4} = 0.987\times10^{-4}\ \mathrm{eV/c^2} \tag{3.25}$$

m_X is about 10 orders of magnitude larger than the axion mass (see equation (3.19)).

The calculated values of the mass and concentration of dineutrinos satisfy the conditions for their Bose-Einstein condensation. Consequently, BEC drops whose masses are about Planck mass can be created. The stability of such drops is provided by the detailed equilibrium between the energy absorption from the Medium of the World (provided by dineutrinos as a result of their Bose-Einstein condensation) and re-emission of this energy in FIRB at the stationary temperature $T_G = 29$ K (Section 3.2).

The FIRB energy density ρ_{FIRB} equals to

$$\rho_{FIRB} = \rho_{ADD} - \rho_X = \frac{1}{5\pi}\frac{m_e}{m_p}\rho_p = \frac{2\pi\alpha}{15}\frac{m_e}{m_p} \tag{3.26}$$

which is 10π times smaller than the energy density of MBR and dineutrinos:

$$\rho_{FIRB} = \frac{1}{10\pi}\rho_{MBR} \approx 0.032\rho_{MBR} \tag{3.27}$$

The ratio between FIRB and MBR corresponds to the value of 3.4% calculated by E. L. Wright [16].

3.6. Star Creation

In our opinion, the BEC drops with mass around M_P are the smallest building blocks that participate in Star creation. According to WUM, a new star arises from cloud of all particles under consideration (including BEC drops) with mass M_{Cl} [2]:

$$M_{Cl} \lesssim m_o\times Q^{3/2} \cong 10^{32}\ \mathrm{kg} \tag{3.28}$$

Formation of a new star starts with a gravitational instability of the cloud of BEC drops and subsequent gravitational collapse of them, with the resulting macroobject (Core) possessing mass about M_{Core}

$$M_{Core} \sim m_o\times Q \cong 10^{12}\ \mathrm{kg} \tag{3.29}$$

A density of Core can be up to the nuclear density $\left(\sim10^{18}\ \frac{\mathrm{kg}}{\mathrm{m}^3}\right)$ [2] and their size is about:

$$R_{Core} \sim 10^{-2}\ \mathrm{m} \tag{3.30}$$

Then according to equation (3.18), all particles heavier than m_0 (neutralinos, WIMPs, protons) will be attracted

to this Core, increasing its mass and attracting lighter particles (DIRACs, ELOPs, sterile neutrinos) which form Shells around the Core [2].

3.7. Conclusion

In this Section we proposed the existence of BEC drops of dineutrinos whose mass is about Planck mass, and temperature of around 29 K. BEC drops are responsible for the FIRB and explain the substantial 100 micron flux in excess of expected zodiacal and Galactic emission.

In our opinion, BEC drops are the smallest building blocks of all macroobjects. Since the drops possess Planck mass, they can be reasoned about from the standpoint of classical physics, validating our calculations of the drops' masses and temperature.

BEC drops do not absorb and re-emit starlight. Instead, they absorb energy directly from the Medium of the World (provided by dineutrinos). We can thus explain the existence of ultra-luminous infrared galaxies in a very active star formation period, which are extremely bright in the infrared spectrum and at the same time faint (often almost invisible) in the optical spectrum (see review papers [64] [65] and references therein).

4. The World

5D World-Universe Model is based on the following primary assumptions:

- The universality of physical laws;
- The cosmological principle which states that on a large scale the World is homogeneous and isotropic;
- The World is finite and is expanding inside the 4-dimensional Universe with speed equal to the gravitoelectrodynamic constant *c*;
- The Medium of the World, consisting of protons, electrons, photons, neutrinos, and dark matter particles (DMP) is an active agent in all physical phenomena in the World.

The Model is based on Maxwell's equations for electromagnetism and gravitoelectromagnetism which have two measurable characteristics: energy density ρ and energy flux density I. All other notions are used for calculations of these two measurable characteristics.

In our discussion we have utilized the particles' four-momentum; however, the final result of the statistical analysis is energy density.

Two Fundamental Parameters in various rational exponents define all macro and micro features of the World: fine-structure constant α and dimensionless quantity Q. While α is constant, Q increases with time, and is in fact the dimensionless fifth coordinate in our Model.

Three Fundamental Units define all physical dimensional parameters of the World: basic unit of momentum $p_0 = \frac{h}{a}$, energy density $\rho_0 = \frac{hc}{a^4}$, and energy flux density $I_0 = \frac{hc^2}{a^4}$.

4.1. WUM Overview

The World was started by a fluctuation in the 4-dimensional Universe, and the Nucleus of the World, which is a 4-ball, was born. The Nucleus antipode length (the furthest distance between any two points of the Nucleus 3-sphere) at the Beginning was equal to a. The Nucleus has since been expanding through the Universe so that the antipode length R is increasing with speed c for cosmological time τ and equals to $R = c\tau$. The antipode length of the 4-ball Nucleus calculated by equation (4.5) equals to the Hubble's radius (about 14.223 Byr). The 4-ball is the interior of a 3-sphere which is the World in our Model.

The World consists of the Medium (protons, electrons, photons, neutrinos, and dark matter particles) and Macroobjects (Galaxy clusters, Galaxies, Star clusters, Extrasolar systems, planets, etc. down to BEC drops) made of these particles. DMP include three Majorana fermions (Neutralinos, WIMPs, and Sterile neutrinos) with spin of 1/2 and two spin-0 bosons (named DIRACs and ELOPs in the WUM) [2]. According to WUM, all stable particles are created in the 3-sphere World due to the surface energy of the 4-ball Nucleus of the World provided by the 4-dimensional Universe [1].

The Medium of the World composed of massive particles is the manifestation of the metric depending on x^4 [66] [67]. There are no empty space and dark energy in the WUM.

The principal idea of WUM is that the energy density of the World ρ_W equals to the critical energy density

ρ_{cr} necessary for a flat World at any cosmological time.

The black body spectrum of the cosmic Microwave Background Radiation (MBR) is due to thermodynamic equilibrium of photons with low density intergalactic plasma. The calculated by the equation (3.13) value of MBR temperature $T_{MBR} = 2.72518\,\mathrm{K}$ is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\,\mathrm{K}$ [68].

Nucleosynthesis of all elements (including light elements) occurs inside stars during their evolution (Stellar nucleosynthesis). The theory of this process is well developed, starting with the publication of a celebrated B^2FH review paper in 1957 [69]. With respect to WUM, stellar nucleosynthesis theory should be enhanced to account for annihilation of heavy DMP (WIMPs and Neutralinos) [2]. The amount of energy produced due to this process is sufficiently high to produce all elements inside stellar cores.

All Macroobjects (MO) of the World (galaxy clusters, galaxies, star clusters, extrasolar systems, and planets) have cores made up of different DMP surrounded by different shells [2]. We have developed the model of the World that describes MO possessing energies proportional to the total World's macroobjects energy $E_{MO} = \frac{1}{3} E_W$ with varying coefficients:

- World: 1
- Galaxy clusters: $Q^{-1/8}$
- Galaxies: $Q^{-1/4}$
- Globular clusters: $Q^{-3/8}$
- Extrasolar systems: $Q^{-1/2}$.

The energy consumption rates are greater for galaxies relative to extrasolar systems, and for the World relative to galaxies. It follows that new stars and star clusters can be created inside of a galaxy, and new galaxies and galaxy clusters can arise in the World. Structures form from top (the World) down to extrasolar systems in parallel around different cores made of different DMP. Formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing.

The World is continuously receiving energy from the Universe that envelopes it. Assuming an unlimited Universe, the numbers of cosmological structures on all levels will increase: new galaxy clusters will form; existing clusters will obtain new galaxies; new stars will be born inside existing galaxies; sizes of individual stars will increase, etc. The temperature of the Medium of the World will asymptotically approach absolute zero (see equation (3.13)).

4.2. Time-Varying Parameters of the World

In accordance with WUM, the dimensionless quantity Q in various rational exponents defines all time-varying parameters of the World as follows [1]:

- Total energy of the World E_W at cosmological time τ

$$E_W = \frac{6}{\pi} E_0 \times Q^2 \propto \tau^2 \tag{4.1}$$

- Newtonian parameter of gravitation G

$$G = \frac{a^2 c^4}{8\pi h c} \times Q^{-1} \propto \tau^{-1} \tag{4.2}$$

- Hubble's parameter H

$$H = \frac{c}{a} \times Q^{-1} \propto \tau^{-1} \tag{4.3}$$

- Age of the World A_τ

$$A_\tau = \frac{a}{c} \times Q \propto \tau \tag{4.4}$$

- Size of the World R

$$R = a \times Q \propto \tau \tag{4.5}$$

- Critical energy density ρ_{cr}

$$\rho_{cr} = 3\rho_0 \times Q^{-1} \propto \tau^{-1} \tag{4.6}$$

- Planck mass M_P

$$M_P = 2\frac{E_0}{c^2} \times Q^{1/2} \propto \tau^{1/2} \tag{4.7}$$

- Temperature of the microwave background radiation T_{MBR}

$$T_{MBR} = \frac{E_0}{k_B}\left(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p}\right)^{1/4} \times Q^{-1/4} \propto \tau^{-1/4} \tag{4.8}$$

- Temperature of the far-infrared background radiation peak T_{FIRB}

$$T_{FIRB} = \frac{E_0}{k_B}\left(\frac{15}{4\pi^5}\right)^{1/4} \times Q^{-1/4} \propto \tau^{-1/4} \tag{4.9}$$

- Fermi coupling parameter G_F

$$\frac{G_F}{(\hbar c)^3} = \sqrt{30}\left(2\alpha\frac{m_e}{m_p}\right)^{1/4}\frac{m_p}{m_e}\frac{1}{E_0^2} \times Q^{-1/4} \propto \tau^{-1/4} \tag{4.10}$$

where the basic unit of energy E_0 equals to [1]

$$E_0 = \frac{hc}{a} = m_0 c^2 \tag{4.11}$$

All parameters of the World depending on Q are a manifestation of the fifth dimension of the World [1]. Their calculated values are in good agreement with the experimentally measured values.

The calculated values of the parameter Q_G (see equation (4.2)) based on the average value of the gravitational parameter $G = 6.67408(31)\times10^{-11}\ \mathrm{m^3 \cdot kg^{-1} \cdot s^{-2}}$ and the parameter Q_F (see equation (4.10)) based on the average value of the Fermi coupling parameter $G_F = 1.1663787(6)\times10^{-5}\ \mathrm{GeV^{-2}}$ are:

$$Q_G = 0.759972 \times 10^{40} \tag{4.12}$$

$$Q_F = 0.75992106 \times 10^{40} \tag{4.13}$$

The value of Q_F is much more precise than the value of Q_G.

To summarize: parameters G_F, G, H_0, A_t, T_{MBR}, and T_{FIRB} are all inter-connected. Today, we can substantially increase the precision of G, H_0, A_t, T_{FIRB}, and T_{MBR} based on Q_F. Looking forward, better precision in measurement of any parameter may potentially increase the precision of all others. We propose introducing Q as a new fundamental parameter tracked by CODATA, and use its value in calculation of all time-dependent parameters.

4.3. Grand Unified Theory

The Grand Unified Theory is a model in particle physics in which at high energy, the three interactions—Weak, Electromagnetic, and Strong, are merged into one single interaction characterized by one Unified Coupling constant. By definition: *Coupling constant is a number that determines the strength of an interaction.* For example, the gravitational coupling constant α_G can be defined as follows:

$$\alpha_G = \frac{m_e^2}{4\pi\varepsilon_g\hbar c} = \frac{Gm_e^2}{\hbar c} = \left(\frac{m_e}{M_P}\right)^2 \tag{4.14}$$

where $\hbar$ is the reduced Planck constant. Electromagnetic coupling constant α_{EM} is defined as:

$$\alpha_{EM} = \frac{e^2}{4\pi\varepsilon_0\hbar c} = \alpha \tag{4.15}$$

α determines the strength of the electromagnetic force of electrons.

At an atomic scale, the strong interaction is about 100 times stronger than electromagnetic interaction, which in turn is about 10^{10} times stronger than the weak force, and about 10^{40} times stronger than the gravitational force, when forces are compared between particles interacting in more than one way.

All these definitions are based on strength of the force between a particular pair of particles, and depend on the choice of such particles. Clearly, the gravity between a pair of electrons will differ from that of a pair of protons. In our opinion, there is no gravitational interaction between elementary particles (see Section 3.3).

In this Section we propose a different way of comparing interactions based on Fundamental parameter *Q* in various rational exponents. Let's start with the gravitational interaction which is expressed by gravitational parameter *G*:

$$\frac{G}{\hbar c} = \frac{1}{4\pi\varepsilon_g\hbar c} \tag{4.16}$$

Let's take a dimension-transposing parameter $P = \frac{c}{h}$ and express mass *m* of an object in terms of Compton length L_{Cm} by multiplying *m* by *P*:

$$mP = m\frac{c}{h} = \frac{1}{L_{Cm}} \tag{4.17}$$

and divide the interaction parameter $\frac{G}{\hbar c}$ by the same coefficient *P* squared:

$$\frac{G}{\hbar c}\left(\frac{h}{c}\right)^2 = S_0 \times Q^{-1} \tag{4.18}$$

where parameter S_0 equals to

$$S_0 = \frac{a^2}{4} = \pi^2 a_0^2 \tag{4.19}$$

By dividing the left side of (4.18) by S_0 we obtain the dimensionless gravitational coupling parameter α_G:

$$\alpha_G = Q^{-1} = 1.315837 \times 10^{-40} \tag{4.20}$$

Using the same approach for electromagnetic interaction, we divide the charge *e* by the magnetic dipole of dark matter particle DIRAC $\frac{\mu a_0}{2}$:

$$\frac{e}{\mu a_0/2} = \frac{4\alpha}{a_0} \tag{4.21}$$

and multiply the interaction parameter $\frac{1}{4\pi\varepsilon_0\hbar c}$ by the magnetic dipole squared:

$$\frac{1}{4\pi\varepsilon_0\hbar c}\left(\frac{\mu a_0}{2}\right)^2 = \frac{1}{16\pi^2\alpha}S_0 \tag{4.22}$$

The dimensionless electromagnetic coupling parameter α_{EM} then equals to

$$\alpha_{EM} = \left(16\pi^2\alpha\right)^{-1} \cong 0.8678 \approx 1 \tag{4.23}$$

The ratio of the coupling parameters is

$$\frac{\alpha_G}{\alpha_{EM}} \cong Q^{-1} \tag{4.24}$$

The coupling parameter α_S of the strong interaction equals to the coupling parameter of the electromagnetic interaction α_{EM}:

$$\alpha_S = \alpha_{EM} = 1 \tag{4.25}$$

The difference between the strong and the electromagnetic interactions lies not in their coupling parameters but in the strength of these interactions depending on the particles involved: electrons with charge *e* and monopoles with charge

$$\mu = \frac{e}{2\alpha} \cong 68.5e \tag{4.26}$$

in electromagnetic and strong interactions respectively.

The weak interaction is about 10^{10} times weaker than electromagnetic. We can therefore assume that its coupling parameter α_W is about 10^{10} times smaller. The ratio of α_W to α_{EM} roughly equals to $Q^{-1/4}$:

$$\frac{\alpha_W}{\alpha_{EM}} \cong Q^{-1/4} = 1.0710273\times10^{-10} \tag{4.27}$$

Substituting the value of Q_G obtained in (4.12) into Fermi coupling parameter equation (4.10) we calculate $\frac{G_F}{(\hbar c)^3}$ to equal

$$\frac{G_F}{(\hbar c)^3} = 1.166359\times10^{-5}\ \text{GeV}^{-2} \tag{4.28}$$

that is in excellent agreement with the commonly adopted value of $1.1663787(6)\times10^{-5}\ \text{GeV}^{-2}$.

At the very Beginning ($Q = 1$) all extrapolated fundamental interactions of the World were characterized by the Unified coupling parameter α_U:

$$\alpha_U = \alpha_S = \alpha_{EM} = \alpha_W = \alpha_G = 1 \tag{4.29}$$

At that time, the extrapolated energy density of the World ρ_{cr0} was:

$$\rho_{cr0} = \frac{3hc}{a^4} = 6.0640\times10^{30}\ \frac{\text{J}}{\text{m}^3} \tag{4.30}$$

Note that the energy density at the Beginning is much smaller than the nuclear density $\sim10^{35}\ \frac{\text{J}}{\text{m}^3}$. An average energy density of the World has since been decreasing, and its present value is given by

$$\rho_{cr} = \rho_{cr0}\times Q^{-1} = 7.9775\times10^{-10}\ \frac{\text{J}}{\text{m}^3} \tag{4.31}$$

The gravitational coupling parameter α_G is similarly decreasing:

$$\alpha_G = Q^{-1} \propto \tau^{-1} \tag{4.32}$$

The weak coupling parameter is decreasing as follows:

$$\alpha_W = Q^{-1/4} \propto \tau^{-1/4} \tag{4.33}$$

The strong and electromagnetic parameters remain constant in time:

$$\alpha_S = \alpha_{EM} = 1 \tag{4.34}$$

Our Model foresees two more types of interactions:

- Super-Weak, coupling parameter α_{SW}:

$$\alpha_{SW} = Q^{-1/2} \propto \tau^{-1/2} \tag{4.35}$$

- Extremely-Weak, coupling parameter α_{EW}:

$$\alpha_{EW} = Q^{-3/4} \propto \tau^{-3/4} \tag{4.36}$$

According to WUM, the super-weak interaction is $\sim 10^{-10}$ times weaker than the weak interaction. The possibility of such ratio of interactions was discussed in theoretical models explaining CP and Strangeness violation [70]-[73]. Super-weak and extremely-weak interactions provide an important clue to physics beyond the standard model.

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