Development of Hypersphere World-Universe Model. Narrative

Part II. 5D World-Universe Model

5D World-Universe Model. Space–Time–Energy

Abstract

5D Space-Time-Energy World – Universe Model is a unified model of the World built around the concept of Medium, composed of massive particles (protons, electrons, photons, neutrinos, and dark matter particles). The Model provides a mathematical framework that enables precise calculation of Medium-bound physical parameters: Hubble's parameter, intergalactic plasma parameters, temperature of microwave background radiation and the rest mass of photons. This paper aligns the World – Universe Model (WUM) with the theoretical framework developed by Prof. P. S. Wesson, albeit assigning a new physical meaning to the fifth coordinate. In the World – Universe Model, the fifth dimension is associated with the total energy of the Medium of the World, and the gravitomagnetic parameter of the Medium serves as the dimension-transposing parameter.

Keywords. 5D World – Universe Model; Space-Time-Energy; Medium of the World; Intergalactic Plasma; Microwave Background Radiation; Mass Varying Photons

1. Introduction

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

Albert Einstein

WUM is proposed as an alternative to the prevailing Big Bang Model of standard physical cosmology. The main difference is the source of the World's energy. In the present work, we focus on the physical meaning of the fifth coordinate and provide a brief overview of WUM.

World – Universe Model (WUM) utilizes the following principles:

Variable gravitational parameter. This hypothesis was proposed by Paul Dirac in 1937 [1].

Continuous creation of matter. F. Hoyle and J. V. Narlikar in 1964 offered an explanation for the appearance of new matter by postulating the existence of what they dubbed the "creation field", or just the "C-field"[2].

According to WUM, the World is a 3-sphere that is the surface of a 4-ball Nucleus of the World. The 4-ball is expanding in the 4-dimensional Universe, and its surface, the 3-sphere, is likewise expanding. The total surface energy of the 4-ball is increasing as it expands, thus creating new matter in our 3-sphere World.

Supremacy of matter postulated by Albert Einstein: "*When forced to summarize the theory of relativity in one sentence: time and space and gravitation have no separate existence from matter*".

Existence of the Medium of the World stated by Nikola Tesla: "*All attempts to explain the workings of the universe without recognizing the existence of the ether and the indispensable function it plays in the phenomena are futile and destined to oblivion*". Unique properties of the Medium were discussed by James McCullagh in 1846. He proposed a theory of a rotationally elastic medium, i.e. a medium in which every particle resists absolute rotation. This theory produces equations analogous to Maxwell's electromagnetic equations [3].

In WUM, 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.) made of these particles. There are no empty space and dark energy in the WUM.

Mach's principle. A very general statement of Mach's principle is "*Local physical laws are determined by the large-scale structure of the universe*".

Fifth dimension. In 1983, Paul S. Wesson suggested that a fifth dimension might be associated with rest mass via $x^4 = Gm/c^2 \propto t$ [4].

WUM follows this idea, albeit associating the fifth dimension with the parameters of the Medium of the World: the gravitomagnetic parameter and the total energy.

Principal role of Maxwell's Equations (ME) that form the foundation of classical electrodynamics. The value of ME is even greater because J. Swain showed that "*linearized general relativity admits a formulation in terms of gravitoelectric and gravitomagnetic fields that closely parallels the description of the electromagnetic field by Maxwell's equations"* [5]. Hans Thirring pointed out this analogy in his "*On the formal analogy between the basic electromagnetic equations and Einstein's gravity equations in first approximation*" paper published in 1918 [6]. It allows us to use formal analogies between the electromagnetism and relativistic gravity. It is worth noting that Oliver Heaviside published the equations for Gravitoelectromagnetism as a separate theory expanding Newton's law as early as 1893, ahead of Einstein's general relativity [7].

Fundamental parameters and units. In accordance with ME, there are two measurable physical characteristics for electromagnetism and gravitoelectromagnetism: energy density and energy flux density. For all particles under consideration we used four-momentum to conduct statistical analysis of particles' ensembles, obtaining the energy density as the final result.

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 in time, and is in fact a measure of the Size and the Age of the World.

In Section 2 we propose a new physical meaning of the fifth coordinate and give a short summary of WUM. In Section 3 we calculate the parameters of Low Density Intergalactic Plasma that is part of the Medium. Based on the plasma parameters, we calculate Temperature of the Microwave Background Radiation and the rest mass of photons. In Section 4 we point out on decisive role of the Medium of the World composed of massive particles in 5D Space-Time-Energy WUM

2. Cosmology

Let's proceed to discuss the origin, evolution, and parameters of the World speculated by the WUM in light of the Space-Time-Matter theory developed by Paul S. Wesson.

2.1. The Beginning and Expansion

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 that is the gravitoelectrodynamic constant, for cosmological time τ and equals to $R = c\tau$. The corresponding diameter of the Nucleus D_N is: $D_N = 2R/\pi$.

The 4-ball is the interior of a 3-sphere which is the World in our Model. The 3-dimensional cubic hyperarea of a 3-sphere V_W is:

$$V_W = \frac{\pi^2}{4} D_N^3 = \frac{2}{\pi} R^3 \qquad 2.1.1$$

Let's introduce a dimensionless time-varying quantity $Q = R/a$. Q is then the size of the World measured in terms of a. The quantity Q is one of the Fundamental parameters of the WUM.

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.) made of these particles. The WUM is based on Maxwell's equations, and McCullagh's theory [3] is a good fit for description of the Medium.

2.2. Newtonian Parameter of Gravitation. Primary Parameters of the World

The (almost) constancy of the universe fundamental constants, including Newtonian constant of gravitation G, is now commonly accepted, although has never been firmly established as a fact. All conclusions on the constancy of G are model-dependent [8, 9]. In our opinion, it is impossible to either prove or disprove the constancy of G. Consequently, variability of G with time can legitimately be explored. Alternative cosmological models describing the Universe with time varying G are widely discussed in literature (see e.g. [8, 9] and references therein).

A commonly held opinion states that gravity has no established relation to other fundamental forces, so it does not appear possible to calculate it indirectly from other constants that can be measured more accurately, as is done in some other areas of physics. The World – Universe Model holds that there indeed exist relations between all Q-dependent, time varying parameters: G, H (Hubble's parameter), R (Size of the World), A_τ (Age of the World), ρ_{cr} (Critical energy density of the World), T_{MBR} (Temperature of the microwave background radiation).

Recall the well-known Friedmann equation for the critical energy density of the World ρ_{cr} :

$$\rho_{cr} = \frac{3H^2c^2}{8\pi G} \qquad 2.2.1$$

Equation 2.2.1 can be rewritten as

$$\frac{4\pi G}{c^2} \times \frac{2}{3}\rho_{cr} = \mu_g \times \rho_M = H^2 = \frac{1}{\tau^2} = \frac{c^2}{R^2} \qquad 2.2.2$$

where $\mu_g = \frac{4\pi G}{c^2}$ is the gravitomagnetic parameter and $\rho_M = \frac{2}{3}\rho_{cr}$ is the energy density of the Medium.

Let's introduce a length parameter L_g that is the geometric mean of the Worlds' current size R and its size at the Beginning a:

$$L_g = \sqrt{aR} \qquad 2.2.3$$

In our Model, L_g is a convenient basic unit of measure of macroobjects' size. Next, we make a seemingly far-fetched assumption that we will soon show to be in excellent numerical agreement with experimental data:

$$2L_g L_P = a^2 \qquad 2.2.4$$

which is equivalent to:

$$D_N l_P^2 = D_N \frac{\hbar G}{c^3} = a_0^3 \qquad 2.2.5$$

where $L_P = 2\pi l_P$, and l_P is Planck length, $\hbar$ is the reduced Planck constant, $a = 2\pi a_0$, and a_0 is the classical electron radius. The size of the World R is then

$$R = a \times Q = \frac{\pi}{2} D_N = \frac{\pi}{2}\frac{a_0^3}{l_P^2} = \frac{\pi}{2}\frac{(a_0 c)^3}{\hbar} \times G^{-1} \qquad 2.2.6$$

According to the equation 2.2.6, G is proportional to R^{-1} and is decreasing in time as $G \propto \tau^{-1}$. It means that ρ_{cr} and ρ_M are also proportional to R^{-1} and are decreasing in time as $\rho_M = \frac{2}{3}\rho_{cr} \propto \tau^{-1}$. From 2.2.6, the gravitational parameter G equals to:

$$G = \frac{(a_0 c)^3}{4\hbar a_0} \times Q^{-1} \qquad 2.2.7$$

and from 2.2.2, the critical energy density equals to:

$$\rho_{cr} = 3\rho_0 \times Q^{-1} \qquad 2.2.8$$

$$\rho_0 = \frac{hc}{a^4} \qquad 2.2.9$$

where ρ_0 is the basic unit of energy density and h is Planck constant. The extrapolated energy density of the World at the Beginning ($Q = 1$) is much smaller than the nuclear energy density. We can now calculate the age of the World A_t at current time t:

$$A_t = \frac{R}{c} = \frac{\pi}{2}\frac{(a_0 c)^3}{\hbar c} \times G^{-1} \qquad 2.2.10$$

Calculating the value of Hubble's parameter H_0 based on A_t, we find

$$H_0 = \frac{1}{A_t} = 68.7457(83)\ \frac{km/s}{Mpc} \qquad 2.2.11$$

which is in good agreement with $H_0 = 69.32 \pm 0.8\ \frac{km/s}{Mpc}$ obtained using WMAP data [10]. Close values of calculated and measured parameter H_0 prove our assumption about the relationship between the basic unit of measure of macroobjects' size L_g, Plank length l_P and the classical electron radius a_0 (2.2.4, 2.2.5). From 2.2.6 we calculate the value of the dimensionless parameter Q:

$$Q = \frac{(a_0 c)^3}{4\hbar a_0} \times G^{-1} = 0.760000(91) \times 10^{40} \qquad 2.2.12$$

Parameter Q defines both the size and the age of the World measured in terms of a and $t_0 = a/c$.

In frames of WUM the parameter G can be calculated based on the value of the energy density of the Medium of the World ρ_M :

$$G = \frac{\rho_M}{4\pi} \times P^2 \qquad 2.2.13$$

where a dimension-transposing parameter P equals to:

$$P = \frac{a^3}{2h/c} \qquad 2.2.14$$

Then the Newton's law of universal gravitation can be rewritten in the following way:

$$F = G\frac{m \times M}{r^2} = \frac{\rho_M}{4\pi} \frac{\frac{a^3}{2L_{Cm}} \times \frac{a^3}{2L_{CM}}}{r^2} \qquad 2.2.15$$

where we introduced the measurable parameter of the Medium ρ_M instead of the phenomenological coefficient G; and gravitoelectromagnetic charges $\frac{a^3}{2L_{Cm}}$ and $\frac{a^3}{2L_{CM}}$ instead of macroobjects masses m and M (L_{Cm} and L_{CM} are Compton length of mass m and M respectively). The gravitoelectromagnetic charges have a dimension of "area", which is equivalent to "energy", with the constant that equals to $\sigma_0 = \rho_0 a$. Following this approach, we can find the gravitomagnetic parameter of the Medium μ_g :

$$\mu_g = \frac{4\pi G}{c^2} = \frac{1}{R} \times P \qquad 2.2.16$$

and the impedance of the Medium Z_g :

$$Z_g = \mu_g c = H \times P \qquad 2.2.17$$

We apply the following transformation to Maxwell's equations for the gravitoelectromagnetism: multiply "mass" by the parameter P and divide the impedance and gravitomagnetic parameter of the Medium by the same parameter P. As a result of this transformation:

- All parameters of the gravitoelectromagnetic field have dimensions of length and time; "mass" dimension has disappeared;
- All physical parameters of the World measured in terms of a and t_0 become scalars;
- Absolute size and age of the World equal to Q;
- The gravitoelectromagnetic charge has a dimension of "area";
- The impedance of the Medium Z_M equals to the Hubble's parameter H for the whole World.

It follows that measuring the value of Hubble's parameter anywhere in the World and taking its inverse value allows us to calculate the absolute age of the World. The Hubble's parameter is then the most important characteristic of the World, as it defines the Worlds' age.
The second important characteristic of the World is the gravitomagnetic parameter μ_M:

$$\mu_M = \frac{1}{R} \qquad 2.2.18$$

Taking its inverse value, we can find the absolute size of the World. We emphasize that the above two parameters (Z_M and μ_M) are principally different physical characteristics of the Medium that are connected through the gravitoelectrodynamic constant c.

In WUM, time and space are closely connected with the Mediums' impedance and gravitomagnetic parameter. It follows that neither time nor space could be discussed in absence of the Medium. Matter, then, is primary to time and space. It follows that the gravitational parameter G can be introduced only for the World filled with matter, as Einstein has postulated.

While in our Model Hubble's parameter H has a clear physical meaning, the gravitational parameter $G = \frac{c^3}{8\pi\sigma_0} H$ is a phenomenological coefficient in the Newton's law of universal gravitation and in Einstein's theory of general relativity.

2.3. The Creation of Matter

Amount of additional surface energy of the 4-ball Nucleus provided by the Universe dE_W is proportional to the increase of the hyperarea of the 3-sphere V_W:

$$dV_W = \frac{6}{\pi} R^2 dR \tag{2.3.1}$$

and the energy density of the Medium ρ_M which is the surface energy density of the Nucleus.

The total amount of the surface energy at cosmological time τ is thus

$$E_W = \frac{12}{\pi} \rho_0 a \int_0^R r dr = \frac{6}{\pi} \rho_0 a R^2 \tag{2.3.2}$$

The energy density of the World ρ_W is inversely proportional to the Nucleus antipode length R:

$$\rho_W = \frac{6\pi^3 \rho_0 a R^2}{2\pi^3 R^3} = 3 \frac{\rho_0 a}{R} = \rho_{cr} \tag{2.3.3}$$

and equals to ρ_{cr} necessary for the flat World at any cosmological time τ. It is important to note that in our calculations we used the measurable Fundamental unit – energy density.

All physical parameters under consideration depend on Nucleus diameter D_N which is in fact the fifth coordinate in our Model. The quantity Q is the dimensionless value of it.

2.4. Physical Meaning of the Fifth Coordinate

According to J. M. Overduin and P. S. Wesson: *"a fifth dimension might be associated with rest mass via* $x^4 = Gm/c^2 \propto t$. *The chief effect of this new coordinate on four-dimensional physics was that particle rest mass, usually assumed to be constant, varied with time"* [11].

In WUM, the Medium of the World has the following parameters:

- The gravitomagnetic parameter $\mu_g = 4\pi G/c^2 \propto \tau^{-1}$;
- The energy density $\rho_M \propto \tau^{-1}$;
- The 3-dimensional cubic hyperarea of a 3-sphere $V_W = \frac{\pi^2}{4} D_N^3 = \frac{2}{\pi} R^3 \propto \tau^3$

In our opinion, the fifth dimension is associated with these parameters via

$$x^4 = \frac{\mu_g}{c^2} \times \rho_M \times V_W = \frac{\mu_g E_M}{c^2} = \frac{V_W}{R^2} = \frac{2}{\pi} R = \frac{2}{\pi} Qa = D_N \propto \tau \quad 2.4.1$$

where $E_M = \rho_M V_W$ is the total surface energy of the 4-ball Nucleus.

2.5. Experimental Evidence of the Fifth Coordinate

The physical laws we observe appear to be independent of the fifth coordinate due to the very small value of the dimension-transposing parameter μ_g. Then direct observation of the fifth dimension would appear to be a hopeless goal.

One way to prove the existence of the fifth dimension is direct measurement of truly large-scale parameters of the World: Gravitational, Hubble's, Temperature of the Microwave Background Radiation. Conducted at various points of time, these measurements would give us varying results, providing insight into the 5D nature of the World. Unfortunately, the accuracy of the measurements is quite poor. Measurement errors far outweigh any possible 5D effects, rendering this technique useless in practice. To be conclusive, the measurements would have to be conducted billions of years apart.

Let's consider an effect that has indeed been observed for billions of years, albeit indirectly. Take the so-called "Faint young Sun" paradox. One of the consequences of WUM holds that all stars were fainter in the past. As their cores absorb new matter, the size of macroobjects R_{MO} and their luminosity L_{MO} are increasing in time $R_{MO} \propto Q^{1/2} \propto \tau^{1/2}$ and $L_{MO} \propto Q \propto \tau$ respectively. Taking the age of the World $\cong$ 14.2 Byr and the age of solar system $\cong$ 4.6 Byr, it is easy to find that the young Suns' output was 67% of what it is today. Literature commonly refers to the value of 70% [12]. This result supports the notion of physical parameters being indeed dependent on the fifth coordinate.

The proposed approach to the fifth dimension is in agreement with Mach's principle: "*Local physical laws are determined by the large-scale structure of the universe*". Applied to WUM, it follows that all parameters of the World depending on Q are a manifestation of the fifth dimension of the World. The Medium of the World composed of massive particles is the manifestation of the metric depending on x^4 [4, 11]. Rest masses of protons, electrons, and Dark Matter particles don't vary with time.

3. Astroparticle Physics

In this Section we prove that the Medium of the World consists of massive particles, including photons. We find parameters of the Low Density Intergalactic Plasma, which allow us to calculate the Temperature of the Microwave Background Radiation and the rest mass of photons.

3.1. Low Density Intergalactic Plasma. Temperature of the Microwave Background Radiation

In our Model, the World consists of stable massive elementary particles with lifetimes longer than the age of the World. Protons with mass m_p and energy $E_p = m_p c^2$ and electrons with mass m_e and energy $E_e = m_e c^2 = \alpha E_0$ have identical concentrations in the World: $n_p = n_e$, where $E_0 = hc/a$ is the basic energy and α is the fine-structure constant.

Low density intergalactic plasma consisting of protons and electrons has plasma frequency ω_{pl}:

$$\omega_{pl}^2 = \frac{4\pi n_e e^2}{4\pi\varepsilon_0 m_e} = 4\pi n_e \alpha \frac{h}{2\pi m_e c} c^2 = 2n_e a c^2 \qquad 3.1.1$$

where e is the elementary charge and ε_0 is the permittivity of the Medium.

Let's assume that ω_{pl} is proportional to $Q^{-1/2}$. ω_{pl}^2 is then proportional to Q^{-1}. Energy densities of protons and electrons are then proportional to $\frac{1}{R}$, similar to the critical energy density $\rho_{cr} \propto \frac{1}{R}$. Since the formula calculating the potential energy of interaction of protons and electrons contains the same parameter k_{pe}:

$$k_{pe} = m_p \omega_{pl}^2 = m_e \left(\frac{2\pi c}{L_g}\right)^2 \qquad 3.1.2$$

we substitute $\omega_{pl}^2 = \frac{m_e}{m_p}\left(\frac{2\pi c}{L_g}\right)^2$ into 3.1.1 and calculate concentration of protons and electrons:

$$n_p = n_e = \frac{2\pi^2}{a^3}\frac{m_e}{m_p} \times Q^{-1} \qquad 3.1.3$$

$\rho_p = n_p E_p$ is the energy density of protons in the Medium. The relative energy density of protons Ω_p is then the ratio of ρ_p/ρ_{cr} :

$$\Omega_p = \frac{\rho_p}{\rho_{cr}} = \frac{2\pi^2\alpha}{3} = 0.048014655 \qquad 3.1.4$$

The above value is in good agreement with ordinary matter's share in the World $\Omega_p \cong 0.049$ found by Planck Collaboration [13].

From equation 3.1.2 we obtain the value of the lowest radio-wave frequency ν_{pl} :

$$\nu_{pl} = \frac{\omega_{pl}}{2\pi} = (\frac{m_e}{m_p})^{1/2} \times \frac{c}{a} \times Q^{-1/2} = 4.5322\ Hz \qquad 3.1.5$$

Substituting size of the World R obtained in 2.2.6, we use equation 3.1.3 to calculate the proton and electron concentrations in the Medium:

$$n_p = n_e = \frac{1}{\pi}\frac{m_e}{m_p}\frac{l_P^2}{a_0^5} = 0.25480\ m^{-3} \qquad 3.1.6$$

A. Mirizzi, G. G. Raffelt, and P. D. Serpico found that the mean diffuse intergalactic plasma density is bounded by $n_e \lesssim 0.27\, m^{-3}$ [14] corresponding to the WMAP measurement of the baryon density [15]. The Mediums' plasma density $n_e = 0.25480\ m^{-3}$ is in good agreement with the measured value and proves the assumption made for plasma frequency: $\omega_{pl} \propto Q^{-1/2}$.

The black body spectrum of Microwave Background Radiation (MBR) is due to thermodynamic equilibrium of photons with low density intergalactic plasma consisting of protons and electrons. $\rho_e = n_e E_e$ is the energy density of electrons in the Medium. ρ_{MBR}, the energy density of MBR, equals to twice the value of ρ_e :

$$\rho_{MBR} = 2\rho_e = 4\pi^2\alpha\frac{m_e}{m_p}\rho_0 \times Q^{-1} = \frac{8\pi^5}{15}\frac{k_B^4}{(hc)^3}T_{MBR}^4 \qquad 3.1.7$$

where k_B is the Boltzmann constant and T_{MBR} is MBR temperature. We can now calculate the value of T_{MBR}:

$$T_{MBR} = \frac{E_0}{k_B}(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p})^{1/4} \times Q^{-1/4} = 2.72518\,K \qquad 3.1.8$$

Thus, calculated value of T_{MBR} is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\,K$ [16] and proves the assumption 3.1.7.

At the Beginning of the World, the extrapolated value of T_{MBR0} at $Q = 1$ is

$$T_{MBR0} = 2.1927\text{ MeV} = 2.5445{\times}10^{10}\text{ K} \qquad 3.1.9$$

Note that T_{MBR0} is considerably smaller than values commonly discussed in literature.

3.2. Mass Varying Photons. Speed of Light

Photons with energy smaller than $E_{ph} = h\nu_{pl}$ cannot propagate in plasma, thus $h\nu_{pl}$ is the smallest amount of energy a photon may possess. This amount of energy can be viewed as a particle (we'll name it axion), whose frequency-independent effective "rest mass" equals to

$$m_a = \frac{E_a}{c^2} = \left(\frac{m_e}{m_p}\right)^{1/2} \times m_0 \times Q^{-1/2} = 1.8743 \times 10^{-14}\frac{eV}{c^2} \qquad 3.2.1$$

where E_a is a rest energy of the axion and m_0 is a basic unit of mass that equals to: $m_0 = E_0/c^2$.

The calculated mass of an axion is in agreement with $m_a \sim 10^{-15}\,eV/c^2$ discussed by C. Csaki *et al* [17].

According to special relativity, energy of an axion E_a moving with a group velocity v_{gr} is given by

$$E_a(v_{gr}) = h\nu_{pl}(1 - \frac{v_{gr}^2}{c^2})^{-1/2} \qquad 3.2.2$$

Taking into account the dispersion relation for plasma:

$$v_{gr}v_{ph} = c^2 \qquad 3.2.3$$

and the value of phase velocity $v_{ph} = \frac{c}{n_{pl}}$, where n_{pl} is the index of plasma refraction:

$$n_{pl} = (1 - \frac{\nu_{pl}^2}{\nu^2})^{1/2} \qquad 3.2.4$$

we calculate moving axion energy $E_a(v_{gr})$ to be

$$E_a(v_{gr}) = h\nu = E_{ph} \qquad 3.2.5$$

where ν is photon frequency. In our Model, the total energy of a moving particle consists of two components: rest energy and constituent energy. A particles' constituent energy is the response of the Medium to the particles' movement.

A photon is then a constituent axion with rest energy $E_a = h\nu_{pl}$ and total energy $E_{ph} = h\nu$. In most cases $\nu \gg \nu_{pl}$, and practically all of the photons' energy is the axions' constituent energy. Axions are fully characterized by their four-momentum. Rest energy of the axion is decreasing with time: $E_a \propto t^{-1/2}$ (see 3.2.1).

The higher the photons' energy, the closer its speed approaches c. But the fact that axions possess non-zero rest masses means that photons can never reach that speed. It is worth to note that the speed of light in vacuum, commonly denoted c, is not related to the World in our Model, because there is no vacuum in it. Instead, there is the Medium of the World consisting of elementary particles.

4. Medium of the World

J. M. Overduin and P. S. Wesson postulated that "*Metrics which do not depend on x^4 can give rise only to induced matter composed of* (massless) *photons; while those which depend on x^4 give back equations of state for fluids composed of massive particles"*[11].

The World – Universe Model supplies the fluid that J. M. Overduin and P. S. Wesson have predicted: it is, in fact, the Medium of the World. According to WUM, empty space does not exist; instead, the World is filled with Medium that consists of massive particles: protons, electrons, photons, neutrinos, and dark matter particles. The inter-galactic voids discussed by astronomers are in fact examples of the Medium in its purest. Consequently, the Medium of the World as described by WUM can serve as further evidence in favor of the fifth-dimensional view of the World.

5. Conclusion

5D Space-Time-Energy World – Universe Model is the unified model of the World around the concept of Medium that successfully describes all of the primary parameters and their relationships. The Model allows for precise calculation of values that were only measured experimentally earlier: Hubble's parameter, low density intergalactic plasma parameters, temperature of microwave background radiation and the rest mass of photons. While the Model needs significant further elaboration, it can already serve as a basis for a new physics proposed by Paul Dirac in 1937 and Paul Wesson in 1983.

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5D World-Universe Model. Multicomponent Dark Matter

Abstract

5D World – Universe Model (WUM) is based on the decisive role of the Medium of the World composed of massive particles: protons, electrons, photons, neutrinos, and Dark Matter Particles (DMP). The Model forecasts the masses of DMP, discusses the possibility of all Macroobject cores consisting of DMP (galaxy clusters, galaxies, star clusters, extrasolar systems, and planets), and explains the diffuse cosmic gamma-ray background radiation as the sum of contributions of multicomponent dark matter annihilation.

The signatures of DMP annihilation with expected masses of 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV, are found in spectra of the diffuse gamma-ray background and the emission of various macroobjects in the World. The correlation between different emission lines in spectra of macroobjects is connected to their structure, which depends on the composition of the cores and surrounding shells made up of DMP. Consequently, the diversity of Very High Energy (VHE) gamma-ray sources in the World has a clear explanation.

Keywords. "5D World – Universe Model", " Medium of the World", " Dark Matter Particles", " Cores of Macroobjects", " Gamma-ray Background Radiation", "Pioneer Anomaly"

1. Introduction

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

Albert Einstein

In the World – Universe Model (WUM) we introduce the basic unit of mass m_0 that equals to

$$m_0 = \frac{\mathrm{h}}{\mathrm{ac}} = 70.025267\ MeV/c^2$$

where h is Planck constant, c is the electrodynamic constant, $a = 2\pi a_0$, and a_0 is the classical electron radius. m_0 plays a key role when masses of Dark Matter Particles (DMP) are discussed in the next Section.

The Fine-structure constant (FSC) α is a fundamental physical constant that has several physical interpretations. α is the rest mass of an electron m_e measured in terms of basic unit m_0 . FSC plays a central role in WUM.

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-dimension Universe. The World consists of the Medium (protons, electrons, photons, neutrinos, and DMP) and Macroobjects (Galaxy clusters, Galaxies, Star clusters, Extrasolar systems, planets, etc.) made of these particles. There is no empty space or dark energy in WUM. The role of the Intergalactic plasma consisting of protons, electrons, and photons as part of the Medium of the World is analyzed in [1].

This paper discusses the Multicomponent Dark Matter and its decisive role in the Medium and Macroobjects of the World. 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 World –

Universe Model), as detailed below. Multicomponent dark matter models consisting of both bosonic and fermionic components were analyzed in literature (for example, see [2-10] and references therein).

2. Dark Matter Particles

Dark Matter (DM) is among the most important open problems in both cosmology and particle physics. There are three prominent hypotheses on nonbaryonic DM, namely Hot Dark Matter (HDM), Warm Dark Matter (WDM), and Cold Dark Matter (CDM).

A neutralino with mass m_N in $100 \Leftrightarrow 10{,}000\ GeV/c^2$ range is the leading CDM candidate. Light DMP that are heavier than WDM and HDM but lighter than neutralinos are DM candidates too. Subsequently, we will refer to the light DMP as WIMPs. Their mass m_{WIMP} falls into $1 \Leftrightarrow 10\ GeV/c^2$ range. It is known that a sterile neutrino with mass m_{ν_s} in $1 \Leftrightarrow 10\ keV/c^2$ range is a good WDM candidate. In our opinion, a tauonic neutrino is a good HDM candidate.

In addition to fermions discussed above, we offer another type of DMP – spin-0 bosons, consisting of two fermions each. There exist two types of DM bosons which we called DIRACs and ELOPS.

DIRACs are magnetic dipoles with mass m_0, consisting of two Dirac monopoles with mass $\frac{m_0}{2}$ and charge $\mu = \frac{e}{2\alpha}$, where e is an electron charge. Dissociated DIRACs can only exist at nuclear densities or at high temperatures. In our opinion, Dirac monopoles are the smallest building blocks of constituent quarks and hadrons (mesons and baryons).

The second spin-0 boson is the ELOP (named by analogy to an **EL**ectron- nortis**OP** dipole). ELOP weighs $\frac{2}{3}m_e$ and consists of two preons with mass $m_{pr} = \frac{1}{3}m_e$ and charge $e_{pr} = \frac{1}{3}e$. ELOPs break into two preons at nuclear densities or at high temperatures. In particle physics, preons are postulated to be "point-like" particles, conceived to be subcomponents of quarks and leptons [11].

We did not take into account the binding energies of DIRACs and ELOPs, and thus the values of the masses of monopoles and preons are approximate. They have negligible electrostatic and electromagnetic charges because the separation between charges is very small. The signatures of these bosons' annihilation in gamma-ray spectra will be discussed in Section 6.

WUM postulates that masses of DMP are proportional to m_0 multiplied by different exponents of α and can be expressed with the following formulae:

CDM particles (neutralinos and WIMPs):

$$m_N = \alpha^{-2}m_0 = 1.3149950\ TeV/c^2 \tag{2.1}$$

$$m_{WIMP} = \alpha^{-1}m_0 = 9.5959823\ GeV/c^2 \tag{2.2}$$

DIRACs:

$$m_{DIRAC} = 2\alpha^0 \frac{m_0}{2} = 70.025267\ MeV/c^2 \tag{2.3}$$

ELOPs:

$$m_{ELOP} = 2\alpha^1 \frac{m_0}{3} = 340.66606 \ keV/c^2 \quad (2.4)$$

WDM particles (sterile neutrinos):

$$m_{\nu_s} = \alpha^2 m_0 = 3.7289402 \ keV/c^2 \quad (2.5)$$

These values fall into the ranges estimated in literature. The roles of those particles in macroobject cores built up from fermionic dark matter, in gamma-ray spectra of the diffuse gamma-ray background, and the emission of various macroobjects in the World will be discussed in Sections 3, 4 and 6 respectively.

Our Model holds that the energy densities of all types of DMP are proportional to the proton energy density ρ_p in the World's Medium [1]:

$$\rho_p = \frac{2\pi^2\alpha}{3}\rho_{cr} \quad (2.6)$$

where ρ_{cr} is a critical energy density of the World:

$$\rho_{cr} = 3\rho_0 \times Q^{-1} \quad (2.7)$$

$$\rho_0 = \frac{\mathrm{hc}}{a^4} \quad (2.8)$$

ρ_0 is a basic unit of energy density and a dimensionless time-varying quantity Q equals to the ratio of the size of the World R at cosmological time τ to the Worlds' size a at the Beginning:

$$Q = \frac{R}{a} \quad (2.9)$$

In all, there are 5 different types of DMP. Then the total energy density of DM is

$$\rho_{DM} = 5\rho_p = 0.24007327\rho_{cr} \quad (2.10)$$

which is close to the measured DM energy density: $\rho_{DM} \cong 0.268\,\rho_{cr}$ [12]. Note that one of outstanding puzzles in particle physics and cosmology relates to so-called cosmic coincidence: the ratio of dark matter density in the World to baryonic matter density in the Medium of the World $\cong 5$ [10], [13].

Neutralinos, WIMPs, and sterile neutrinos are Majorana fermions, which partake in the annihilation interaction with strength equals to α^{-2}, α^{-1}, and α^2 respectively (see Section 3). The signatures of DMP annihilation with expected masses of 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV are found in spectra of the diffuse gamma-ray background and the emission of various macroobjects in the World (see Section 6).

3. Macroobject Cores Built Up From Fermionic Dark Matter

In this section, we discuss the possibility of all macroobject cores consisting of DMP introduced in Section 2. The first phase of stellar evolution in the history of the World may be dark stars, powered by Dark Matter heating rather than fusion. Neutralinos and WIMPs, which are their own antiparticles, can annihilate and provide an important heat source for the stars and planets in the World.

In our view, all macroobjects of the World (including galaxy clusters, galaxies, star clusters, extrasolar systems, and planets) possess the following properties:

- Macroobject cores are made up of DMP;
- Macroobjects consist of all particles under consideration, in the same proportion as they exist in the World's Medium;
- Macroobjects contain other particles, including DM and baryonic matter, in shells surrounding the cores.

Taking into account the main principle of the World – Universe Model (all physical parameters can be expressed in terms of α, Q, small integer numbers, and π) we modify the published theory of Fermionic Compact Stars (FCS) developed by G. Narain, *et al.* [14] as follows. We take a scaling solution for a free Fermi gas consisting of fermions with mass m_f in accordance with following equations:

$$\text{Maximum mass: } M_{max} = A_1 M_F; \tag{3.1}$$

$$\text{Minimum radius: } R_{min} = A_2 R_F; \tag{3.2}$$

$$\text{Maximum density: } \rho_{max} = A_3 \rho_0 \tag{3.3}$$

where

$$M_F = \frac{M_P^3}{m_f^2}; \quad R_F = \frac{M_P}{m_f}\frac{L_{Cf}}{2\pi}; \quad \rho_0 = \frac{hc}{a^4} \tag{3.4}$$

and M_P is Planck mass, L_{Cf} is a Compton length of the fermion. A_1, A_2, and A_3 are parameters. Let us choose π as the value of A_2 (instead of $A_2 = 3.367$ taken by G. Narain, *et al.* [14]). Then diameter of FCS is proportional to the fermion Compton length L_{Cf}. We use $\pi/6$ as the value of A_1 (instead of $A_1 = 0.384$ taken by G. Narain, *et al.* [14]). Then A_3 will equal to

$$A_3 = (\frac{m_\mathrm{f}}{m_0})^4 \tag{3.5}$$

Table 1 summarizes the parameter values for FCS made up of various fermions.

A Compact Star made up of heavier particles – WIMPs and neutralinos – could in principle have a much higher density. In order for such a star to remain stable and not exceed the nuclear density, WIMPs and neutralinos must partake in an annihilation interaction whose strength equals to α^{-1} and α^{-2} respectively.

Scaling solution for interacting WIMPs can also be described with equations (3.1), (3.2), (3.3) and the following values of A_1, A_2 and A_3:

$$A_{1max} = \frac{\pi}{6}(\alpha\beta)^{-2} \tag{3.10}$$

$$A_{2min} = \pi(\alpha\beta)^{-2} \tag{3.11}$$

$$A_{3max} = \beta^4 \tag{3.12}$$

The maximum mass and minimum radius increase about two orders of magnitude each and the maximum density equals to the nuclear density. Note that parameters of a FCS made up of strongly interacting WIMPs are identical to those of neutron stars.

Table 1

Fermion	Fermion relative mass m_f/m_0	Macroobject relative mass M_{max}/M_0	Macroobject relative radius R_{min}/L_g	Macroobject relative density ρ_{max}/ρ_0
Sterile neutrino	α^2	α^{-4}	α^{-4}	α^8
Preon	$3^{-1}\alpha^1$	$3^2\alpha^{-2}$	$3^2\alpha^{-2}$	$3^{-4}\alpha^4$
Electron-proton (white dwarf)	α^1, β	β^{-2}	$(\alpha\beta)^{-1}$	$\alpha^3\beta$
Monopole	2^{-1}	2^2	2^2	2^{-4}
WIMP	α^{-1}	α^2	α^2	α^{-4}
Neutralino	α^{-2}	α^4	α^4	α^{-8}
Interacting WIMPs	α^{-1}	β^{-2}	β^{-2}	β^4
Interacting neutralinos	α^{-2}	β^{-2}	β^{-2}	β^4
Neutron (star)	$\approx \beta$	β^{-2}	β^{-2}	β^4

where

$$M_0 = \frac{4\pi m_0}{3} \times Q^{3/2} \tag{3.6}$$

$$L_g = a \times Q^{1/2} \tag{3.7}$$

$$\beta = \frac{m_p}{m_0} \tag{3.8}$$

and m_p is the mass of a proton. A maximum density of neutron stars equals to the nuclear density:

$$\rho_{max} = \beta^4 \rho_0 \tag{3.9}$$

which is the maximum possible density of any macroobject in the World.

In accordance with the paper by G. Narain, *et al.* [14], the most attractive feature of the strongly interacting Fermi gas of WIMPs is practically constant value of FCS minimum radius in the large range of masses M_{WIMP} from

$$M_{WIMPmax} = \frac{\pi}{6}(\alpha\beta)^{-2} M_F = \frac{1}{\beta^2} M_0 \tag{3.13}$$

down to

$$M_{WIMPmin} = \alpha^4 M_{WIMPmax} \tag{3.14}$$

$M_{WIMPmin}$ is more than eight orders of magnitude smaller than $M_{WIMPmax}$. It makes strongly interacting WIMPs good candidates for stellar and planetary cores of extrasolar systems with Red stars (see Section 4).

When the mass of a FCS made up of WIMPs is much smaller than the maximum mass, the scaling solution yields the following equation for parameters A_1 and A_2:

$$A_1 A_2^3 = \pi^4 \tag{3.15}$$

Compare $\pi^4 \cong 97.4$ with the value of 91 used by G. Narain, *et al.* [14].

Minimum mass and maximum radius take on the following values:

$$A_{1min} = \frac{\pi}{6}\sqrt{6}(\alpha\beta)^2 \tag{3.16}$$

$$A_{2max} = \pi\sqrt[6]{6}(\alpha\beta)^{-2/3} \tag{3.17}$$

It follows that the range of FCS masses ($A_{1min} \Leftrightarrow A_{1max}$) spans about three orders of magnitude, and the range of FCS core radii ($A_{2min} \Leftrightarrow A_{2max}$) – one order of magnitude. It makes WIMPs good candidates for brown dwarf cores too (see Section 4).

Scaling solution for interacting neutralinos can be described with the same equations (3.1), (3.2), (3.3) and the following values of A_1^*, A_2^* and A_3^*:

$$A_{1max}^* = \frac{\pi}{6}(\alpha^2\beta)^{-2} \tag{3.18}$$

$$A_{2min}^* = \pi(\alpha^2\beta)^{-2} \tag{3.19}$$

$$A_{3max}^* = \beta^4 \tag{3.20}$$

In this case, the maximum mass and minimum radius increase about four orders of magnitude each and the maximum density equals to the nuclear density. Note that parameters of a FCS made up of strongly interacting neutralinos are identical to those of neutron stars.

Practically constant value of FCS minimum radius takes place in the huge range of masses M_N from

$$M_{Nmax} = \frac{\pi}{6}(\alpha\beta)^{-2}\alpha^2 M_F = \frac{1}{\beta^2}M_0 \tag{3.21}$$

down to

$$M_{Nmin} = \alpha^8 M_{Nmax} \tag{3.22}$$

M_{Nmin} is more than seventeen orders of magnitude smaller than M_{Nmax}. It makes strongly interacting neutralinos good candidates for stellar and planetary cores of extrasolar systems with Main-sequence stars (see Section 4).

When the mass of a FCS made up of neutralinos is much smaller than the maximum mass, the scaling solution yields the following equation for parameters A_1^* and A_2^*:

$$A_1^* {A_2^*}^3 = \pi^4 \tag{3.23}$$

Minimum mass and maximum radius take on the following values:

$$A_{1min}^* = \frac{\pi}{6}\sqrt{6}(\alpha^2\beta)^2 \tag{3.24}$$

$$A_{2max}^* = \pi\sqrt[6]{6}(\alpha^2\beta)^{-2/3} \tag{3.25}$$

It means that the range of FCS masses ($A_{1min}^* \Leftrightarrow A_{1max}^*$) is about twelve orders of magnitude, and the range of FCS core radiuses ($A_{2min}^* \Leftrightarrow A_{2max}^*$) is about four orders of magnitude. The numerical values for FCS masses and radii will be given in Section 4.

Fermionic Compact Stars have the following properties:

- The maximum potential of interaction U_{max} between any particle or macroobject and FCS made up of any fermions

$$U_{max} = \frac{GM_{max}}{R_{min}} = \frac{c^2}{6} \tag{3.26}$$

does not depend on the nature of fermions;
- The minimum radius of FCS made of any fermion

$$R_{min} = 3R_{SH} \tag{3.27}$$

equals to three Schwarzschild radii and does not depend on the nature of the fermion;
- FCS density does not depend on M_{max} and R_{min} and does not change in time while $M_{max} \propto \tau^{3/2}$ and $R_{min} \propto \tau^{1/2}$.

4. Macroobjects of the World

According to WUM, all macroobjects of the World (galaxies, stars, planets) possess cores consisting of DMP. The theory of fermion compact stars made up of DMP is well developed. Scaling solutions are derived for a free and an interacting Fermi gas in Section 3. **Table 2** describes the numerical values for masses and radii of FCS made up of different fermions:

Table 2

Fermion	Fermion mass $m_f, MeV/c^2$	Macroobject mass M_{max}, kg	Macroobject radius R_{min}, m	Macroobject density $\rho_{max}, kg/m^3$
Sterile neutrino	3.73×10^{-3}	1.2×10^{41}	5.4×10^{14}	1.8×10^{-4}
Preon	$\gtrsim 0.17$	5.9×10^{37}	2.6×10^{11}	7.8×10^{2}
Monopole	$\gtrsim 35$	1.4×10^{33}	6.2×10^{6}	1.4×10^{12}
Interacting WIMPs	9,596	1.9×10^{30}	8.6×10^{3}	7.2×10^{17}
Interacting neutralinos	$1{,}315\times10^{3}$	1.9×10^{30}	8.6×10^{3}	7.2×10^{17}
Electron; proton (white dwarf)	0.511; 938.3	1.9×10^{30}	1.6×10^{7}	1.2×10^{8}
Neutron (star)	939.6	1.9×10^{30}	8.6×10^{3}	7.2×10^{17}

The calculated parameters of FCS show that

- White Dwarf Shells (WDS) around the nuclei made of strongly interacting WIMPs or neutralinos compose cores of stars in extrasolar systems;
- Shells of dissociated DIRACs to monopoles around the nuclei made of strongly interacting WIMPs or neutralinos form cores of globular clusters;
- Shells of dissociated ELOPs to preons around the nuclei made of strongly interacting WIMPs or neutralinos constitute cores of galaxies;

- Shells of sterile neutrinos around the nuclei made of strongly interacting WIMPs or neutralinos make up cores of galaxy clusters.

Although there are no free Dirac's monopoles and preons in the World, they can arise in the cores of FCS as the result of DIRACs and ELOPs gravitational collapse with density increasing up to the nuclear density ($\sim 10^{17}\ \frac{kg}{m^3}$) and/or at high temperatures, with subsequent dissociation of dipoles to monopoles and preons.

4.1. Galaxies and Galaxy Clusters

A number of non-traditional models explaining the supermassive dark objects observed in galaxies and galaxy clusters, formed by self-gravitating non-baryonic matter composed of fermions and bosons, are widely discussed in literature [2-10].

Dark matter can be, in principle, achieved also through extended theories of gravity. It has been shown, for example, that in the framework of R^2 gravity and in the linearized approach, it is possible to obtain spherically symmetric and stationary galaxy states which can be interpreted like an approximated solution of the Dark Matter problem [15], [16].

According to WUM, the heaviest macroobjects include a high-density preon plasma shell around their cores:

- Macroobjects with a cold preon shell emit strong radio waves. Such objects are good candidates for the compact astronomical radio sources at centers of galaxies like Sagittarius A* in the Milky Way Galaxy;
- Red Giants are macroobjects with hot preon shells;
- Blazars are members of a larger group of active galaxies that host active galactic nuclei (AGN). They are macroobjects with hot preon and sterile neutrinos shells;
- Quasars are the most energetic and distant members of AGN. They are macroobjects with very hot preon and sterile neutrinos shells;
- Seyfert galaxies are one of the two largest groups of AGN, along with quasars. They have quasar-like nuclei, but unlike quasars, their host galaxies are clearly detectable. Seyfert galaxies account for about 10% of all galaxies.

Note that the temperature of the preon and sterile neutrinos shells depends on the composition of the macroobject core. Macroobjects whose cores are made up of WIMPs and preons remain cold. Macroobjects with cores made up of WIMPs and WDS produce hot preon and sterile neutrino shells. Macroobjects whose cores consist of neutralinos and WDS have very hot preon and sterile neutrino shells.

The mass of an AGN is about 7-11 orders of magnitude larger than the mass of the Sun. The radius of an AGN is about 4-7 orders of magnitude larger than the radius of WDS (see **Table 2**). The area of the closed spherical surface around the AGN is 8-14 orders of magnitude greater than the surface area of WDS. Luminosity of the AGN is then 8-14 orders of magnitude higher than the luminosity of the largest star. This take on AGNs explains the fact that the most luminous quasars radiate at a rate that can exceed the output of average galaxies, equivalent to two trillion suns.

To summarize, macroobjects of the World have cores made up of DM particles. The cores are surrounded by shells made up of DM and baryonic matter. Every macroobject consists of all particles under consideration that are present in the same proportion as they exist in the World's Medium. No compact stars are made up solely of fermionic DMP, for instance.

4.2. Extrasolar Systems

There are two primary types of stars: main-sequence stars and red stars. They differ in their surface temperatures and radii:

- Red stars have cool surface temperatures: 3,500 ⟺ 4,500 K for Hypergiants, Supergiants, Giants, lower for Red dwarfs (2,300 ⟺ 3,800 K), and significantly lower for Brown dwarfs (300 ⟺ 1,000 K). These stars have enormous range of radii: from 1,650 R_{Sun} for Hypergiants down to 0.08 R_{Sun} for Red dwarfs, and lower still for Brown dwarfs.
- Main-sequence stars have surface temperatures in the range of 3,000 ⟺ 45,500 K, and radii in the range from 35 R_{Sun} for the most massive known star R136a1 down to 0.1 R_{Sun} for least heavy stars.

In our opinion, the difference between main-sequence stars and red stars lies in composition of stellar cores. Main-sequence stars cores are made up of neutralinos, while red star cores consist of WIMPs. As we have shown in Section 3, in both cases the cores' maximum mass and minimum radius equals to that of a neutron star. The fermions, however, have drastically different interaction strength of annihilation: α^{-1} in case of WIMPs and α^{-2} in case of neutralinos.

The Core temperature is therefore much higher in main-sequence stars whose cores are made up of neutralinos. Ignition of proton-proton chain reaction with the interaction strength equal to $\beta \approx 13.4$ developing in the surrounding WDS happens much more efficiently in these stars.

The developed star model explains the very low power production density produced by fusion inside of the Sun. Wikipedia humorously notes that the power output of the Sun *more nearly approximates reptile metabolism than a thermonuclear bomb*. In our Model, the core made up of strongly interacting neutralinos is the supplier of proton-electron pairs into WDS and igniter of the proton-proton chain reaction developing in the surrounding WDS with small interaction strength $\beta \cong 13.4$.

New neutralinos freely penetrate through the entire stellar envelope, get absorbed into the core and support neutralino annihilation and proton fusion in the WDS. An important consequence for Solar system, and in fact for all other stars in the World, is that they will never burn their "fuel" out. On the contrary, stars accumulate more fuel with time, and output more power.

Enormous radii of Hypergiants (up to 1,650 $R_{Sun} \cong 10^{12}\ m$) and huge luminosity of giant stars can be explained by an additional shell of preons – particles whose charge equals to $\frac{1}{3}e$. They compose hot high-density plasma with surface temperature in the range of 3,500 ⟺ 4,500 K. The minimum radius of preon shell $R_{min} \cong 2.6 \times 10^{11}\ m$ (see **Table 2**).

Brown dwarfs are sub-stellar objects whose masses range from 13 to 80 Jupiter masses. In our opinion, Brown dwarfs differ from red stars in that the density of their cores is smaller than nuclear density. Consequently, WIMPs annihilation takes place less efficiently.

4.3. Extrasolar System Formation

The Nebular Hypothesis is the most widely accepted model of planetary formation. It holds that 4.6 Billion years ago, the Solar System was formed during a gravitation collapse of a giant molecular cloud, some light years across. The most significant criticism of the hypothesis is its inability to explain the Sun's relative lack of angular momentum when compared to the planets [17].

According to WUM, Extrasolar systems arise from clouds of all particles under consideration with mass M_{Cl} . As a result of gravitational instability, gravitational collapse takes place and one third of M_{Cl} is concentrating at the center of the cloud, increasing the density of the core up to the nuclear density.

The heaviest particles – neutralinos or WIMPs – are the first in this stream of matter. When their density achieves the nuclear density, self-annihilation process ignites. As the result, the Stellar Nucleus (SN) grows up to 10^4 for neutralinos and 10^2 times for WIMPs taking additional mass of neutralinos and WIMPs from oncoming stream.

The next heaviest particles – protons, joined by electrons – will follow neutralinos or WIMPs during the gravitational collapse, and form the White Dwarf Shell (WDS) around the SN made of strongly interacting WIMPs or neutralinos.

Expansion of the hot Stellar Core (SC), consisting of SN with WDS, is progressing. Drops of the SC are ejected from the equatorial bulges of an overspinning SC (outward centrifugal forces exceed the inward gravitational force) and give birth to the cores of planets.

The following facts support the creation picture of extrasolar systems outlined above:

- The analysis of a mass – radius ratio for compact stars made of strongly interacting fermions shows that the radius remains approximately constant for a wide range of compact stars masses;
- The analysis of a mass – radius ratio for the lowest mass white dwarfs shows the same behavior – radius does not depend on mass. It happens because at the low mass end the Coulomb pressure (which is characterized by constant density $\propto M/r^3$ and thus $r \propto M^{1/3}$) starts to compensate the degeneracy: $r \propto M^{-1/3}$. The two effects nearly cancel each other out, so $r \propto M^0$ – no dependency at all;
- Recent analysis of the Solar and Heliospheric Observatory (SOHO) mission data favors a faster rotation rate in the solar core (below 0.2 solar radius) than in the rest of the radiative zone[18];
- By analyzing the minute changes in travel times and wave shapes for earthquake doublets, the researchers of [19] concluded that the Earth's inner core is rotating faster than its surface by about 0.3-0.5 degrees per year;
- The authors of [20] found that Earth's inner core, made up of solid iron, 'superrotates' in an eastward direction -- meaning it spins faster than the rest of the planet -- while the outer core, comprising mainly molten iron, spins westwards at a slower pace.

In our opinion, the Earth's inner core is made up of neutralinos, while the outer core is the WDS. The cores of the Sun and the planets comprising the Solar System are not rotating with the same speed as their surfaces. When analyzing the angular momentum distribution of the entire Solar System, one must consider these additional angular momentums. Moreover, the remainder of the original particle cloud weighing $\frac{2}{3}M_{Cl}$ may possess additional angular momentum.

As discussed above, the minimum radius of the hot neutralinos and WIMPs core $R_{min} \cong 8.6\ km$, and it remains essentially constant whether the core belongs to a star or to a planet. The masses of planets formed around red stars and main-sequence stars differ:

- The smallest possible mass of planets formed around red stars is 8 orders of magnitude smaller than maximum star mass M_0 ;
- Planets formed around main-sequence stars may be 17 orders of magnitude lighter than the maximum star mass.

Consequently, all round objects in hydrostatic equilibrium, down to Mimas in Solar system, contain hot neutralinos cores with WDS and should be considered planets. Planets can arise only around main sequence and red stars. Due to the less violent nature of their formation, brown dwarfs do not create planets.

4.4. Pioneer Anomaly

According to WUM, the macroobject energy E_{MO} enclosed in surface S_{MO} is proportional to the area of that surface:

$$E_{MO} = \sigma_0 S_{MO} \tag{4.4.1}$$

where σ_0 is the basic unit of surface energy density: $\sigma_0 = \rho_0 a$. It is natural to define surface S_{MO} as the boundary between macroobject and surrounding environment. In case of our Solar system, such a surface is named Heliosphere. We will refer to such a surface as Macroobject Boundary (MOB). According to the developed Model, Macroobjects have cores made up of fermionic DMP possessing minimum radii R_{min} described in Tables 1 & 2. In case of extrasolar systems, the cores are made up of interacting neutralinos or WIMPs surrounded with White Dwarf Shells (WDS).

The cores are surrounded by the transitional region. In this region, the density decreases rapidly to the point of the zero level of the fractal structure [21] characterized by radius R_f and energy density ρ_f that satisfy the following equation for $r \geq R_f$:

$$\rho(r) = \frac{\rho_f R_f}{r} \tag{4.4.2}$$

According to Yu. Baryshev: *For a structure with fractal dimension $D = 2$ the constant $\rho_f R_f$ may be actually viewed as a new fundamental physical constant* [21]. In our Model, it is natural to connect this constant with the constant σ_0 :

$$\rho_f R_f = 4\sigma_0 \tag{4.4.3}$$

The value of 4 above follows from the ratio for all Macroobjects of the World: 1/3 of the total energy is in the central macroobject (for example, star in extrasolar system) and 2/3 of the total energy is in the fractal structure around it. Taking the radius of a Macroobject Boundary R_{MOB} we find the macroobject energy:

$$E_{MO} = 4\pi R_{MOB}^2 \sigma_0 \tag{4.4.4}$$

The energy in the fractal structure E_{FS} at $R_{MOB} \gg R_f$ is:

$$E_{FS} = \int_{R_f}^{R_{MOB}} \frac{4\sigma_0}{r} \times 4\pi r^2 dr \approx 8\pi R_{MOB}^2 \sigma_0 \tag{4.4.5}$$

and the total energy E_{tot} equals to: $E_{tot} = 12\pi R_{MOB}^2 \sigma_0$.

It allows us to explain the so-called “Pioneer anomaly”. Wikipedia describes this effect the following way: *The Pioneer anomaly is the observed deviation from predicted accelerations of the Pioneer 10 and Pioneer 11 spacecraft after they passed about 20 astronomical units (*$3 \times 10^9\ km$; $2 \times 10^9\ mi$) *on their trajectories out of the Solar System. An unexplained force appeared to cause an approximately constant sunward acceleration of* $a_P = 8.74 \pm 1.33 \times 10^{-10}\ m/s^2$ *for both spacecraft. The magnitude of the Pioneer effect* a_P *is numerically quite close to the product of the speed of light* c *and the Hubble constant* H_0 *hinting at cosmological connection.*

Let us calculate a deceleration a_P at the distance $r_P \gg R_f$ due to the additional mass of the fractal structure $M_{FS}(r_P) \propto r_P^2$ with the following equation for the gravitational parameter G [1]:

$$G = \frac{c^4}{8\pi\sigma_0 R_0} \tag{4.4.6}$$

$$a_P = \frac{GM_{FS}}{r_P^2} = \frac{c^4}{8\pi\sigma_0 R_0} \times \frac{8\pi\sigma_0}{c^2} = \frac{c^2}{R_0} = cH_0 = 6.68 \times 10^{-10}\ m/s^2 \tag{4.4.7}$$

which is in good agreement with the experimentally measured value (R_0 and H_0 are the values of the World’s size R and Hubble’s parameter H at the current time t). It is important to notice that the calculated deceleration does not depend on r_P and equals to cH_0 for all objects around the macroobject at the distance $r > R_f$.

Mass of the fractal structure around Sun M_V at distances $R_V \gg R_f$ is

$$M_V = 8\pi R_V^2 \sigma_0 / c^2 \tag{4.4.8}$$

At distance $R_V = 1.8 \times 10^{13}\ m$ away from the Sun (approximate distance to Voyager 1 [22]),

$$M_V \cong 3.3 \times 10^{27} kg \tag{4.4.9}$$

that is $\sim 0.15\%\ M_{Sun}$. Note that the distances traveled by Voyagers are much smaller than the radius of the MOB: $R_V \ll R_{MOB} \sim 10^{15}\ m$.

5. X Rays and Gamma Rays

All “elementary” particles of the World are fermions and they possess masses. Bosons such as photons, X-quants, and Gamma-quants are composite particles and consist of two fermions. Gamma rays are usually distinguished from X rays by their origin: X rays are emitted by electrons outside the nucleus, while gamma rays are emitted by the nucleus. A better way to distinguish the two, in our opinion, is the type of fermions composing the core of X-quants and Gamma-quants.

Super-soft X rays possess energies in the 0.09 ⟺ 2.5 keV range, whereas soft Gamma rays have energies in the 10 ⟺ 5000 keV range. We assume that X-quants are composed of two interacting neutrinos. New Physics with the dineutrinos in the Rare Decay $B \to K\nu\bar{\nu}$ is actively discussed in literature in recent years (for example, see [23], [24]).

Soft Gamma-quants are composed of two sterile neutrinos (*3.7 keV* each). Hard and super-hard Gamma-quants may be composed of two preons (≳ 0.17 MeV each), which are ELOPs in our Model, two Dirac monopoles (≳ *35 MeV* each) which are, in fact, DIRACs.

We propose that Super-soft gamma rays ($< 10\ keV$) can arise as the result of sterile neutrino annihilation in the low energy case. Two or three super-soft gamma-quants with the energy $<$ 3.7 keV are created. Similarly,

- ELOP annihilation produces hard gamma rays with energies $< 340\ keV$;
- DIRAC annihilation produces hard gamma rays with energies $< 70\ MeV$;
- WIMP annihilation produces super-hard gamma rays with energies $< 9.6\ GeV$;
- Neutralino annihilation produces super-hard gamma rays with energies $< 1.3\ TeV$.

Diffuse cosmic gamma-ray background is the sum of the contributions of the multicomponent self-interacting dark matter annihilation.

6. Dark Matter Signatures in Gamma-Ray Spectra

Large number of papers has been published in the field of X-ray and gamma-ray astronomy. The X-ray and gamma-ray background from $\lesssim 0.1\ keV$ to $\gtrsim 10\ TeV$ has been studied using high spectral and spatial resolution data from different spectrometers. Numerous papers were dedicated to Dark Matter searches with astroparticle data (see reviews [25-34] and references therein). Dark Matter annihilation is proportional to the square of the DM density and is especially efficient in places of highest concentration of dark matter, such as compact stars built up from fermionic dark matter particles (see Section 3).

The models of DM annihilation and decay for various types of macroobjects (galaxy clusters, blazars, quasars, Seyfert galaxies) are well-developed. Physicists working in the field X-ray and gamma-ray astronomy attempt to determine masses of DM particles that would fit the experimental results with the developed models.

Recall that no macroobjects are made up of just a single type of DM particles, since other DM particles as well as baryonic matter are present in the shells. It follows that macroobjects cannot irradiate gamma rays in a single spectral range. On the contrary, they irradiate gamma-quants in different spectral ranges with ratios of fluxes depending on structure of a given macroobject.
WUM forecasts existence of DM particles with 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV masses. We will look for signs of annihilation of these particles in the observed gamma-ray spectra. We connect gamma-ray spectra with the structure of macroobjects (core and shells composition).

C. Boehm, P. Fayet, and J. Silk have this to say about Light and Heavy Dark Matter Particles:

It has recently (2003) *been pointed out that the 511 keV emission line detected by Integral/SPI from the bulge of our galaxy could be explained by annihilations of light Dark Matter particles into* e^+e^-*. If such a signature is confirmed, then one might expect a conflict with the interpretation of very high energy gamma rays if they also turn out to be due to Dark Matter annihilations.*

They proposed a way *to reconcile the low and high energy signatures, even if both of them turn out to be due to Dark Matter annihilations. One would be a heavy fermion for example, like the lightest neutralino (> 100 GeV) and the other one a possibly light spin-0 particle (~ 100 MeV). Both of them would be neutral and also stable as a result of two discrete symmetries (say R and M-parities)* [9], [35].

According to our Model, the two couples of coannihilating DMP are: a heavy fermion – neutralino with mass 1.3 TeV and a light spin-0 boson – DIRAC with mass 70 MeV; a heavy fermion – WIMP with mass 9.6 GeV and a light spin-0 boson – ELOP with mass 340 keV.

6.1. Neutralino 1.3 TeV

J. Holder has this to say about TeV Gamma-ray Astronomy: *In leptonic scenarios, a population of electrons is accelerated to TeV energies, typically through Fermi acceleration by shocks in the AGN jet. These electrons then cool by radiating X-ray synchrotron photons. TeV emission results from inverse Compton interactions of the electrons with either their self-generated synchrotron photons, or an external photon field. The strong correlation between X-ray and TeV emission which is often observed provides evidence for a common origin such as this, although counter examples do exist* [36].

In our opinion, the TeV blazar emission should be classified as extremely-hard X rays and not gamma rays, since by definition: X rays are emitted by electrons outside the nucleus, while gamma rays are emitted by the nucleus.

R. C. G. Chaves, *et al.* have found that a significant fraction of the Galactic VHE (Very High Energy) gamma-ray sources (from the observed approximately 100 VHE γ -ray sources [38-42]) do not appear to have obvious counterparts at other wavelengths [37].

This correlation between keV emission and TeV emission can be easily explained by the annihilation of the sterile neutrinos (3.7 keV) in the shell around the core of AGN made of neutralinos (1.3 TeV). Lack of the counterpart in gamma-ray spectra means the absence of sterile neutrino shell.

A detailed global analysis on the interpretation of the latest data of PAMELA, Fermi-LAT, AMS-02, H.E.S.S, and other collaborations in terms of dark matter annihilation and decay in various propagation models showed that for the Fermi-LAT and H.E.S.S. data favor DMP mass is $m_\chi \approx 1.3\ TeV$ [43-46]. The obtained data in [47-55] require DM mass m_χ to be around 1 to 1.5 TeV which is in good agreement with the predicted mass of a neutralino (1.3 TeV). Pulsars are the most natural candidates for such sources [41].

The presence of spectral break at 1.3 TeV in VHE spectra was measured for different blazars [56 -58]. Some nearby sources, e.g. Vela, Cygnus Loop, and Monogem Supernova Remnant (SNR) have unique signatures in the electron energy spectrum in the TeV region: broken power-law at $\sim$ 1.3 TeV [59]. The DM interpretations of the $e^\pm$ excesses observed by PAMELA, Fermi and ATIC suggest the DMP mass of 1.3 TeV [60].

As we mentioned above, pulsars are the most natural candidates for such VHE gamma-ray sources. According to WUM, FCS made up of strongly interacting neutralinos and WIMPs have maximum mass and minimum size which are exactly equal to parameters of neutron stars (see **Table 1** and **2**). It follows that pulsars might be in fact rotating Neutralino stars and WIMP stars with different shells around them.

The cores of such pulsars may also be made up of the mixture of neutralinos (1.3 TeV) and WIMPs (9.6 GeV) surrounded by shells composed of the other DMP: DIRACs (70 MeV), ELOPs (340 keV), and sterile neutrinos (3.7 keV). Annihilation of those DMP can give rise to any combination of gamma-ray lines. Thus, the diversity of VHE gamma-ray sources in the World has a clear explanation in frames of the World – Universe Model.

In our opinion, results obtained by the CALET program are the closest to the ultimate discovery of the first confirmed dark matter particle – neutralino with mass 1.3 TeV [59].

6.2. WIMP 9.6 GeV

Dan Hooper summarized and discussed the body of evidence which has accumulated in favor of dark matter in the form of approximately 10 GeV particles, including *the spectrum and angular distribution of gamma rays from the Galactic Center, the synchrotron emission from the Milky Way's radio filaments, the diffuse synchrotron emission from the Inner Galaxy (the "WMAP Haze") and low-energy signals from the direct detection experiments DAMA/LIBRA, CoGeNT and CRESST-II.* Dan Hooper finds that *gamma-ray signal observed from the Galactic Center is consistent with 7-12 GeV dark matter particles annihilating mostly to leptons* [61], [62].

Based on EGRET observations, P. Sreekumar, *et al.* attribute the high-energy gamma ray emissions to blazars: *Most of the measured spectra of individual blazars only extend to several GeV and none extend above 10 GeV, simply because the intensity is too weak to have a significant number of photons to measure* [63]. WUM proposes that cores of blazars are composed of annihilating WIMPs (9.6 GeV), explaining why no observed radiation extends above 10 GeV. The results of gamma-ray emission between 100 MeV to 10 GeV detected from 18 globular clusters in our Galaxy are also in a good correlation with the predicted mass of WIMPs [64], [65].

The DAMA/LIBRA, CoGeNT, CRESST-II, CDMS-II collaborations conduct direct detections of DMP by nuclear recoils due to the elastic scattering of DMP. An 8.6 GeV DMP is deemed most probable [66]. Based on its core assumptions, WUM analytically predicts WIMPs to possess the mass of 9.6 GeV. A large number of experimental results seem to converge to a number in the neighborhood of 10 GeV, providing additional support to WUM.

6.3. DIRAC 70 MeV

S. D. Hunter, *et al.* discuss a peak at 67.5 MeV: *Below about 100 MeV, gamma rays produced via electron bremsstrahlung are the dominant component of the observed spectrum, whereas, above about 100 MeV, the gamma-rays from* π^0 *decay, which form the broad "pion bump" centered at 67.5 MeV, are the dominant component of the spectrum. The "pion bump ", clearly visible in this spectrum, is the only spectral feature in the diffuse gamma ray emission in the EGRET energy range* [67].

70 MeV peak in EGRET data was discussed by Golubkov and Khlopov [68]. They explained this peak by the decay of π^0-mesons, produced in nuclear reactions. B. Wolfe, *et al.* said that gamma rays at 70 MeV are notably detectable by GLAST and EGRET [69]. R. Yamazaki, *et al.* attribute the 70 MeV peak in the emission spectrum from an old supernova remnant (SNR) to π^0-decay [70], [71].

Note that whenever the 70 MeV peak appears in gamma-ray spectra, it is always attributed to pion decay. We claim that π^0 decay produces a 67.5 MeV peak, while DIRAC annihilation is responsible for 70 MeV peak. To find out the source of the observed broad peak about 70 MeV, we suggest utilization of exponentially cutoff power-law for analysis of experimental data for gamma-ray energies $<$ 70 MeV. A better fit of experimental data will be evidence of DIRACs annihilation.

In our opinion, the DIRAC may indeed be the so-called U boson, target of intense search by the scientific community. Note that the mass of DIRAC proposed by WUM – $0.07 GeV/c^2$ – falls into the mass range of U boson: $M_U = 0.02 - 0.1\ GeV/c^2$ [72-77].

6.4. ELOP 340 keV

An ELOP is a spin-0 boson with 340 keV mass. Existence of DMP of similar masses ($m_\chi < 0.42$ MeV) has been discussed by Y. Rasera, *et al.* [78]. The experimental 100-400 keV "bump" [79] is in good agreement with the theoretical analysis in [78] and with annihilating ELOPs with mass 340 keV proposed in our Model.

D. E. Gruber, *et al.* describes a wide gamma-ray extragalactic background spectrum between 1 keV and 10 GeV: *Above 60 keV selected data sets included the HEAO 1 A-4 (LED and MED), balloon, COMPTEL, and EGRET data. The fit required the sum of three power laws* [80].

According to our Model, the fit of the total diffuse spectrum in the range between 3 keV and 10 GeV should be performed based on three exponentially cutoff power-laws with injection spectral $J(E) \propto E^{-\gamma} exp\{-E/E_{cut}\}$ with the spectral index γ and E_{cut} being the cutoff energy of the source spectra.

For values of E_{cut}, we should use

- 9.6 GeV (annihilating WIMPs) in the 9.6 GeV – 70 MeV range;
- 70 MeV (annihilating DIRACs) in the 70 MeV – 340 keV range;
- 340 keV (annihilating ELOPs) in the 340 keV – 3.7 keV range.

The fit in the range between 9.6 GeV and 1.3 TeV should be done with $E_{cut} = 1.3\ TeV$, which equals to the mass of a neutralino.

6.5. Sterile Neutrino 3.7 keV

The very first signature of the emission around 3.7 keV was found in 1967 by P. Gorenstein, R. Giacconi, and H. Gursky. They analyzed the counting rate in the 2-5 keV range and found that *the sources GX-10.7, +9.1, +13.5, and +16.7 are qualitatively different from Sco X-1, Cyg X-1 or Cyg X-2 in that the highest number of net counts is recorded in the bin centered at 3.75 keV* [81].

An important result was obtained by S. Safi-Harb and H. Ogelman in 1997. They reported that *the observations of the X-ray lobes of the large Galactic source W50 [are] associated with the two-sided jets source SS 433. A broken power-law model gives the best fit. The power-law indices are 1.9 and 3.6, with the break occurring at 3.7 keV* [82].

T. Itoh analyzed the broad-band (3.0-50 keV) spectra of NGC 4388 and found line-like residual around 3.7 keV at the high confidence level [83].

A. Bykov, *et al.* investigated *the nature of the extended hard X-ray source XMMU J061804.3+222732 and its surroundings using XMM-Newton, Chandra, and Spitzer observations. The X-ray emission consists of a number of bright clumps embedded in an extended structured non-thermal X-ray nebula larger than 30" in size. Some clumps show evidence for line emission at ∼ 1.9 keV and ∼ 3.7 keV at the 99% confidence level. A feature at 3.7 keV was found in the X-ray spectrum of Src 3 at the 99% confidence level* [84].

In our opinion, the line emission ~ 3.7 keV corresponds to the annihilation of sterile neutrinos and the line ~ 1.9 keV corresponds to their decay.

R. Fukuoka, *et al.* observed the South End of the Radio Arc and found the line-like residual at ~ 3.7 keV with ~ 3σ significance [85]. In 2012, A. Moretti, *et al.* measured the diffuse gamma-ray emission at the deepest level and with the best accuracy available today. An emission line around 3.7 keV is clearly visible in the obtained spectrum [86].

6.6. Conclusion

- Emission lines of 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV, can be found in spectra of the diffuse gamma-ray background radiation and various macroobjects of the World in different combinations depending on their structure.
- The diffuse cosmic gamma-ray background radiation in the < 1.3 TeV range is the sum of the contributions of multicomponent dark matter annihilation.
- The total cosmic-ray radiation consists of gamma-ray background radiation plus X-ray radiation from the different highly ionized chemical elements in the hot areas of the World and is due to various electron processes such as synchrotron radiation, electron bremsstrahlung, and inverse Compton scattering.

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5D World – Universe Model. Neutrinos. The World

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 inter-connected 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

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

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

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].

Let's take neutrino masses m_{ν_e}, m_{ν_μ}, m_{ν_τ} 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]:

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

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

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_{sol}^2 given by

$$2.3 \times 10^{-5}\ eV^2/c^4 \le \Delta m_{sol}^2 \le 9.3 \times 10^{-5}\ eV^2/c^4 \tag{2.6}$$

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

$$1.6 \times 10^{-3}\ eV^2/c^4 \le \Delta m_{atm}^2 \le 3.9 \times 10^{-3}\ eV^2/c^4 \tag{2.7}$$

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

$$m_{\nu_\mu} = m_\nu = m_0 \times Q^{-1/4} \cong 7.5 \times 10^{-3}\ eV/c^2 \tag{2.9}$$

From equation (2.8) it then follows that

$$m_{\nu_\tau} = 6 m_\nu \cong 4.5 \times 10^{-2}\ eV/c^2 \tag{2.10}$$

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

$$m_{\nu_\mu}^2 \cong 5.6 \times 10^{-5}\ eV^2/c^4$$

$$m_{\nu_\tau}^2 \cong 2 \times 10^{-3}\ eV^2/c^4 \tag{2.11}$$

Let's assume that electronic neutrino mass equals to

$$m_{\nu_e} = \frac{1}{24} m_\nu \cong 3.1 \times 10^{-4}\ eV/c^2 \tag{2.12}$$

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]:

$$m_{\nu_\tau} \cong 4.9 \times 10^{-2}\ eV/c^2$$

$$m_{\nu_\mu} \cong 7.8 \times 10^{-3}\ eV/c^2$$

$$m_{\nu_e} \cong 2.5 \times 10^{-4}\ eV/c^2 \tag{2.13}$$

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

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

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

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

$$(\frac{E_{\nu i}}{c})^2 - \boldsymbol{p}_{\nu i}^2 = (m_{\nu i} c)^2$$

$$i = e, \mu, \tau \tag{2.15}$$

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]:

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

where p_F is Fermi momentum,

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

$$x_{\nu i} = (\frac{p_F}{m_{\nu i}c})^2 \tag{2.18}$$

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

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

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

$$p_F^2 = \frac{h^2}{2\pi^2 L_F^2} = \frac{h^2}{2\pi^2 a^2} \times Q^{-1/2} = p_{\mathrm{F}0}^2 \times Q^{-1/2} \tag{2.21}$$

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 $\Omega_{\nu i}$ in the Medium in terms of the critical energy density ρ_{cr}:

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

where

$$y_{\nu i} = (2\pi^2 A_i^2)^{-1} \tag{2.23}$$

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:

$$\Omega_\nu = \frac{\rho_\nu}{\rho_{cr}} = \frac{\rho_{\nu e}+\rho_{\nu \mu}+\rho_{\nu \tau}}{\rho_{cr}} = 0.45801647 \tag{2.24}$$

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_ν to equal

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

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 $\Omega_{\nu tot}$ (in the Medium and in Macroobjects) in terms of the critical energy density ρ_{cr} equals to

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

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:

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

We took additional energy density ρ_{ADD}

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

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 $1 \leq z \leq 4$, 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 30K with spectral energy distributions peaking at 100μm* [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:

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

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

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

The density of grains ρ_G is about:

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

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,

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

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:

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

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

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

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)):

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

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

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

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

$$mM = \frac{1}{2}M_P^2 = 2m_0^2 \times Q = 2.36851 \times 10^{-16}\ kg^2 \tag{3.18}$$

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]:

$$m_a = \left(\frac{m_e}{m_p}\right)^{1/2} \times m_0 \times Q^{-1/2} = 1.8743 \times 10^{-14}\ eV/c^2 \tag{3.19}$$

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:

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

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

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

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

$$\zeta(3/2) \approx 2.6124 \quad (3.22)$$

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)):

$$\rho_X = n_X m_X = 2\frac{m_e}{m_p}\rho_p = 4\pi^2\alpha\frac{m_e}{m_p}\frac{hc}{L_F^4} = 1.5690 \times 10^{-4} \times \frac{hc}{L_F^4} \quad (3.23)$$

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

$$n_X = [47.672\pi^2\alpha\frac{m_e}{m_p}\left(\frac{15}{4\pi^5}\right)^{1/4}]^{3/5} \times L_F^{-3} =$$

$$= 0.011922 \times L_F^{-3} = 2.6386 \times 10^9\ m^{-3} \quad (3.24)$$

and the value of the mass m_X :

$$m_X = \frac{\rho_X}{n_X c^2} = 0.013161 \times m_0 \times Q^{-1/4} = 0.987 \times 10^{-4}\ eV/c^2 \quad (3.25)$$

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

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

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

$$\rho_{FIRB} = \frac{1}{10\pi}\rho_{MBR} \approx 0.032\rho_{MBR} \quad (3.27)$$

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]:

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

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}

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

A density of Cores can be up to the nuclear density ($\sim 10^{18}\ \frac{kg}{m^3}$) [2] and their size is about:

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

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 $T_{MBR} = 2.72518\,K$ is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\,K$ [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^{2}FH 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

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

- Newtonian parameter of gravitation G

$$G = \frac{a^2 c^4}{8\pi hc} \times Q^{-1} \propto \tau^{-1} \quad (4.2)$$

- Hubble's parameter H

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

- Age of the World A_τ

$$A_\tau = \frac{a}{c} \times Q \propto \tau \quad (4.4)$$

- Size of the World R

$$R = a \times Q \propto \tau \quad (4.5)$$

- Critical energy density ρ_{cr}

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

- Planck mass M_P

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

- 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]

$$E_0 = \frac{hc}{a} = m_0c^2 \tag{4.11}$$

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 $G = 6.67408(31) \times 10^{-11}\ m^3kg^{-1}s^{-2}$ and the parameter Q_F (see equation (4.10)) based on the average value of the Fermi coupling parameter $G_F = 1.1663787(6) \times 10^{-5}\ GeV^{-2}$ 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 ħ 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

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

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

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

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 $Q^{-1/4}$:

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

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

$$\frac{G_F}{(\hbar c)^3} = 1.166359 \times 10^{-5} GeV^{-2} \tag{4.28}$$

that is in excellent agreement with the commonly adopted value of $1.1663787(6) \times 10^{-5} GeV^{-2}$.

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:

$$\rho_{cr0} = \frac{3hc}{a^4} = 6.0640 \times 10^{30}\ \frac{J}{m^3} \tag{4.30}$$

Note that the energy density at the Beginning is much smaller than the nuclear density $\sim 10^{35}\ \frac{J}{m^3}$.

An average energy density of the World has since been decreasing, and its present value is given by

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

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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5D World-Universe Model. Gravitation

Abstract

5D World – Universe Model is based on the decisive role of the Medium of the World composed of massive particles: protons, electrons, photons, neutrinos, and Dark Matter particles. In this manuscript we discuss different aspects of the gravitation: measured values of the Newtonian parameter of Gravitation and different gravitational effects (gravitational lensing, cosmological redshift, gravitational deflection of light and gravitational refraction, proposed in the present paper). We show inter-connectivity of all cosmological parameters and provide a mathematical framework that allows direct calculation of them based on the value of the Gravitational parameter. We analyze the difference between Electromagnetism and Gravitoelectromagnetism and make a conclusion about the mandatory existence of the Medium of the World. This paper aligns the World – Universe Model with the Le Sage's theory of gravitation and makes a deduction on Gravity, Space and Time to be emergent phenomena.

Keywords

5D World – Universe Model; Newtonian parameter of Gravitation; Le Sage's gravity; Cosmic Neutrino Background; Gravitoelectromagnetism; Medium of the World; Cosmological Parameters; Emergent Phenomena

1. Introduction

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

Albert Einstein

Today, a growing feeling of stagnation is shared by a large number of researchers. In his "The Twilight of the Scientific Age" (2013), Martin Lopez Corredoira outlines the most significant issues he believes Physics todays' experiences as a discipline: increasingly expensive experiments that yield less and less, lack of outstanding results, lack of openness to new ideas exhibited by scientific journals and community as a whole.

In some respects, the situation today is similar to that at the end of 19th century, when the common consensus held that the body of Physics was nearly complete. Discoveries of special and general relativity, quantum mechanics and elementary particles shook that belief and led to a new renaissance in Physics that lasted for a century. The genius of Einstein, Planck, Bohr, Dirac, Heisenberg, and Schrödinger allowed them to propose fundamentally new theories with very little experimental data to back them up.

During the 20th century, their theories were validated and elaborated with newly acquired experimental results. The pendulum may, however, have swung too far: today, all results must be made fit into the existing framework. The frameworks get adjusted when necessary, particularly inconvenient results may even get discarded at times. The time may be ripe to propose new fundamental models that will be both simpler than the current state of the art, as well as open up new areas of research.

In 1937, Paul Dirac proposed a new basis for cosmology: the hypothesis of a variable gravitational "constant"; and later added the notion of continuous creation of matter in the World. In 1983, Paul Wesson developed 5D Space-Time-Mass theory that associates the fifth dimension with rest mass of particles. The gravitational constant serves as the dimension-transposing parameter.

5D World – Universe Model (WUM) follows these ideas, albeit introducing a different mechanism of matter creation. WUM rests on the theoretical basis developed by Prof. Wesson, with the following modifications [1]: the fifth dimension is associated with the total energy of the Medium of the World, and the gravitomagnetic parameter of the Medium serves as the dimension-transposing parameter.

A number of ideas presented in this paper are not new, and I don't claim credit for them. In fact, several ideas belonging to classical physicists such as P. A. M. Dirac, P. S. Wesson, A. D. Sakharov, O. Heaviside, Le Sage, and J. McCullagh, are revisited in a new light.

The 5D WUM is proposed as an alternative to the prevailing Bing Bang Model of standard physical cosmology. The main differences are the existence of the Medium of the World and the source of the World's energy.

WUM analyzes the role of the Intergalactic plasma consisting of protons, electrons, and photons as part of the Medium of the World [1], discusses Multicomponent Dark Matter and its decisive role in the Medium and Macroobjects of the World [2], and considers mass-varying neutrinos as part of the Medium of the World [3].

This paper discusses the Gravitation of the World. In Section 2 we make analysis of the measured values of the Newtonian parameter of Gravitation. In Section 3 we show inter-connectivity of all cosmological parameters and provide a mathematical framework that allows their direct calculation based on the value of the Gravitational parameter. In section 4 we present different gravitational effects: gravitational lensing, cosmological redshift, gravitational deflection of light and gravitational refraction, proposed in the present paper. The Gravitoelectromagnetism is discussed in Section 5. Le Sage's gravity mechanism is analyzed in Section 6. In Section 7 we deduce on Gravity, Space and Time to be emergent phenomena.

2. Observations of Newtonian Parameter of Gravitation

The accuracy of the measured value of Gravitational parameter G has increased only modestly since the original Cavendish experiment. Published values of G have varied rather broadly, and some recent measurements of high precision are, in fact, mutually exclusive.

Table 1, borrowed from CODATA Recommended Values of the Fundamental Physical Constants, 2010, summarizes the results of measurements of the Newtonian parameter of gravitation relevant to the 2010 adjustment [4].

Observe that the values of G vary significantly depending on method. The disagreement in the values of G obtained by the various teams far exceeds the standard uncertainties provided with the values.

Detailed analysis of the results of measurements of the Newtonian parameter of gravitation in Table 1 shows that there are three groups of measurements. Inside each such group, the measurements are not mutually exclusive; however, measurements outside of a group contradict the entire group:

Table 1. Measurements of Newtonian parameter of gravitation

Source	Identification[a]	Method	10^{11} G $m^3\ kg^{-1}\ s^{-2}$	Rel. stand. uncert u_r
Luther and Towler (1982)	NIST-82	Fiber torsion balance, dynamic mode	6.672 48(43)	6.4×10^{-5}
Karagioz and Izmailov (1996)	TR&D-96	Fiber torsion balance, dynamic mode	6.672 9(5)	7.5×10^{-5}
Bagley and Luther (1997)	LANL-97	Fiber torsion balance, dynamic mode	6.673 98(70)	1.0×10^{-4}
Gundlach and Merkowitz (2000, 2002)	UWash-00	Fiber torsion balance, dynamic compensation	6.674 255(92)	1.4×10^{-5}
Quinn et al. (2001)	BIPM-01	Strip torsion balance, compensation mode, static deflection	6.675 59(27)	4.0×10^{-5}
Kleinevoß (2002); Kleinvoß et al. (2002)	UWup-02	Suspended body, displacement	6.674 22(98)	1.5×10^{-4}
Armstrong and Fitzgerald (2003)	MSL-03	Strip torsion balance, compensation mode	6.673 87(27)	4.0×10^{-5}
Hu et al. (2005)	HUST-05	Fiber torsion balance, dynamic mode	6.672 28(87)	1.3×10^{-4}
Schlamminger et al. (2006)	UZur-06	Stationary body, weight change	6.674 25(12)	1.9×10^{-5}
Luo et al. (2009); Tu et al. (2010)	HUST-09	Fiber torsion balance, dynamic mode	6.673 49(18)	2.7×10^{-5}
Parks and Faller (2010)	JILA-10	Suspended body, displacement	6.672 34(14)	2.1×10^{-5}

[a]NIST: National Institute of Standards and Technology, Gaithersburg, MD, USA; TR&D: Tribotech Research and Development Company, Moscow, Russian Federation; LANL: Los Alamos National Laboratory, Los Alamos, New Mexico, USA; UWash: University of Washington, Seattle, Washington, USA; BIPM: International Bureau of Weights and Measures, S`evres, France; UWup: University of Wuppertal, Wuppertal, Germany; MSL: Measurement Standards Laboratory, Lower Hutt, New Zeland; HUST: Huazhong University of Science and Technology, Wuhan, PRC; UZur: University of Zurich, Zurich, Switzerland; JILA: JILA, University of Colorado and National Institute of Standards and Technology, Boulder, Colorado, USA.

- The first such group consists of six measurements with the average value of

$$G_1 = 6.67401(19) \times 10^{-11}\ m^3 kg^{-1} s^{-2} \qquad 2.1$$

and relative standard uncertainty 28.5 ppm;

- The second one consists of four measurements with the average value of

$$G_2 = 6.67250(16) \times 10^{-11}\ m^3 kg^{-1} s^{-2} \qquad 2.2$$

and relative standard uncertainty 24 ppm;

- The third one consists of one measurement with the value of

$$G_3 = 6.67559(27) \times 10^{-11}\, m^3 kg^{-1} s^{-2} \qquad 2.3$$

and relative standard uncertainty 40 ppm.

Clearly, the relative uncertainty of any such group is better than the uncertainty of the entire result set. G_1, G_2, and G_3 have relative standard uncertainties that are smaller than the average value of G. Out of the three distinct groups of G measurements, how shall we identify the correct one?

In accordance with WUM, the Gravitational parameter G and Fermi coupling parameter G_F can be expressed as follows [3]:

$$G = \frac{a^2 c^4}{8\pi hc} \times Q^{-1} \qquad 2.4$$

$$\frac{G_F}{(\hbar c)^3} = \sqrt{30}\left(2\alpha \frac{m_e}{m_p}\right)^{1/4} \times \frac{m_p}{m_e} \frac{1}{E_0^2} \times Q^{-1/4} \qquad 2.5$$

where $\hbar$ is Dirac constant, c is the electrodynamic constant, α is fine-structure constant, m_p is the mass of a proton, m_e is the mass of an electron, and basic energy unit E_0 equals to

$$E_0 = \frac{hc}{a} \qquad 2.6$$

where $h = 2\pi\hbar$ is Planck constant, a_0 is the classical radius of an electron , and $a = 2\pi a_0$.

For the three groups of G measurements, parameter Q will take on the following values, respectively (see 2.4):

$$Q_1 = 0.759981(22) \times 10^{40} \qquad 2.7$$

$$Q_2 = 0.760153(18) \times 10^{40} \qquad 2.8$$

$$Q_3 = 0.759801(30) \times 10^{40} \qquad 2.9$$

The calculated value of the parameter Q_F (see 2.5) based on the average value of the Fermi coupling parameter $G_F = 1.1663787(6) \times 10^{-5}\, GeV^{-2}$ is:

$$Q_F = 0.75992106 \times 10^{40} \qquad 2.10$$

The value of Q_F is much more precise than the values of Q_1 , Q_2 , Q_3 . With this value of Q_F we can make the choice of the first group of G measurements and significantly increase the precision of all Q-dependent parameters (see Section 3).

The calculated value of the parameter Q_G based on the average value of the gravitational parameter $G = 6.67408(31) \times 10^{-11}\, m^3 kg^{-1} s^{-2}$ (CODATA, 2014)

$$Q_G = 0.759972 \times 10^{40} \qquad 2.11$$

is very close to the value of Q_1 and correspond to the value of Q_F . The calculated value of G based on the average value of G_F

$$G = 6.6745358 \times 10^{-11}\, m^3 kg^{-1} s^{-2} \qquad 2.12$$

The CODATA, 2014 value of G is slightly smaller (<0.007%) than this calculated value.

The gravitational parameter G in our Model is changing in time $G \propto \tau^{-1}$ with the following rate:

$$\dot{G}/G = 7.03 \times 10^{-11}\, yr^{-1} \qquad 2.13$$

During the 216 years elapsed from the first measurement of the value of G by Henry Cavendish, value of G has decreased by ΔG :

$$\Delta G = 1.52 \times 10^{-8}\, m^3 kg^{-1} s^{-2} \qquad 2.14$$

The above ΔG is far smaller than the precision that we have attained when measuring G, and thus measuring ΔG directly seems to be impossible using contemporary techniques.

In his papers Jean-Philippe Uzan reviewed the main experimental and observational constraints that have been obtained for variations of the gravitational parameter in different areas [5], [6]:

- Solar systems constraints
- Pulsar timing
- Stellar constraints
- Cosmological constraints

and found that

$$\dot{G}/G \lesssim 10^{-11} \Leftrightarrow 10^{-12} yr^{-1} \qquad 2.15$$

The experimentally obtained constraints on G variation rates are significantly larger than theoretically calculated 2.13. Note that all obtained constraints are the results of the calculations based on different theoretical models. One example from review [6]:

"The Lunar Laser Ranging (LLR) experiment has measured the relative position of the Moon with respect to the Earth with accuracy of the order of 1 cm over 3 decades. An early analysis of this data ***assuming a Brans-Dicke theory of gravitation*** *gave that* $\dot{G}/G \leq 3 \times 10^{-11}\, yr^{-1}$. *It was improved by using 20 years of observation to get* $\dot{G}/G \leq 1.04 \times 10^{-11}\, yr^{-1}$, ***the main uncertainty arising from Lunar tidal acceleration****. With 24 years of data, one reached* $\dot{G}/G \leq 6 \times 10^{-12}\, yr^{-1}$ *and finally, the latest analysis of the Lunar laser ranging experiment increased the constraint to*

$$\dot{G}/G \leq (4 \pm 9) \times 10^{-13}\, yr^{-1}$$

Another example from Uzan's review [5]:

"Teller (1948) first emphasized that Dirac hypothesis may be in conflict with paleontological evidence. His argument is based on the ***estimation of the temperature at the center of the Sun*** $T_\odot \propto G\, M_\odot / R_\odot$ *using the virial theorem. The luminosity of the Sun is then proportional to the radiation energy gradient times the mean free path of a photon times the surface of the Sun, that is* $L_\odot \propto T_\odot^7 R_\odot^7 M_\odot^{-2}$ *, hence concluding that* $L_\odot \propto T_\odot^7 M_\odot^5$ *. Computing the radius of the Earth orbit in Newtonian mechanics,* ***assuming the conservation of angular momentum*** *(so that* $G M_\odot R_{Earth}$ *is constant) and* ***stating that the Earth mean temperature*** *is proportional to the fourth root of the energy received, he concluded that*

$$T_{Earth} \propto G^{2.25} M_\odot^{1.75}$$

If $\boldsymbol{M_\odot}$ ***is constant and G was 10% larger 300 million years ago****, the Earth surface temperature should have been 20% higher, that is close to the boiling temperature. This was in contradiction with the existence of trilobites in the Cambrian".*

Moreover, Teller didn't take the "Faint Young Sun" paradox into account: the young Sun's output was only about 70% of what it is today [1]. So, all conclusions on the (almost) constancy of the Newtonian parameter of gravitation are model-dependent.

3. Cosmological Parameters

The advantage of WUM is that 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 a measure of the size and the age of the World, as well as all other time-varying parameters of the World [1-3]. Q can be calculated based on the value of the gravitational parameter G:

$$Q = \frac{a^2 c^4}{8\pi hc} \times G^{-1} \qquad 3.1$$

Then all time-varying cosmological parameters can be calculated based on the value of G:

- Hubble's parameter H

$$H = \frac{c}{a} \times Q^{-1} \propto G \qquad 3.2$$

- Age of the World A_τ

$$A_\tau = \frac{a}{c} \times Q \propto G^{-1} \qquad 3.3$$

- Size of the World R

$$R = a \times Q \propto G^{-1} \qquad 3.4$$

- Critical energy density ρ_{cr}

$$\rho_{cr} = 3\rho_0 \times Q^{-1} \propto G \qquad 3.5$$

- Temperature of the microwave background radiation T_{MBR}

$$T_{MBR} = \frac{E_0}{k_B}\left(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p}\right)^{1/4} \times Q^{-1/4} \propto G^{1/4} \qquad 3.6$$

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

$$T_{FIRB} = \frac{E_0}{k_B}\left(\frac{15}{4\pi^5}\right)^{1/4} \times Q^{-1/4} \propto G^{1/4} \qquad 3.7$$

- Planck mass M_P

$$M_P = 2m_0 \times Q^{1/2} \propto G^{-1/2} \qquad 3.8$$

- Electronic neutrino mass m_{ν_e}

$$m_{\nu_e} = \frac{1}{24} m_0 \times Q^{-1/4} \propto G^{1/4} \qquad 3.9$$

- Muonic neutrino mass m_{ν_μ}

$$m_{\nu_\mu} = m_0 \times Q^{-1/4} \propto G^{1/4} \tag{3.10}$$

- Tauonic neutrino mass m_{ν_τ}

$$m_{\nu_\tau} = 6m_0 \times Q^{-1/4} \propto G^{1/4} \tag{3.11}$$

- Axion mass m_a

$$m_a = \left(\frac{m_e}{m_p}\right)^{1/2} \times m_0 \times Q^{-1/2} \propto G^{1/2} \tag{3.12}$$

where k_B is the Boltzmann constant, ρ_0 is a basic unit of energy density:

$$\rho_0 = \frac{\text{hc}}{a^4} \tag{3.13}$$

and m_0 is a basic unit of mass:

$$m_0 = \frac{h}{ac} = 70.025267\ MeV/c^2 \tag{3.14}$$

As shown in [1-3], the calculated values of these parameters are in a good agreement with the latest results of their measurements. For example, calculating the value of Hubble's parameter H_0 based on G we find

$$H_0 = \frac{8\pi hc}{a^3c^3} \times G = 68.7457(83)\ \frac{km/s}{Mpc} \tag{3.15}$$

which is in good agreement with $H_0 = 69.32 \pm 0.8\ \frac{km/s}{Mpc}$ obtained using WMAP data [7].

We can calculate the value of T_{MBR} (see 3.6) and get $T_{MBR} = 2.72518\,K$ which is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\,K$ [8].

In frames of WUM, some cosmological parameters are constants and can be calculated based on the value of the fine-structure constant α . WUM postulates that masses of Dark Matter Particles (DMP) are proportional to m_0 multiplied by different exponents of α [2]:

Cold DMP (neutralinos and WIMPs):

$$m_N = \alpha^{-2} m_0 = 1.3149950\ \ TeV/c^2 \tag{3.16}$$

$$m_{WIMP} = \alpha^{-1} m_0 = 9.5959823\ \ GeV/c^2 \tag{3.17}$$

DIRACs:

$$m_{DIRAC} = 2\alpha^0 \frac{m_0}{2} = 70.025267\ \ MeV/c^2 \tag{3.18}$$

ELOPs:

$$m_{ELOP} = 2\alpha^1 \frac{m_0}{3} = 340.66606\ \ keV/c^2 \tag{3.19}$$

Warm DMP (sterile neutrinos):

$$m_{\nu_s} = \alpha^2 m_0 = 3.7289402\ \ keV/c^2 \tag{3.20}$$

These values fall into the mass ranges estimated in literature [2]. The roles of those particles in macroobject cores built up from fermionic dark matter, in gamma-ray spectra of the diffuse gamma-ray background and the emission of various macroobjects in the World are discussed in [2].

One of the principal ideas of WUM holds that relative energy densities of the World's particles in terms of the critical energy density ρ_{cr} are constants in all times; depend only on the fundamental parameter α and proportional to proton energy density in the World's Medium [1]:

$$\Omega_p = \frac{2\pi^2\alpha}{3} = 0.048014655 \qquad 3.21$$

The relative energy densities of the components of the World are:

Protons Ω_{ptot}

$$\Omega_{ptot} = 1.5\Omega_p = \pi^2\alpha \qquad 3.22$$

Electrons Ω_{etot}

$$\Omega_{etot} = 1.5\frac{m_e}{m_p}\Omega_p = \frac{m_e}{m_p}\pi^2\alpha \qquad 3.23$$

Microwave background radiation Ω_{MBR}

$$\Omega_{MBR} = 3\frac{m_e}{m_p}\Omega_p = 2\frac{m_e}{m_p}\pi^2\alpha \qquad 3.24$$

Dark Matter Ω_{DMtot}

$$\Omega_{DMtot} = 5\Omega_p = \frac{10}{3}\pi^2\alpha = 0.24007328 \qquad 3.25$$

Cosmic Neutrino Background Ω_{CNB}

$$\Omega_{CNB} = \frac{45}{\pi}\Omega_p = 30\pi\alpha = 0.68775927 \qquad 3.26$$

Dineutrinos $\Omega_{\nu\bar{\nu}}$

$$\Omega_{\nu\bar{\nu}} = 3\frac{m_e}{m_p}\Omega_p = 2\frac{m_e}{m_p}\pi^2\alpha \qquad 3.27$$

Far-infrared background radiation Ω_{FIRB}

$$\Omega_{FIRB} = \frac{3}{10\pi}\frac{m_e}{m_p}\Omega_p = \frac{1}{5\pi}\frac{m_e}{m_p}\pi^2\alpha \qquad 3.28$$

The sum of all components' densities of the World Ω_W is

$$\Omega_W = \Omega_{ptot} + \Omega_{etot} + \Omega_{MBR} + \Omega_{DM} + \Omega_{CNB} + \Omega_{\nu\bar{\nu}} + \Omega_{FIRB} =$$

$$= \left[\frac{45}{\pi} + 6.5 + \left(5.5 + \frac{1}{5\pi}\right)\frac{m_e}{m_p}\right]\frac{2\pi^2\alpha}{3} = 1 \qquad 3.29$$

in all times. The implication is that the World is flat.

From (3.29) we can calculate the value of α, using electron-to-proton mass ratio $\frac{m_e}{m_p}$

$$\frac{1}{\alpha} = \frac{\pi}{15}\left[450 + 65\pi + (55\pi + 2)\frac{m_e}{m_p}\right] = 137.03600 \qquad 3.30$$

which is in excellent agreement with the commonly adopted value of 137.035999074(44). It means that $\frac{m_e}{m_p}$ is not an independent constant but is instead derived from α [3].

With the exception of neutrinos, the calculated values of the energy densities of the components of the World are in good agreement with their latest measurements [1-3]. When it comes to neutrinos, WUM postulates a much higher energy density than is commonly accepted in literature. As we proceed to show in the next section, there is no need for Dark Energy in WUM.

4. Gravitational Effects

The very first gravitational effect was calculated by J. G. von Soldner in 1801. In his paper "*The deflection of a light ray from its rectilinear motion, by the attraction of a celestial body at which it nearly passes by"* he found for the angle of deflection by Sun θ the value $\theta = 0.84\ arcsec$ which is very close to the value $\theta = 0.87\ arcsec$ calculated by Einstein in 1908 [9]. And only in 1915 Einstein presented the $\theta = 1.75\ arcsec$ calculation based on General Theory of Relativity.

In our opinion, there is another possibility to explain an increased value of the deflection angle by Sun. According to WUM, all macroobjects of the World have cores made up of fermionic DMP. In case of extrasolar systems, the cores of stars are made up of interacting neutralinos or WIMPs surrounded with white dwarf shells.

Surrounding the cores, there is a transitional region in which the density decreases rapidly to the point of the zero level of the fractal structure [10] characterized by radius R_f and energy density ρ_f that satisfy the following equation for $r \geq R_f$:

$$\rho(r) = \frac{\rho_f R_f}{r} \qquad 4.1$$

The transition region between solar core and the beginning of the Heliosphere, in which the density considerably decreases, may cause an additional deflection of a light ray due to the gravitational refraction.

A gravitational lens refers to a distribution of matter (such as a cluster of galaxies) between a distant source and an observer that is capable of bending the light from the source, as it travels towards the observer. Fritz Zwicky posited in 1937 that the effect could allow galaxy clusters to act as gravitational lenses. It was not until 1979 that this effect was confirmed by observation of the so-called "Twin QSO" SBS 0957+561.

According to WUM, sterile neutrinos make up cores of galaxy clusters. The cores are surrounded by shells made up of DM and baryonic matter. Every macroobject consists of all particles under consideration that are present in the same proportion as they exist in the World's Medium [2].

In our opinion, the structure of galaxy clusters described above should be taken into account whenever gravitational lenses are calculated.

Gravitational redshift is the process by which electromagnetic radiation originating from a source that is in a gravitational field is reduced in frequency, or redshifted, when observed in a region of a weaker gravitational field.

This effect is now considered to have been definitively verified by the experiments of Pound, Rebka and Snider between 1959 and 1965.

The gravitational redshift depends on the mass of the gravitating body. WUM holds that 1/3 of the total mass is in the central macroobject (for example, a star in extrasolar system) and 2/3 of the total

mass is in the fractal structure around it [1]. This mass ratio should be taken into account when calculating gravitational redshift.
The gravitational redshift is a part of the total cosmological redshift. Let us analyze the movement of photons as they travel from distant galaxies to Earth in the time-varying Medium. As we have shown in [1], energy of photons remains constant in the ideal frictionless Medium. In the actual rotationally elastic Medium [11] with a friction coefficient for photons

$$k_{ph} \sim \tau^{-1} \tag{4.2}$$

the equation for the photons' momentum p_{ph} is:

$$\frac{dp_{ph}}{d\tau} = -\delta \frac{p_{ph}}{\tau} \tag{4.3}$$

where δ is a parameter. Solving equation 4.3 we obtain

$$p_{ph}\tau^{\delta} = const \tag{4.4}$$

Consider a photon with initial momentum p_{emit} emitted at time τ_{emit}. The photon is continuously losing momentum as it moves through the Medium until time τ_{obsv} when it is observed. The observer will measure λ_{obsv}, compare it with well-known wavelength λ_{emit}, and calculate a redshift:

$$z = \frac{\lambda_{obsv}-\lambda_{emit}}{\lambda_{emit}} \tag{4.5}$$

By definition, $\lambda = \frac{h}{p}$. When $\delta = 1$ we obtain:

$$p_{obsv}\tau_{obsv} = p_{emit}\tau_{emit} \tag{4.6}$$

$$1 + z = \frac{\lambda_{obsv}}{\lambda_{emit}} = \frac{p_{emit}}{p_{obsv}} = \frac{\tau_{obsv}}{\tau_{emit}} \tag{4.7}$$

Recall that τ_{emit} and τ_{obsv} are cosmological times (ages of the World at the moments of emitting and observing), both measured from the Beginning of the World. τ_{obsv} equals to the present age of the World A_{τ}. If the photon travelled for time t_{ph}, then

$$\tau_{obsv} = \tau_{emit} + t_{ph} \tag{4.8}$$

$$t_{ph} = \tau_{obsv} - \tau_{emit} = A_{\tau} - t_{emit} \tag{4.9}$$

The cosmological redshift is then described by a nonlinear equation on t_{ph}:

$$1 + z = \frac{1}{1-t_{ph}/A_{\tau}} \tag{4.10}$$

As an example, a photon travelling for 7.11 Byr (half of the World's age A_{τ}) will have a redshift of $1 + z = 2$. Photon travelling for 12.64 Byr will have a redshift of $1 + z = 9$. The difference is due to the dependence of the Medium friction on time: it was 9 times greater at $\tau_{emit} = 1.58\ Byr$ than it is now at $\tau_{obsv} \approx 14.22\ Byr$.

In accordance with Hubble's law, the distance d to galaxies for $z \ll 1$ is found to be proportional to z:

$$d = \frac{c}{H_0} z = Rz \tag{4.11}$$

The relationship of distance d to the redshift z for large values of z is not presently conclusive, active research is conducted in the area. In our Model, the distance to galaxies equals to:

$$d = \frac{c}{H}\frac{z}{1+z} = R\frac{z}{1+z} \qquad 4.12$$

which reduces to 4.11 for $z \ll 1$ and $d = R$ for $z \to \infty$.

Experimental observations measuring light from distant galaxies and supernovae seem to imply that the World is expanding at an accelerated pace, as is evident from the observed redshift. Since 1990s, Dark Energy became the widely accepted hypothesis that explains this phenomenon.

The time varying friction of the Medium offered above provides an alternative interpretation of these observations. For $z > 1$, the distance to supernovae is smaller than expected and hence supernovae are brighter. There is then no reason to introduce dark energy in order to explain the nonlinear relationship of distance to the redshift.

In WUM the theoretical need for additional energy density distinct from the baryon matter and dark matter densities to form our observationally flat World is satisfied with the considerably larger fraction of the neutrino energy density in the total energy density of the World (see 3.26). Consequently, we are dealing with well-known particles instead of dark energy.

The idea of loss of energy of the photon in the intergalactic medium was first suggested in 1929 by Zwicky. But there are two problems: 1) all images of distant objects look blurred if the intergalactic space produces scattering; 2) the scattering effect and the consequent loss of energy is frequency dependent [12].

Different mechanisms were proposed to avoid blurring and scattering. Laio A., *et al.* showed that the shift of photon frequency in low density plasma (which is the case in our Model [1]) could come from quantum effects derived from standard quantum electrodynamics [13]. According to E. J. Lerner, quantum mechanics indicates that a photon gives up a tiny amount of energy as it collides with an electron, but its trajectory does not change [14].

There is another way to explain the absence of the blurring and scattering. Back in 1846 James McCullagh proposed a theory of rotationally elastic medium, i.e. the medium in which every particle resists absolute rotation [11]. This theory produces equations analogous to Maxwell's electromagnetic equations. In our opinion, the Medium of the World is in fact such a rotationally elastic medium. We propose to review the interaction of photons with the Medium in light of this unique theory.

5. Gravitoelectromagnetism

Gravitoelectromagnetism (GEM) refers to a set of formal analogies between the equations for electromagnetism and relativistic gravitation. GEM is an approximation to the Einstein field equations for general relativity in the weak field limit. The equations for GEM were first published in 1893, before general relativity, by O. Heaviside as a separate theory expanding Newton's law [15]. WUM follows this theory.

Maxwell's equations (ME) vary with the unit system used. Although the general shape remains the same, various definitions are changed, and different constants appear in different places. We'll start our discussion with ME in SI units. We will not rewrite well-known equations, but only provide the relationships between physical quantities used in ME for electromagnetism and gravitoelectromagnetism in the **Tables 2** and **3**:

Table 2. Electromagnetism

Charge	Impedance of Electromagnetic Field	Magnetic Flux
q, C	$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = \mu_0 c\,, \Omega$	ϕ_q, Wb
Electric Current	Magnetic Constant	Electric Potential
I_q, A	$\mu_{0,}\ Hm^{-1}$	U_q, V
Magnetic Field Intensity	Electric Constant	Electric Field
$\boldsymbol{H}_q, Am^{-1}$	$\varepsilon_0 = (\mu_0 c^2)^{-1}, \phi m^{-1}$	$\boldsymbol{E}_q, Vm^{-1}$
Electric Flux Density	Electrodynamic Constant	Magnetic Flux Density
$\boldsymbol{D}_q, Cm^{-2}$	c, ms^{-1}	$\boldsymbol{B}_q, Wbm^{-2}$

Table 3. Gravitoelectromagnetism

Mass	Impedance of Gravitational Field	Gravitomagnetic Flux
m, kg	$Z_g = \sqrt{\frac{\mu_g}{\varepsilon_g}} = \mu_g c$	$\phi_m, m^2 s^{-1}$
Mass Current	Gravitomagnetic Parameter	Gravitoelectric potential
I_m, kgs^{-1}	$\mu_g = \frac{4\pi G}{c^2}$	$U_m, m^2 s^{-2}$
Gravitomagnetic Field Intensity	Gravitoelectric Parameter	Gravitoelectric Field
$\boldsymbol{H}_m, kgm^{-1}s^{-1}$	$\varepsilon_g = (\mu_g c^2)^{-1}$	$\boldsymbol{E}_m, ms^{-2}$
Gravitoelectric Flux Density	Gravitoelectrodynamic Constant	Gravitomagnetic Flux Density
$\boldsymbol{D}_m, kgm^{-2}$	c, ms^{-1}	$\boldsymbol{B}_m, s^{-1}$

In Maxwell's equations, electrodynamic constant c is defined as the ratio of the absolute electromagnetic unit of charge to the absolute electrostatic unit of charge.

From the above Tables it becomes clear that the dimensions of all physical quantities depend on the choice of the charge and mass dimensions (Coulomb & kilogram in SI units). In other unit systems the dimensions are different. For instance, in Gaussian units (CGSE):

- $[q_e] = cm^{3/2} g^{1/2} s^{-1}$
- $[Z_e] = cm^{-1} s$

In CGSM:

- $[q_m] = cm^{1/2} g^{1/2}$
- $[Z_m] = cms^{-1}$

We seem to possess a substantial degree of freedom when it comes to choosing the dimension of charge. For an arbitrary dimension-transposing parameter P we can

- Multiply the charge and mass and all physical quantities on the left side of Tables 2 and 3 by an arbitrary parameter P
- Divide impedances by P^2
- Divide magnetic fluxes and all physical quantities on the right side of Tables 2 and 3 by P.

Following such a transformation, all physically measurable parameters such as energy density and energy flux density remain the same, and have the same mechanical dimensions.

By definition, 1 Coulomb equals to one tenth of the absolute electromagnetic unit of charge. It follows that in SI we use electromagnetic unit of charge e in the electrostatic Coulomb law instead of the electrostatic unit $\frac{e}{c}$. This seems a bit odd.

Likewise, when describing Newtonian law of gravitation, we use m – the inertial mass, instead of gravitoelectrostatic charge mc – the gravitational mass. The gravitoelectromagnetic charge is then mc^2. Similarly to the electromagnetic field, the gravitoelectrodynamic constant c is the ratio of the absolute gravitoelectromagnetic unit of charge to the absolute gravitoelectrostatic unit of charge.

All elementary particles in the World are fully characterized by their four-momentum $\left(\frac{E}{c}, \boldsymbol{p}\right)$ that satisfies the following equation:

$$(\frac{E}{c})^2 - \boldsymbol{p}^2 = Inv = (mc)^2 \quad 5.1$$

where the invariant is, in fact, the gravitoelectrostatic charge mc squared, and E is the gravitoelectromagnetic charge.

The inertial mass and the gravitational mass are not the same physical quantity. Instead, they are proportional to each other, and their ratio equals to the gravitoelectrodynamic constant c . The classical theory offers no compelling reason why the gravitational mass mc has to equal the inertial mass m, commonly referred to as "rest mass."

Analogous to electromagnetism, we can think of m as a gravitocapacitor. Then, $E = mc^2$ describes the accumulation of energy by gravitocapacitor with capacity m, rather than transformation of energy to mass. But there is a principal physical difference between Electromagnetism (EM) and Gravitoelectromagnetism (GEM):

- In EM, the magnetic constant μ_0 and electric constant ε_0 are the vacuum permeability and vacuum permittivity of free (empty) space correspondingly;
- In GEM, the gravitomagnetic parameter μ_g depends on the gravitational parameter G:

$$\mu_g = \frac{4\pi G}{c^2} \quad 5.2$$

which is not a constant in our model and cannot be introduced without the Medium of the World. In frames of WUM the gravitomagnetic parameter μ_g can be calculated based on the value of the energy density of the Medium of the World ρ_M :

$$\mu_g = \frac{4\pi G}{c^2} = \frac{\rho_M}{c^2} \times P^2 \quad 5.3$$

where a dimension-transposing parameter P equals to [1]:

$$P = \frac{a^3}{2h/c} \qquad 5.4$$

Nikola Tesla stated the existence of the Medium of the World: *"All attempts to explain the workings of the universe without recognizing the existence of the ether and the indispensable function it plays in the phenomena are futile and destined to oblivion".*

James McCullagh has this to say about the Medium: "*The constitution of the ether, if it ever would be discovered, will be found to be quite different from anything that we are in the habit of conceiving, though at the same time very simple and very beautiful. An elastic medium composed of points acting on each other in the way supposed by Poisson and others will not answer".*

Long time ago it was realized that there are no longitudinal waves in the Medium, and hence the Medium could not be an elastic matter of an ordinary type. In 1846 James McCullagh proposed a theory of a rotationally elastic medium, i.e. a medium in which every particle resists absolute rotation [11].

The potential energy of deformation in such a medium depends only on the rotation of the volume elements and not on their compression or general distortion. This theory produces equations analogous to Maxwell's electromagnetic equations.

The World – Universe Model is based on Maxwell's equations, and McCullagh's theory is a good fit for description of the Medium.

As the conclusion:

- The gravitation does not exist without the Medium of the World;
- The gravitation is connected to the main characteristic of the Medium – energy density.

6. Le Sage's Theory of Gravitation

Wikipedia summarizes this unique theory as follows:

"Le Sage's theory of gravitation is a kinetic theory of gravity originally proposed by Nicolas Fatio de Duillier in 1690 and later by Georges-Louis Le Sage in 1748. The theory proposed a mechanical explanation for Newton's gravitational force in terms of streams of tiny unseen particles (which Le Sage called ultra-mundane corpuscles) impacting all material objects from all directions. According to this model, any two material bodies partially shield each other from the impinging corpuscles, resulting in a net imbalance in the pressure exerted by the impact of corpuscles on the bodies, tending to drive the bodies together".

Le Sage proposed quantitative estimates for some of the theory's parameters:

- He called the gravitational particles ultramundane corpuscles, because he supposed them to originate beyond our known universe. The distribution of the ultramundane flux is isotropic and the laws of its propagation are very similar to that of light.
- He suggested that the ultramundane corpuscles might move at the speed of light.

- To maintain mass proportionality, ordinary matter consists of cage-like structures, in which their diameter is only the 10^7th part of their mutual distance, so the particles can travel through them nearly unhindered.

Lyman Spitzer in 1941 calculated, that absorption of radiation between two dusts particles lead to a net attractive force which varies proportional to 1/r2 [16]. The Le Sage mechanism also has been identified as a significant factor in the behavior of dusty plasma. A. M. Ignatov has shown that an attractive force arises between two dust grains suspended in isotropic collisionless plasma due to inelastic collisions between ions of the plasma and the grains of dust. This attractive force is inversely proportional to the square of the distance between dust grains and can counterbalance the Coulomb repulsion between dust grains [17].
Although it is not regarded as a viable theory within the mainstream scientific community, there are some attempts to re-habilitate the theory [18-25]. In this respect, we would like to stress the importance of the extended theories of gravity in the debate about gravitation, as it is clarified in [26].
Every Le Sage-type model assumes the existence of a space-filling isotropic flux or radiation of enormous intensity and penetrating capability. The flux of neutrinos emanating from the Sun was discussed in literature. This flux possesses the penetrating properties envisaged by Le Sage, but it is not isotropic, and its intensity is even smaller than that of the Cosmic Microwave Background radiation.
In our model, the Cosmic Neutrino Background (CNB) is indeed a space-filling and fairly isotropic flux. It has a high intensity since its total neutrino energy density Ω_{CNB} is about 69% of the total energy density of the World Ω_W (see 3.26). One may wonder – if there are so many neutrinos out there, how come the numerous neutrino detectors do not register them in significant quantities?

According to WUM, CNB consists of three different types of neutrinos: electronic ν_e, muonic ν_μ, and tauonic ν_τ, and their antiparticles with masses m_{ν_e}, m_{ν_μ}, m_{ν_τ} [3]:

$$m_{\nu_e} = \frac{1}{24} m_0 \times Q^{-1/4} \cong 3.1 \times 10^{-4}\ eV/c^2 \qquad 6.1$$

$$m_{\nu_\mu} = m_0 \times Q^{-1/4} \cong 7.5 \times 10^{-3}\ eV/c^2 \qquad 6.2$$

$$m_{\nu_\tau} = 6m_0 \times Q^{-1/4} \cong 4.5 \times 10^{-2}\ eV/c^2 \qquad 6.3$$

For Fermi momentum p_F we took the following value [3]:

$$p_F^2 = \frac{m_0^2 c^2}{2\pi^2} \times Q^{-1/2} \qquad 6.4$$

Then for Fermi energy E_F we obtain:

$$E_{F\nu_e} = p_F c = \frac{1}{\sqrt{2}\pi} m_0 c^2 \times Q^{-1/4} \cong 7.2\ k_B T_{MBR} \qquad 6.5$$

$$E_{F\nu_\mu} = \frac{p_F^2}{2m_{\nu_\mu}} = \frac{1}{4\pi^2} m_0 c^2 \times Q^{-1/4} \cong 0.81\ k_B T_{MBR} \qquad 6.6$$

$$E_{F\nu_\tau} = \frac{p_F^2}{2m_{\nu_\tau}} = \frac{1}{24\pi^2} m_0 c^2 \times Q^{-1/4} \cong 0.135\ k_B T_{MBR} \qquad 6.7$$

It follows that CNB consists of very low-energy neutrinos, whose energy is similar to that of the Cosmic Microwave Background radiation. Their interaction with matter is very weak. Since the neutrino-induced cross-sections depend on the neutrinos' energy linearly, such background neutrinos will not be registered by standard neutrino detectors. In fact, we might never be able to directly observe the CNB.

The obtained results show that the proposed CNB mechanism of Gravitation is relevant for the Le Sage’s theory.
In our model, Dark Matter particles (DMP) are a space-filling and fairly isotropic flux as well. It possesses the penetrating properties envisaged by Le Sage for his ultramundane corpuscles and has a high intensity since the total DMP energy density Ω_{DM} is about 24% of the Ω_W (see 3.25).
We should recall that 1/3 of the World energy E_W is in all Macroobjects and 2/3 of E_W is in the Medium of the World which is a space-filling and fairly isotropic in our model [1] and is responsible for the Le Sage's mechanism of the gravitation.
According to WUM, all material objects of the World have gravitational charges. 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, and serves as a natural borderline between classical and quantum physics [3].
It is obvious that for the realization of Le Sage's mechanism of gravitation at least one material object must be a macroobject. In our opinion, the smallest such macroobject has Planck mass. The validity of this statement follows from the work of Lyman Spitzer [16] and A. M. Ignatov [17] who identified Le Sage's mechanism as a significant factor in the behavior of dust particles and dusty plasma.
As the conclusion:

- Gravity is not an interaction but a manifestation of the Medium of the World;
- Le Sage's theory is the very first theory which defines the Gravity as an emergent phenomenon.

7. Emergent Gravity, Space and Time

By definition, an emergent phenomenon is a property that is a result of simple interactions that work cooperatively to create a more complex interaction. Physically, the simple interactions occur at a microscopic level, and the collective result can be observed at a macroscopic level. In Le Sage's theory the gravity is just a result of microscopic interactions which appear to average out on a macroscopic scale and give us gravity as we recognize it.
C. Barcelo, S. Liberati, and M. Visser have this to say about emergent gravity:
“One of the more fascinating approaches to “quantum gravity” is the suggestion, typically attributed to Sakharov [27], [28] that gravity itself may not be “fundamental physics”. Indeed it is now a relatively common opinion, maybe not mainstream but definitely a strong minority opinion, that gravity (and in particular the whole notion of spacetime and spacetime geometry) might be no more “fundamental” than is fluid dynamics. The word “fundamental” is here used in a rather technical sense – fluid mechanics is not fundamental because there is a known underlying microphysics that of molecular dynamics, of which fluid mechanics is only the low-energy low-momentum limit” [29].

With Albert Einstein’s principle at heart – *“When forced to summarize the theory of relativity in one sentence: time and space and gravitation have no separate existence from matter”* – we introduced the Medium of the World consisting of protons, electrons, photons, neutrinos, and dark matter particles. In our model the Medium is not fundamental and has the macroscopic parameters like in fluid mechanics: impedance, gravitomagnetic parameter, etc.
In frames of WUM we can find the gravitomagnetic parameter of the Medium μ_g :

$$\mu_g = \frac{4\pi G}{c^2} = \frac{1}{R} \times P \qquad 7.1$$

and the impedance of the Medium Z_g :

$$Z_g = \mu_g c = H \times P = \frac{1}{\tau} \times P \qquad 7.2$$

where R is the size of the World, H is Hubble's parameter and τ is the absolute cosmological time measured from the Beginning of the World like absolute temperature measured from absolute zero in kelvins.

It follows that measuring the value of Hubble's parameter anywhere in the World and taking its inverse value allows us to calculate the absolute time of the World τ . The Hubble's parameter is then the most important characteristic of the World, as it defines the Worlds' age.

The second important characteristic of the World is the gravitomagnetic parameter. Taking its inverse value, we can find the absolute size of the World R . We emphasize that the above two parameters (Z_g and μ_g) are principally different physical characteristics of the Medium that are connected through the gravitoelectrodynamic constant c .

In WUM, time and space are closely connected with the Mediums' impedance and gravitomagnetic parameter. It follows that neither time nor space could be discussed in absence of the Medium. The gravitational parameter G can be introduced only for the World filled with matter. Matter, then, is primary to time and space and gravity, as Einstein has postulated.

It follows that the gravity, space and time itself can be introduced only for the World filled with matter consisting of elementary particles which take part in simple interactions at a microscopic level. The collective result of their interactions can be observed at a macroscopic level. It means that Gravity, Space and Time are the emergent phenomena.

When in history of the World can we introduce the Medium of the World – a macroscopic notion? According to WUM, at the Beginning when the size of the World was equal to a and the extrapolated density ρ_{cr0} equaled to (see 3.5 at $Q = 1$)

$$\rho_{cr0} = 3\rho_0 \qquad 7.3$$

the extrapolated total amount of the surface energy of the World E_{W0} was equal to [1]

$$E_{W0} = \frac{6}{\pi} E_0 \qquad 7.4$$

which is sufficient to produce DIRACs and lighter particles only. The conditions for generating the very first ensemble of particles and the first objects actualized when the size of the World a_M was about the Bohr radius multiplied by 2π (see 3.4)

$$a_M = \frac{a}{\alpha^2} \cong 3.3 \times 10^{-10}\ m \qquad 7.5$$

at the cosmological time τ_M (see 3.3)

$$\tau_M = \frac{1}{\alpha^2}\frac{a}{c} \cong 1.1 \times 10^{-18}\ s \qquad 7.6$$

The total energy E_{WM} was equal to

$$E_{WM}\left(Q = \frac{1}{\alpha^2}\right) = \frac{6E_0}{\pi\alpha^4} \qquad 7.7$$

and the Planck mass was equal to twice the mass of WIMPs (see 3.8)

$$M_P = 2m_{WIMP} = 2\frac{m_0}{\alpha} \quad 7.8$$

At that time, neutralinos (the heaviest particles in our model with mass $m_N = \frac{m_0}{\alpha^2}$) could initiate a gravitational collapse of all particles heavier than $2m_0$ (neutralinos, WIMPs, protons) [3] with the resulting microobjects – nuclei. All lighter particles would then be attracted to the nuclei, increasing their masses and initiating the macroobjects' formation.

As the conclusion:

- The macroscopic notion - Medium of the World can be introduced at the cosmological time τ_M .
- The emergent Gravity, Space and Time can be introduced for cosmological times $\tau \geq \tau_M$.

While the Model needs significant further elaboration, it can already serve as a basis for a new physics proposed by Le Sage, J. McCullagh, O. Heaviside, P. Dirac, A. D. Sakharov, and P. Wesson.

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