Development of Hypersphere World-Universe Model. Narrative

Part III. Hypersphere World-Universe Model

Overview of Hypersphere World-Universe Model

Abstract

This paper provides an overview of the Hypersphere World – Universe Model (WUM). WUM unifies and simplifies existing cosmological models and results into a single coherent picture, and proceeds to discuss the origin, evolution, structure, ultimate fate, and primary parameters of the World. WUM explains the experimental data accumulated in the field of Cosmology and Astroparticle Physics over the last decades: the age of the World and critical energy density; the gravitational parameter and Hubble's parameter; temperatures of the cosmic microwave background radiation and the peak of the far-infrared background radiation; gamma-ray background and cosmic neutrino background; macrostructure of the World and macroobjects structure. Additionally, the Model makes predictions pertaining to masses of dark matter particles, photons, and neutrinos; proposes new types of particle interactions (Super Weak and Extremely Weak); shows inter-connectivity of primary cosmological parameters of the World and the rise of the solar luminosity during the last 4.6 Byr. The Model proposes to introduce a new fundamental parameter Q in the CODATA internationally recommended values.

Keywords. "Hypersphere World – Universe Model"; "Medium of the World"; "Macroobjects Structure"; "Gravitoelectromagnetism"; "Dark Matter Particles"; "Intergalactic Plasma"; "Microwave Background Radiation"; "Far-Infrared Background Radiation"; "Gamma-ray Background Radiation"; "Cosmic Neutrino Background"; "Q-Dependent Cosmological Parameters"; "Emergent Phenomena"; "Grand Unified Theory"; "CODATA"

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 Physics' stagnation is shared by a large number of researchers. 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 is nearly complete. 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. 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 scientists such as McCullagh, Riemann, Clifford, Heaviside, Dirac, and Sakharov are revisited in a new light. In the present article I am attempting to describe the World while unifying and simplifying existing models and results in Cosmology into a single coherent picture. The Hypersphere World–Universe Model (WUM) is proposed as an alternative to the prevailing Big Bang Model of the standard physical cosmology. The main advantage of WUM is the elimination of the singularity of an energy density at the Beginning of the World (Big

Bang) and Inflation Epoch which lasted from 10^{-36} to approximately 10^{-32} seconds after the Big Bang and produced an extremely rapid exponential expansion of the volume of the early universe by a factor of at least 10^{78}. This manuscript provides an overview of WUM. The core ideas of the Model are described in four papers published in the "Journal of High Energy Physics, Gravitation and Cosmology" journal [1]-[4]. A number of results obtained there are quoted in the current work without a full justification; an interested reader is encouraged to view the referenced papers in such cases.

2. Cosmology

The Hypersphere World – Universe Model (WUM) is a classical model. It should then be described by classical notions which are emergent phenomena and can be introduced only for a World filled with Matter consisting of elementary particles [4]. The interactions that occur between the particles happen at a microscopic level and are thus described by Quantum mechanics. The collective result of their interactions, however, is observed at a macroscopic level. Hence, classical notions can be introduced only when the very first ensemble of particles was created at the cosmological time $\cong 10^{-18}\,s$ [4]. The World at cosmological times less than $10^{-18}\,s$ is best described by Quantum mechanics.

WUM differs from the hot Big Bang model in the following important aspect: according to Big Bang, the energy density at the Beginning was infinite (singularity), whereas WUM extrapolates the energy density to have been finite, namely, four orders of magnitude smaller than the nuclear energy density [3]. The key concepts and observations of WUM are the following:

- Expansion and Creation of Matter;
- Content of the World;
- Cosmic Microwave Background Radiation;
- Cosmological Redshift;
- Structure of Macroobjects;
- Inter-Connectivity of Primary Cosmological Parameters.

WUM makes reasonable assumptions in each of these areas. The remarkable agreement of the calculated values of the primary cosmological parameters with the observational data gives us considerable confidence in the Model. While WUM needs significant further elaboration, it can already serve as a basis for a new Physics proposed by Paul Dirac in 1937.

Let's discuss the origin, evolution, structure, ultimate fate, and primary cosmological parameters of the World speculated by the Hypersphere World – Universe Model.

2.1. Expansion and Creation of Matter

Before the Beginning of the World there was nothing but an Eternal Universe. About 14 billion years ago the World was started by a fluctuation in the Eternal Universe, and the Nucleus of the World, which is a four-dimensional 4-ball, was born. 4-ball is the interior of a three-dimensional hypersphere. An extrapolated Nucleus radius at the Beginning was equal to $a = 2\pi a_0$, a_o being the classical electron radius. The radius a is chosen to fit the Age of the World. In WUM, a classical notion of "Size" can only be introduced when the very first ensemble of particles was created at the Nucleus radius about $a/\alpha^2 \cong 3 \times 10^{-10}\ m$, where α is the Fine-structure constant [4]. The 3D World is a hypersphere that is the surface of a 4-ball Nucleus. All points of the hypersphere are equivalent; there are no preferred centers or boundary of the World.

The 4-ball is expanding in the Eternal Universe, and its surface, the hypersphere, is likewise expanding so that the radius of the Nucleus R is increasing with speed c that is the gravitoelectrodynamic constant, for the absolute cosmological time τ from the Beginning and equals to $R = c\tau$. The need for Inflation Epoch with its exponential expansion of volume does not arise in WUM.

According to the Model, the value of the Worlds' radius of curvature in the fourth spatial dimension R in the present cosmological epoch equals to the Hubble's radius about 14.223 Byr (see equation 3.6). The gravitoelectrodynamic constant c (identical to the electrodynamic constant c in Maxwell's equations) equals to the ratio of a gravitoelectromagnetic unit of charge to a gravitoelectrostatic unit of charge. In WUM, the gravitoelectromagnetic charge $E_0 = hc/a$ has a dimension of "Energy" and the gravitoelectrostatic charge $p_0 = h/a$ – of "Momentum" (h is Planck constant). Throughout the expansion, total energy density of the World is decreasing inversely proportional to the absolute cosmological time τ.

The expansion of the Hypersphere World can be understood by the analogy with an expanding 3D balloon: imagine small enough "flat" observer residing in a curved flatland on the surface of a balloon; as the balloon is blown up, the distance between all neighboring points grows; the two-dimensional world grows but there is no preferred center. It is well-known that formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing [5]. For example, the estimates of star generation in MS1358arc Galaxy made by M. Swinbank, *et al.* show that within the star-forming regions of this infant galaxy, new stars are being created at a rate of about 50 main sequence stars per year – around 100 times faster than had been previously thought [6].

What is the origin of the Matter necessary for the formation of new galaxies and stars? According to WUM, the surface of the 4-ball (hypersphere) is created in a process analogous to sublimation. Continuous creation of matter is the result of this process. Sublimation is a well-known endothermic process that happens when surfaces are intrinsically more energetically favorable than the bulk of a material, and hence there is a driving force for surfaces to be created. Matter arises from the fourth spatial dimension. The Universe is responsible for the creation of Matter (see Section 3.3). Thus, instead of an instantaneous Big Bang, in WUM the World is being created continuously. It is important to emphasize that

- Creation of Matter is a direct consequence of expansion:
- Creation of Matter occurs homogeneously in all points of the hypersphere World.

2.2. Content of the World

The existence of the Medium is a principal point of WUM. It follows from the observations of Intergalactic Plasma; Cosmic Microwave Background Radiation (MBR); Far-Infrared Background Radiation; Gamma-ray Background Radiation; Cosmic Neutrino Background. There is no empty space (vacuum) in WUM. Inter-galactic voids discussed by astronomers are in fact examples of the Medium in its purest. Cosmic MBR is part of the Medium; it then follows that the Medium is the absolute frame of reference. Relative to MBR rest frame, Milky Way galaxy and Sun are moving with the speed of 552 $\pm$ 6 km/s and $\approx$ 370 km/s respectively.

The Medium consists of stable elementary particles with lifetimes longer than the age of the World: protons, electrons, photons, neutrinos, and dark matter particles. The Medium is not Aether; it is a mixture of gases composed of different elementary particles. The total energy density of the Medium is 2/3 of the overall energy density of the World in all cosmological times. Galaxy clusters, Galaxies, Star clusters, Extrasolar systems, planets, etc. are made of the same particles. The energy density of Macroobjects adds up to 1/3 of the total energy density of the World throughout the World's evolution.

2.3. Cosmic Microwave Background Radiation

By definition, Black-body radiation is electromagnetic radiation within or surrounding a body in thermodynamic equilibrium with its environment. According to WUM, black-body spectrum of the cosmic MBR is due to thermodynamic equilibrium of photons with low density Intergalactic plasma [1]. WUM calculates the value of MBR temperature T_{MBR} (see equation 3.9) to be in excellent agreement with experimentally measured value (see Section 3.1). We are not aware of any other model that allows calculation of T_{MBR} with such accuracy. The Big Bang model explains cosmic MBR as follows: the photons that existed at the time of photon decoupling (when the Universe was just 380,000 years old) have been propagating ever since. The photons' wavelengths have been stretching due to expansion of the Universe. Since wavelength is inversely proportional to energy, today we observe these photons as MBR. According to WUM, photons are fully characterized by their four-momentum. The notion of "Wavelength" is a macroscopic notion, namely, gravitomagnetic flux of particles characterized by four-momentum only. It means that photons do not have a wavelength. There is no Wave–Particle duality in WUM. Wavelength is an emergent phenomenon (see Section 6.2).

2.4. Cosmological Redshift

WUM views Cosmological Redshift as a phenomenon dependent on the curvature of the World in the 4th dimension. In this Section we derive the non-linear relationship of distance d to the redshift z for large values of z. While photons travel along straight lines in the 3-dimensional World, due to expansion of the Hypersphere, there is also a 4th dimension to the photons' trajectories. The Radius of the World at the time when photons are emitted from distant galaxies is smaller than its Radius when the photons are observed. Consequently, photons are moving along spiral trajectories. It follows that they are subjected to centripetal acceleration $g_W(\tau)$:

$$g_W(\tau) = cH = c/\tau \qquad 2.1$$

and are losing their kinetic energy on the way to the observer. The lost kinetic energy is transforming to the gravitational potential energy of photons due to the movement along the fourth spatial dimension (H is Hubble's parameter). This transformation is analogous to the energy transformation of any body that is thrown at an angle with respect to the ground on Earth.

Consider a photon with initial frequency ν_{emit} and energy E_{emit} emitted at time τ_{emit} when the Nucleus radius was R_{emit} . The photon is continuously losing kinetic energy as it moves through the

Medium until time τ_{obsv} when it is observed and has energy E_{obsv}. The observer will measure ν_{obsv} at the time τ_{obsv} when the Nucleus radius is $R_{obsv} = R_0$, compare it with well-known frequency ν_{emit}, and calculate a redshift:

$$1 + z = \frac{\nu_{emit}}{\nu_{ovsv}} = \frac{E_{emit}}{E_{obsv}} \qquad 2.2$$

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 light travel time distance to a galaxy d equals to

$$d = c(\tau_{obsv} - \tau_{emit}) = R_0 - R_{emit} \qquad 2.3$$

A cosmological centripetal acceleration $g_W(\tau)$ depends on cosmological time $g_W(\tau) \propto \tau^{-1}$ (2.1). It is reasonable to assume that photons are losing their energy E_{ph} in a similar fashion:

$$E_{ph} = E_{emit}\frac{\tau_{emit}}{\tau} = E_{emit}\frac{R_{emit}}{R} \qquad 2.4$$

Then the total loss of energy by a photon ΔEph is

$$\Delta E_{ph} = E_{emit}\int_{R_{emit}}^{R_0}\frac{R_{emit}}{c^2 r}\frac{c^2}{r}dr = E_{emit}(1 - \frac{R_{emit}}{R_0}) \qquad 2.5$$

and the redshift is:

$$1 + z = \frac{R_0}{R_{emit}} = \frac{R_0}{R_0 - d} \qquad 2.6$$

From (2.6) we can find the light travel time distance to the galaxy that emitted the light:

$$d = R_0\frac{z}{1+z} \qquad 2.7$$

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

$$d = \frac{c}{H_0}z = R_0 z \qquad 2.8$$

In WUM, the distance to galaxies equals to (2.7) which reduces to (2.8) for $z \ll 1$ and $d = R_0$ for $z \to \infty$. Experimental observations measuring light from supernovae Ia 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. WUM gives an alternative interpretation of these observations. For $z > 1$, the distance to supernovae is smaller than expected and hence supernovae are brighter. When $z = 1$, for instance, Hubble's law yields $d = R_0$ (2.8), and WUM - $d = R_0/2$ (2.7). There is then no reason to introduce dark energy in order to explain the nonlinear relationship of distance to redshift.

2.5. Structure of Macroobjects

The existence of supermassive objects in galactic centers is now commonly accepted. A number of non-traditional models explaining the supermassive dark objects observed in galaxies and galaxy clusters, formed by self-gravitating Dark Matter (DM) composed of fermions or bosons, are widely discussed in literature (see [8-14] and references therein). The first phase of stellar evolution in the history of the World may be Dark Stars, powered by DM heating rather than fusion [7]. Neutralinos and WIMPs can annihilate and provide an important heat source for the stars and planets in the World [2] (see Sections 6.6, 6.7).

In our view, all Macroobjects (MO) of the World (galaxy clusters, galaxies, star clusters, extrasolar systems, and planets) possess the following properties [2]:

- Macroobject cores are made up of Dark Matter Particles (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 their cores.

Heaviest Macroobjects include shells of high-density preon plasma and sterile neutrinos around their cores (see Section 6.6). WUM predicts existence of DM particles with 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV masses. The signs of annihilation of these particles are found in the observed gamma-ray spectra which we connect with the structure of MO (core and shells composition). Annihilation of those DMP can give rise to any combination of gamma-ray lines. Thus, the diversity of Very High Energy gamma-ray sources in the World has a clear explanation in frames of WUM [2] (see Section 6.9).

2.6. Nucleosynthesis

Large-Scale Structures. Ultimate Fate 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 B²FH review paper in 1957 [15]. With respect to WUM, the theory of stellar nucleosynthesis should be expanded to include annihilation of heavy DMP (WIMPs and Neutralinos). The amount of energy produced due to this process is sufficiently high to create all elements inside stellar cores (see Section 6.7).

Formation and Evolution of Large-Scale Structures. All Macroobjects of the World have cores made up of different DMP. The matter creation is occurring homogeneously in all points of the World. 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 in parallel around different cores made of different DMP. In WUM Dark Matter plays the main role inside of all Macroobjects. Formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing.

Ultimate Fate of the World. The Universe is continuously creating Matter in the World. Assuming an Eternal 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 is proportional to the absolute time $\propto \tau^{-1/4}$ (see 3.9) and will asymptotically reach zero.

3. Inter-Connectivity of Primary Cosmological Parameters

The constancy of the universe fundamental constants, including Newtonian constant of gravitation, Fermi coupling constant, Planck mass, is now commonly accepted, although has never been firmly established as a fact. All conclusions on the (almost) constancy of the Newtonian parameter of gravitation are model-dependent [4]. 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. WUM holds that there indeed exist relations between all cosmological parameters which depend on dimensionless time-varying quantity Q [4]. This parameter increases in time and is a measure of the Hypersphere Worlds' radius of curvature in the fourth spatial dimension in terms of a :

$$Q = R/a \tag{3.1}$$

3.1. Q-Dependent Time-Varying Parameters of the World

According to WUM, the following parameters of the World depend on Q [1-4]:

- Newtonian parameter of gravitation G

$$G = \frac{a^2c^4}{8\pi hc} \times Q^{-1} \tag{3.2}$$

- Planck mass M_P

$$M_P = 2m_0 \times Q^{1/2} \tag{3.3}$$

- Hubble's parameter H

$$H = \frac{c}{a} \times Q^{-1} \tag{3.4}$$

- Age of the World A_τ

$$A_\tau = H^{-1} = \frac{a}{c} \times Q \tag{3.5}$$

- The Worlds' radius of curvature in the fourth spatial dimension R

$$R = cH^{-1} = a \times Q \tag{3.6}$$

- Critical energy density ρ_{cr}

$$\rho_{cr} = 3\rho_0 \times Q^{-1} \tag{3.7}$$

- Cosmological acceleration g_W

$$g_W = cH = g_0 \times Q^{-1} \tag{3.8}$$

- Temperature of the Microwave Background Radiation (MBR) T_{MBR}

$$T_{MBR} = \frac{E_0}{k_B}\left(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p}\right)^{1/4} \times Q^{-1/4} \tag{3.9}$$

- Temperature of the Far-Infrared Background Radiation (FIRB) peak T_{FIRB}

$$T_{FIRB} = \frac{E_0}{k_B}\left(\frac{15}{4\pi^5}\right)^{1/4} \times Q^{-1/4} \tag{3.10}$$

- Fermi coupling parameter G_F

$$\frac{G_F}{(\hbar c)^3} = \sqrt{30}\left(2\alpha\frac{m_e}{m_p}\right)^{1/4}\frac{m_p}{m_e}\frac{1}{E_0^2} \times Q^{-1/4} \tag{3.11}$$

- Electronic neutrino mass m_{ν_e}

$$m_{\nu_e} = \frac{1}{24} m_0 \times Q^{-1/4} \qquad 3.12$$

- Muonic neutrino mass m_{ν_μ}

$$m_{\nu_\mu} = m_0 \times Q^{-1/4} \qquad 3.13$$

- Tauonic neutrino mass $m\nu\tau$

$$m_{\nu_\tau} = 6m_0 \times Q^{-1/4} \qquad 3.14$$

- Photons rest mass m_{phi}

$$m_{phi} = (\frac{m_e}{m_p})^{1/2} m_0 \times Q^{-1/2} \qquad 3.15$$

where k_B is Boltzmann constant, m_p is the mass of a proton, m_e is the mass of an electron (m_0 , ρ_0 , g_0 and E_0 are Basic units of mass, energy density, acceleration, and energy respectively, (see Section 4). Comparing equations 3.9 and 3.10, we can find the relation between temperatures T_{FIRB} and T_{MBR} :

$$T_{FIRB} = (3\Omega_e)^{-1/4} \times T_{MBR} \qquad 3.16$$

where Ω_e is the relative energy density of electrons in the Medium in terms of the critical energy density ρ_{cr} . As shown in [1-3], the calculated values of these parameters are in good agreement with the results of their measurements. For example, calculating the value of Hubble's parameter H_0 based on the average value of the gravitational parameter G we find $H_0 = 68.7457(83)\ km/s\ Mpc$ (see 3.4) which is in good agreement with $H_0 = 69.32 \pm 0.8\ km/s\ Mpc$ obtained using WMAP data [16]. The calculated value is between the latest values of Hubble's parameters $H_0 = 67.6 \pm 0.7\ km/s\ Mpc$ and $H_0 = 73.00 \pm 1.75\ km/s\ Mpc$ obtained using SDSS-III data [73] and Hubble Space Telescope data [74] respectively. Observe that values of H_0 vary significantly depending on a method. The disagreement in the values of H_0 obtained by the various teams far exceeds the provided standard uncertainties provided. The value of H_0 calculated by WUM is closest to the value obtained by WMAP [16].

The black-body spectrum of the cosmic MBR is due to thermodynamic equilibrium of photons with low density intergalactic plasma [1]. WUM calculates the value of T_{MBR} (see 3.9) to be $T_{MBR} = 2.72518\ K$, which is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\ K$ [17].

Based on the thermo-equilibrium of drops of Bose-Einstein-condensed dineutrinos [3] (see Section 6.4) we calculate their stationary temperature that corresponds to the FIRB temperature peak (see 3.10) and obtain $T_{FIRB} = 28.955\ K$, which is in an excellent agreement with experimentally measured value of $29\ K$ [18-29].

Today, Fermi coupling parameter is known with the highest precision. Based on its average value we can calculate and significantly increase the precision of all Q-dependent parameters [4]. We propose to introduce Q as a new Fundamental Parameter tracked by CODATA and use its value in calculation of all Q-dependent parameters.

3.2. Gravitation

In frames of WUM the parameter G can be calculated based on the value of the energy density of the Medium ρ_M [1]:

$$G = \frac{\rho_M}{4\pi} \times P^2 \qquad 3.17$$

where a dimension-transposing parameter P equals to:

$$P = \frac{a^3}{2h/c} \qquad 3.18$$

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

$$F = G\frac{m \times M}{r^2} = \frac{\rho_M}{4\pi}\frac{\frac{a^3}{2L_{Cm}} \times \frac{a^3}{2L_{CM}}}{r^2} \qquad 3.19$$

where we introduced the measurable parameter of the Medium ρ_M ρM 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 Mrespectively). The gravitoelectromagnetic charges in 3.19 have a dimension of "Area", which is equivalent to "Energy", with the constant that equals to the basic unit or surface energy density $\sigma 0$ (see Section 4). Following the approach developed in [1] we can find the gravitomagnetic parameter of the Medium μ_M:

$$\mu_M = R^{-1} \qquad 3.20$$

and the impedance of the Medium Z_M :

$$Z_M = \mu_M c = H = \tau^{-1} \qquad 3.21$$

These parameters are analogous to the magnetic constant μ_0 and impedance of electromagnetic field $Z_0 = (\frac{\mu_0}{\varepsilon_0})^{1/2} = \mu_0 c$, where ε_0 is electric constant and $\mu_0\varepsilon_0 = c^{-2}$ [4]. 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. 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. The second important characteristic of the World is the gravitomagnetic parameter μM . Taking its inverse value, we can find the absolute radius of curvature of the World in the fourth spatial dimension. 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 .

It means that Time is not a physical dimension and is absolutely different entity than Space. Time is a factor of the World. It follows that Gravity, Space and Time itself can be introduced only for a 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. Gravity, Space and Time are then emergent phenomena [4].

Paper [4] aligns WUM with Le Sage's theory of gravitation. According to the Model, two particles or microobjects will not exert gravity on one another when their masses are smaller than the Planck mass [4] (see Section 6.8). The validity of this statement follows from the work of Lyman Spitzer [30] and A. M. Ignatov [31] who identified Le Sage's mechanism as a significant factor in the behavior of dust particles and dusty plasma. Although it is not regarded as a viable theory within the mainstream scientific community, there are some attempts to re-habilitate Le Sage's theory [32-39].

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 [40]. A possibility that gravity is not an interaction, but a manifestation of a symmetry based on a Galois field is discussed in [41]. In 1870, William Clifford made the statement that matter is nothing, but ripples, hills and bumps of space curved in a higher dimension and the motion of matter is nothing more than variations in that curvature (see Section 5). Hypersphere WUM follows this idea of the 3D curved World locally bent in a fourth dimension. The local bending depends on a gravitoelectromagnetic charge of a macroobject and the elasticity of the hypersphere that is the surface energy density of the 4-ball Nucleus and is in fact the volume energy density of the Medium of the World. Then, according to Clifford the force of Gravity depends on the gravitoelectromagnetic charges of macroobjects and energy density of the Medium (see equation 3.19).

To summarize:

- The gravitation is connected to the main characteristic of the Medium – energy density;
- The Gravity, Space and Time are emergent phenomena.

3.3. Critical Energy Density

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 3-Manifold at any cosmological time. A 3-Manifold is a space that locally looks like Euclidean 3-dimensional space: just as a sphere looks like a plane to small enough observers. In WUM the World is a Hypersphere that is an example of a 3-Manifold. ρ_{cr} can be estimated by considering a sphere of radius R_M and enclosed mass M, with a small test mass m on the periphery of the sphere. Mass M can be calculated by multiplication of ρ_{cr} by the volume of the sphere. The equation for ρ_{cr} can be found from the escape speed calculation for test mass m:

$$\rho_{cr} = \frac{3H^2c^2}{8\pi G} \qquad 3.22$$

According to WUM, creation of Matter in the Hypersphere World continually occurs through a process analogous to sublimation (see Section 2.1). The Eternal Universe is responsible for the creation of Matter. The physical conditions at the moving 4-ball Nucleus and Universe boundary remain constant in all times. If we assume that the content of Matter in 4-ball Nucleus is proportional to the surface of the hypersphere and Basic unit of surface energy density σ_0 , then an energy density of the Nucleus ρ_N :

$$\rho_N = \frac{2\pi^2R^3\sigma_0}{0.5\pi^2R^4} = \frac{4hc}{a^3R} = 4\rho_0 \times Q^{-1} \qquad 3.23$$

is higher than the critical energy density of the World (compare with equation 3.7). It means that the surface of the 4-ball Nucleus is intrinsically more energetically favorable than the bulk of a material and hence there is a driving force for surface to be created. It is worth to note that energy density of the Nucleus $\rho_N \propto R^{-1}$ (3.23) and hence the surface energy density of the hypersphere $\rho_{cr} \propto R^{-1}$. Taking into account that $H \propto R^{-1}$ it is easy to see that the gravitational parameter $G \propto R^{-1}$ (3.22).

3.4. Grand Unified Theory

At the very Beginning ($Q=1$) all extrapolated fundamental interactions of the World – strong, electromagnetic, weak, Super Weak and Extremely Weak (proposed in WUM), and gravitational – had the same cross-section of $(\frac{\pi a}{2})^2$ and could be characterized by the Unified coupling constant: $\alpha_U = 1$. The extrapolated energy density of the World was four orders of magnitude smaller than the nuclear energy density [3]. The average energy density of the World has since been decreasing in time $\rho_W \propto Q^{-1} \propto \tau^{-1}$. The gravitational coupling parameter α_G is similarly decreasing:

$$\alpha_G \propto Q^{-1} \propto \tau^{-1} \qquad 3.24$$

The weak coupling parameter α_W is decreasing as follows:

$$\alpha_W \propto Q^{-1/4} \propto \tau^{-1/4} \qquad 3.25$$

The strong α_S and electromagnetic α_{EM} coupling parameters remain constant in time:

$$\alpha_S = \alpha_{EM} = 1 \qquad 3.26$$

The difference in the strong and the electromagnetic interactions is not in the coupling parameters but in the strength of these interactions depending on the particles involved: electrons with charge e and monopoles with charge $\mu = e/2\alpha$ in electromagnetic and strong interactions respectively.

The super weak coupling parameter α_{SW} and the extremely weak coupling parameter α_{EW} proposed in WUM are decreasing as follows:

$$\alpha_{SW} \propto Q^{-1/2} \propto \tau^{-1/2} \qquad 3.27$$

$$\alpha_{EW} \propto Q^{-3/4} \propto \tau^{-3/4} \qquad 3.28$$

According to WUM, the coupling strength of super-weak interaction is $\sim 10^{-10}$ times weaker than that of weak interaction. The possibility of such ratio of interactions was discussed in the developed theoretical models explaining CP and Strangeness violation [42-45]. Super-weak and Extremely-weak interactions provide an important clue to Physics beyond the Standard Model.

4. Fundamental Parameters and Units

WUM is based on Maxwell's equations (ME) which form the foundation of Electromagnetism and Gravitoelectromagnetism (see Section 5.1). According to ME, there are two measurable physical characteristics: energy density and energy flux density. For all particles under consideration we use four-momentum to conduct statistical analysis of particles' ensembles, obtaining the energy density as the final result. In WUM we introduce the following measurable Fundamental Units:

- The basic unit of momentum $p_0 = h/a$;
- The basic unit of energy density $\rho_0 = hc/a^4$;
- The basic unit of energy flux density $I_0 = hc^2/a^4$.

All physical dimensional parameters of the World can be expressed through the Fundamental Units:

$a = (\frac{p_0 I_0}{\rho_0^2})^{1/3}$ Extrapolated Worlds' radius of curvature at the Beginning

$c = \frac{I_0}{\rho_0}$ Gravitoelectrodynamic constant

$h = p_0 (\frac{p_0 I_0}{\rho_0^2})^{1/3}$ Planck constant

$t_0 = \frac{a}{c} = (\frac{p_0 \rho_0}{I_0^2})^{1/3}$ Basic unit of time

$g_0 = \frac{c^2}{a} = \frac{I_0}{\rho_0} (\frac{I_0^2}{p_0 \rho_0})^{1/3}$ Basic unit of acceleration

$E_0 = \frac{hc}{a} = \frac{p_0 I_0}{\rho_0}$ Basic unit of energy

$m_0 = \frac{h}{ac} = \frac{p_0 \rho_0}{I_0}$ Basic unit of mass

$\sigma_0 = \frac{hc}{a^3} = (p_0 \rho_0 I_0)^{1/3}$ Basic unit of surface energy density

In WUM we often use well-known physical parameters, keeping in mind that all of them can be expressed through the measurable Fundamental Units. Taking the relative values of energy densities, energy flux densities and momenta in terms of the Fundamental Units we can express all physical dimensionless parameters of the World through two Fundamental Parameters α and Q in various rational exponents, as well as small integer numbers and π .

It is the main goal of WUM to develop a Model based on two Fundamental Parameters only: the time-varying parameter Q and the constant α – to describe physical parameters which are constants. The second parameter appears in the Model as the result of the analysis of Intergalactic plasma composed of protons and electrons whose mass m_e equals to: $m_e = \alpha m_0$. Masses of all stable elementary particles of the World can be expressed in terms of m_0 and α (see Sections 6.4, 6.5).

5. Basic Ideas and Evidences of Hypersphere World

In this Section, we review a number of Great Ideas proposed by outstanding Scientists in the past and re-evaluate them with respect to WUM.

5.1. Basic Ideas

WUM is based on Maxwell's equations (ME) which form the foundation of Electromagnetism and Gravitoelectromagnetism (GEM). 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*" [46]. It allows us to use formal analogies between the electromagnetism and relativistic gravity.

Theory of a Rotationally Elastic Medium. Long time ago it was realized that there are no transverse waves in the Aether, and hence the Aether 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 [47]. 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 ME. James McCullagh has this to say about the Medium: "*The constitution of the aether, 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*". WUM is based on Maxwell's equations, and McCullagh's theory is a good fit for description of the Medium. In our opinion, we should review interactions of all objects in the World with the Medium in light of this unique theory.

Hypersphere Universe. In 1854, Georg Riemann proposed the hypersphere as a model of a finite universe [48]. WUM follows the idea of a hypersphere World, albeit proposing that the World is expanding and filled with Medium consisting of stable elementary particles.

4D Space Model. In 1870, William Clifford postulated that matter is nothing, but ripples, hills and bumps of space curved in a higher dimension and the motion of matter is nothing more than variations in that curvature. He speculated that the force of electricity and magnetism is caused by the bending of higher-dimensional space and planned to add gravity to his theory at later date [49]. Hypersphere World – Universe Model follows this idea of the 3D World locally bent in a fourth dimension, albeit introducing the Medium of the World instead of the empty space.

Gravitoelectromagnetism (GEM) refers to a set of formal analogies between the equations for electromagnetism and relativistic gravitation. GEM is an approximation to the Einstein's field equations for General Relativity in the weak field limit. The equations for GEM were first published in 1893 by O. Heaviside as a separate theory expanding Newton's law [50]. WUM follows this theory.

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 aether and the indispensable function it plays in the phenomena are futile and destined to oblivion*". 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.

Dirac Large Number Hypothesis is an observation made by Paul Dirac in 1937 relating ratios of size scales in the Universe to that of force scales. The ratios constitute very large, dimensionless numbers: some 40 orders of magnitude in the present cosmological epoch. According to Dirac's hypothesis, the apparent equivalence of these ratios might not to be a mere coincidence but instead could imply a cosmology with this unusual feature: the strength of gravity, as represented by the gravitational "constant", is inversely proportional to the cosmological time τ : $G \propto \tau^{-1}$ [51]. WUM follows this idea of time-varying G and proposes to introduce a new dimensionless Fundamental Parameter Q that has a value of

$$Q = 0.759972 \times 10^{40} \qquad 5.1$$

in the present cosmological epoch [4].

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"[52]. Paul Dirac in 1974 discussed the continuous creation of matter by the additive mechanism (uniformly throughout space) and the multiplicative mechanism (proportion to the amount of the existing matter) [53]. WUM follows the idea of the continuous creation of matter, albeit introducing a different mechanism of matter creation (see Section 2.1).

Emergent Gravity, Space and Time. 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 [54], [55] 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*" [56].

In WUM Time, Space and Gravitation are emergent phenomena and have no separate existence from Matter; they are closely connected with the parameters of the Medium [4].

5.2. Evidences of the Hypersphere World

The physical laws we observe appear to be independent of the Worlds' curvature in the fourth spatial dimension due to the very small value of the dimension-transposing gravitomagnetic parameter of the Medium [1]. Then direct observation of the Worlds' curvature would appear to be a hopeless goal. One way to prove the existence of the Worlds' curvature 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 curved nature of the World. Unfortunately, the accuracy of the measurements is quite poor. Measurement errors far outweigh any possible "curvature effects", rendering this technique useless in practice. To be conclusive, the measurements would have to be conducted billions of years apart.

"Faint Young Sun" Paradox. Let's consider an effect that has indeed been observed for billions of years, albeit indirectly. Take the so-called "Faint young Sun" paradox that describes the apparent contradiction between observations of liquid water early in Earth's history and the astrophysical expectation that the Suns' output would be only 70 percent as intense during that epoch as it is during the modern epoch. One of the consequences of WUM holds that all stars were fainter in the past. As their cores absorb new dark matter, size of macroobjects cores RMO and their luminosity LMO 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 [2]. Literature commonly refers to the value of 70% [57]. This result supports the notion of physical parameters being indeed dependent on the Worlds' curvature in the fourth dimension.

Cosmological Redshift. Another way to prove the existence of the Worlds' curvature in the fourth spatial dimension is direct measurements of redshifts of galaxies billions of years away from the Earth. In Section 2.4 we found the light travel time distance to a galaxy

$$d = c(\tau_{obsv} - \tau_{emit}) \quad 5.2$$

based on a redshift calculated for the spiral movement of photons in the hypersphere (2.7). We could prove the validity of equation 2.7 and hence the existence of the Worlds' curvature in the fourth spatial dimension if we had an independent way of measuring a distance to a distant Galaxy. There are several ways of measuring distances in the expanding World. The best-known way to trace the evolution of the World observationally is to look into the redshift - luminosity distance relation. The luminosity distance d_L is defined by the relation $d_L^2 = L/4\pi F$, where L is the luminosity of the object and F is the measured flux from the object. For the object whose luminosity is known in some way, we can determine its luminosity distance from the measured flux. Astronomers measure distance in terms of the ``distance modulus'' (m – M), where m is the apparent magnitude of the source and M its absolute magnitude. The distance modulus is related to the luminosity distance via

$$m - M = 5log_{10}[d_L(Mpc)] + 25 \quad 5.3$$

Of course, it is easy to measure the apparent magnitude, but notoriously difficult to infer the absolute magnitude of a distant object. Methods to estimate the relative absolute luminosities of various kinds of objects (such as galaxies with certain characteristics) have been pursued, but most have been plagued by unknown evolutionary effects or simply large random errors [58]. In the last two decades, significant progress has been made by using type Ia supernovae as ``standardizable candles''. Supernovae Ia are bright and seem to be of nearly uniform intrinsic luminosity (absolute magnitude M ~ -19.5). Therefore, they can be detected at high redshifts (z ~ 1), allowing in principle a good handle on cosmological effects [59].

Unfortunately, luminosity distance is not a realistic distance scale. It is useful for determining how faint very distant galaxies appear to us. Hence, we cannot use d_L to validate the equation 2.7 for the cosmological redshift and confirm the curvature of the World in the fourth spatial dimension. From an observational viewpoint, one of the fundamental question of cosmology is measuring cosmological distances and then to build up a suitable and reliable cosmic distance ladder. In our opinion, the redshift is a very important distance indicator, since astronomers can measure it easily, while the size or luminosity of a galaxy needed to compute size or luminosity distance are always very hard to determine.

Fast Radio Bursts. Transient radio sources are difficult to detect but can potentially provide insights into a wide variety of astrophysical phenomena. Of particular interest is the detection of short-duration (about few milliseconds) radio bursts that may be produced by exotic events at cosmological distances such as merging neutron stars [60]. The developed model of Intergalactic plasma (see Section 6.2) can explain the results of observations of Fast Radio Bursts (FRB) which are bright, unresolved, broadband, millisecond flashes found in parts of the sky outside the Milky Way. Astronomers believe that the pulses are emitted simultaneously over a wide range of frequencies. However, as observed on Earth, the components of each pulse emitted at higher radio frequencies arrive before those emitted at lower frequencies. This delay is described by a value referred to as a Dispersion Measure which depends on the number density of electrons integrated along the path traveled by the photon from the source of FRB to the Earth [61], [62].

We propose to calculate a Dispersion Measure based on the electron concentration in the Medium of the World (see 6.2). Then we can measure a distance to the source of FRB by the delay between the components of each pulse emitted at higher and lower radio frequencies and at the same time we can find the cosmological redshift for the same source of FRB. It allows us to validate equation 2.7 for the cosmological redshift and confirm the curvature of the World in the fourth spatial dimension. We emphasize that the described astrophysical phenomenon, Fast Radio Bursts, manifests the existence of the Intergalactic plasma.

Mach's Principle. In WUM, local Physics is linked with the large-scale structure of the Hypersphere World through the dimensionless quantity Q. The proposed approach to the fourth spatial 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 Worlds' curvature in the fourth dimension.

6. Astroparticle Physics

6.1. Basic Unit of Mass

In 1952 Y. Nambu proposed an empirical mass spectrum of elementary particles with a mass unit close to one quarter of the mass of a pion (about $m_0/2 \cong 35\ MeV/c^2$ [63]. He noticed that meson masses are even multiples of a mass unit $m_0/2$, baryon (and also unstable lepton) masses are odd multiplies, and mass differences among similar particles are quantized by $m_0 \cong 70\ MeV/c^2$. During the last 47 years M. Mac Gregor studied this property extensively [64]. In WUM we introduced a basic unit of mass m_0 that equals to

$$m_0 = h/ac = 70.025267\ MeV/c^2 \qquad 6.1$$

6.2. Low Density Plasma.

Mass-Varying Photons. Speed of Light In our Model, the World consists of stable elementary particles with lifetimes longer than the age of the World. Protons and electrons have identical concentrations in the Medium of the World [1]:

$$n_p = n_e = \frac{2\pi^2}{a^3}\frac{m_e}{m_p} \times Q^{-1} = 0.25480\ m^{-3} \qquad 6.2$$

A. Mirizzi, *et al*. found that the mean diffuse intergalactic plasma density is bounded by $n_e \lesssim 0.27\ m^{-3}$ [65] corresponding to the WMAP measurement of the baryon density [66]. The Mediums' plasma density (6.2) is in good agreement with the measured value [65]. The relative energy density of protons in the Medium of the World Ω_p in terms of critical energy density ρ_{cr} :

$$\Omega_p = \rho_p/\rho_{cr} = 2\pi^2\alpha/3 = 0.048014655 \qquad 6.3$$

which depends on the Fundamental Parameter α and is in good agreement with ordinary matters' share in the World $\Omega_p \cong 0.049$ found by Planck Collaboration [67]. Low density intergalactic plasma has plasma frequency ν_{pl} [1]:

$$\nu_{pl} = \frac{c}{a}\left(\frac{m_e}{m_p}\right)^{1/2} \times Q^{-1/2} = 4.5322\ Hz \qquad 6.4$$

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 will name it phion), whose frequency-independent effective "rest mass" m_{phi} equals to [1]:

$$m_{phi} = m_0(\frac{m_e}{m_p})^{1/2} \times Q^{-1/2} = 1.8743 \times 10^{-14}\ eV/c^2 \qquad 6.5$$

The calculated mass of a phion is in agreement with axion mass $m_a{\sim}10^{-15}\ eV/c^2$ discussed by C. Csaki, *et al.* [68] and with experimental checks of Coulomb's law on photon mass m_{ph}. A null result of such an experiment has set a limit of $m_{ph} \lesssim 10^{-14}\ eV/c^2$ [69]. The calculated mass of a phion (6.5) contradicts photon mass $m_{ph} < 10^{-18}\ eV/c^2$ as presented by Particle Data Group [75]. However, the Particle Data Group value seems to contradict the experimental results that measured the Intergalactic plasma concentration $n_e \lesssim 0.27\ m^{-3}$ [65], [66]. In conjunction with a value of a Dispersion Measure which depends on the number density of electrons integrated along the path traveled by the photon from the source of Fast Radio Bursts to the Earth [61], [62] (see Section 5.2), it is unclear how a photon of $m_{ph} < 10^{-18}\ eV/c^2$ mass can propagate through space.

In WUM, the total energy of a moving particle consists of two components: "rest" energy and "coat" energy. A particles' coat is the response of the Medium to the particles' movement. A photon is then a constituent phion with rest energy $E_{phi} = h\nu_{pl}$ and total energy $E_{ph} = h\nu$. In most cases $\nu \gg \nu_{pl}$ and practically all of the photons' energy is concentrated in the phions' coat that is a part of the Medium surrounding the phion. Energy of a phion is decreasing with time: $E_{phi} \propto \tau^{-1/2}$ (6.5), and total energy of a photon remains constant in the ideal 3D Flat Medium [1].

According to WUM, the World is 3D Hypersphere that is curved in the fourth spatial dimension. As we showed in Section 2.4 this macrostructure of the World causes the loss of kinetic energy by photons on their way from galaxies to the Earth and explains the observed redshift. The higher the photons' energy, the closer its speed approaches c. But the fact that phions possess non-zero mass 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. According to WUM, phions are fully characterized by their four-momentum $(\frac{E}{c}, \boldsymbol{p})$ that satisfies the following equation:

$$(\frac{E}{c})^2 - \boldsymbol{p}^2 = Inv = (m_{phi}c)^2 \qquad 6.6$$

where the invariant is, in fact, the gravitoelectrostatic charge $m_{phi}c$ squared, and E is the gravitoelectromagnetic charge [4]. When a gravitoelectrostatic charge of any moving particle equals to momentum p_{DB}, gravitomagnetic flux ϕ_{DB} is

$$\phi_{DB} = h/p_{DB} = \lambda_{DB} \qquad 6.7$$

known as de Broglie wavelength. The notion of "Wavelength" is thus a macroscopic notion, namely, gravitomagnetic flux of particles characterized by four-momentum only. It means that there is no Wave–Particle duality in WUM. Hence wavelength is an emergent phenomenon.

6.3. Mass-Varying Neutrinos

According to WUM, Cosmic Neutrino Background (CNB) consists of three different types of neutrinos: electronic ν_e , muonic ν_μ , tauonic ν_τ , and their antiparticles. Pontecorvo and Smorodinskii discussed the possibility of energy density of neutrinos exceeding that of baryonic matter [70]. Neutrino oscillations imply that neutrinos have non-zero masses. In WUM, neutrino masses are related to and proportional to m_0 multiplied by fundamental parameter $Q^{-1/4}$ and different coefficients that were found in [3]. This assumption follows from the Fermi statistics for neutrinos taking into account that their energy density should be inversely proportional to Q. Neutrinos exist in superposition of the following mass eigenstates predicted by WUM [3]:

$$m_{\nu_e} = \frac{1}{24} m_0 \times Q^{-1/4} = 3.1250 \times 10^{-4}\ eV/c^2 \qquad 6.8$$

$$m_{\nu_\mu} = m_0 \times Q^{-1/4} = 7.4999 \times 10^{-3}\ eV/c^2 \qquad 6.9$$

$$m_{\nu_\tau} = 6 m_0 \times Q^{-1/4} = 4.5000 \times 10^{-2}\ eV/c^2 \qquad 6.10$$

The squared values of the muonic and tauonic masses fall into the ranges of mass splitting Δm_{sol}^2 and Δm_{atm}^2 for solar and atmospheric neutrinos respectively estimated in literature [71], [72]. One of the principal ideas of WUM holds that energy densities of the Worlds' particles are proportional to the proton energy density in the World's Medium (6.3). Therefore, the total neutrinos relative energy density $\Omega_{\nu tot}$ of the CNB in terms of the critical energy density ρ_{cr} equals to [3]:

$$\Omega_{\nu tot} = \frac{45}{\pi} \Omega_p = 30\pi\alpha = 0.68775927 \qquad 6.11$$

The reason to go with a much higher total energy density of neutrinos is to get the total energy density of the World to equal to the critical energy density that provides 3-Manifold in all times. One may wonder – if there are so many neutrinos out there, how come the numerous neutrino detectors do not register them in significant quantities? The answer on this question follows from the calculations of neutrinos energies made in [4]: the 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.

6.4. Cosmic Far-Infrared Background

A cosmic Far-Infrared Background (FIRB), which was announced in January 1998, is the part of the Cosmic Infrared Background with wavelengths near 100 microns that is the peak power wavelength of the black-body radiation at 29 K.

Observations. The FIRB radiation was observed for different galaxies in [18-29], [77-84]. 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 [78]. E. L. Wright in 1999 made the computation of the FIRB and found its total intensity to be about 3.4% of the MBR intensity [80].

Model. According to WUM, the total neutrinos energy density in the World $\Omega_{\nu tot}$ is almost 10 times greater than the total baryonic energy density Ω_B :

$$\Omega_B = 1.5\Omega_p \qquad 6.12$$

At such a high neutrino concentration, "neutrinos pairs" $\nu\bar{\nu}$ (dineutrinos) can be created. Their concentration may indeed be sufficient to undergo Bose-Einstein Condensation (BEC), and as a result create BEC drops. In WUM we introduce a new component of the Medium – BEC drops of dineutrinos whose masses about equal to Planck mass M_P and their temperature is around 29 K. These drops are responsible for the FIRB. The calculated values of the dineutrinos' mass $m_{\nu\bar{\nu}}$ and concentration $n_{\nu\bar{\nu}}$

$$m_{\nu\bar{\nu}} = 0.013161 m_0 \times Q^{-1/4} = 0.987 \times 10^{-4}\ eV/c^2 \qquad 6.13$$

$$n_{\nu\bar{\nu}} = 0.01922 a^{-3} \times Q^{-3/4} = 2.6386 \times 10^9\ m^{-3} \qquad 6.14$$

satisfy the conditions for their Bose-Einstein condensation. Consequently, BEC drops can be created. The stability of such drops is provided by the detailed equilibrium between energy absorption from the Medium provided by dineutrinos and re-emission of this energy in FIRB at the stationary temperature T_{FIRB}. Based on the thermo-equilibrium of BEC drops we calculate the stationary temperature of them [3]: $T_{FIRB} = 28.955\ K$, which is in an excellent agreement with experimentally measured value of $29\ K$ [18-29]. The BEC drops do not absorb and re-emit starlight. Instead, they absorb energy directly from the Medium of the World. 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 [85]. Cosmic FIRB radiation is not a black-body radiation. Otherwise, its energy density ρ_{FIRB} at temperature T_{FIRB} would equal to the energy density of the Medium ρ_M:

$$\rho_{FIRB} = \frac{8\pi^5}{15}\frac{k_B^4}{(hc)^3}T_{FIRB}^4 = \frac{2}{3}\rho_{cr} = \rho_M \qquad 6.15$$

The total flux of the FIRB radiation is the sum of the contributions of all individual BEC drops. In our opinion, BEC drops with mass around M_P are the smallest building blocks of all macroobjects.

Energy Density of Dineutrinos, FIRB and the World. Our Model holds that the energy densities of all types of Dark Matter particles (DMP) are proportional to the proton energy density in the World's Medium (6.3). In all, there are 5 different types of DMPs [2] (see Section 6.5). Then the total energy density of Dark Matter (DM) Ω_{DM} is

$$\Omega_{DM} = 5\Omega_p \qquad 6.16$$

The total electron energy density Ω_{etot} is:

$$\Omega_{etot} = 1.5\frac{m_e}{m_p}\Omega_p \qquad 6.17$$

The MBR energy density Ω_{MBR} equals to [1]:

$$\Omega_{MBR} = 2\frac{m_e}{m_p}\Omega_p \qquad 6.18$$

We took additional energy density of dineutrinos $\Omega_{\nu\bar{\nu}}$ and FIRB Ω_{FIRB}:

$$\Omega_{\nu\bar{\nu}} = \Omega_{MBR} = 2\frac{m_e}{m_p}\Omega_p \qquad 6.19$$

$$\Omega_{FIRB} = \frac{1}{5\pi}\frac{m_e}{m_p}\Omega_p = \frac{1}{10\pi}\Omega_{MBR} \approx 0.032\Omega_{MBR} \quad 6.20$$

The ratio between FIRB and MBR corresponds to the value of 3.4% calculated by E. L. Wright [80]. Then the energy density of the World ΩW

$$\Omega_W = \left[\frac{13}{2} + \left(\frac{11}{2} + \frac{1}{5\pi}\right)\frac{m_e}{m_p} + \frac{45}{\pi}\right]\Omega_p = 1 \quad 6.21$$

Equation 6.21 contains such exact terms as the result of the Models' predictions and demonstrates consistency of WUM. From 6.21 we can calculate the value of α, using electron-to-proton mass ratio $\frac{m_e}{m_p}$:

$$\frac{1}{\alpha} = \frac{\pi}{15}\left[450 + 65\pi + (55\pi + 2)\frac{m_e}{m_p}\right] = 137.03600 \quad 6.22$$

which is in an excellent agreement with the commonly adopted value of 137.035999074(44). It follows that there exists a direct correlation between constants α and $\frac{m_e}{m_p}$ expressed by equation 6.21. As shown above, $\frac{m_e}{m_p}$ is not an independent constant but is instead derived from α.

6.5. Multi-Component Dark Matter

The main idea of WUM is to build a model based only on two Fundamental Parameters: α – the Fine-structure constant and dimensionless time-varying quantity Q. All constant physical characteristics of the World should be expressed through α. As shown in Section 6.4, the relative energy densities of all stable elementary particles in the World can be expressed through α. Below we assume that masses of DMP also depend on α in various rational exponents. The validity of this assumption will be checked by experimental results of Gamma-Ray Spectra measurements presented in Section 6.9. There are three prominent hypotheses on nonbaryonic DM, namely Hot Dark Matter (HDM), Warm Dark Matter (WDM), and Cold Dark Matter (CDM). In WUM, DM particle masses are proportional to m_0 multiplied by different exponents of α. Consequently, we can predict the masses of various types of DM particles:

CDM particles (fermions Neutralinos and WIMPs):

$$m_N = \alpha^{-2}m_0 = 1.3149950\ TeV/c^2 \quad 6.23$$

$$m_{WIMP} = \alpha^{-1}m_0 = 9.5959823\ GeV/c^2 \quad 6.24$$

DIRACs (bosons):

$$m_{DIRAC} = 2\alpha^0\frac{m_0}{2} = 70.025267\ MeV/c^2 \quad 6.25$$

ELOPs (bosons):

$$m_{ELOP} = 2\alpha^1\frac{m_0}{3} = 340.66606\ keV/c^2 \quad 6.26$$

WDM particles (fermions sterile neutrinos):

$$m_{\nu_s} = \alpha^2 m_0 = 3.7289402\ keV/c^2 \quad 6.27$$

These values fall into the ranges estimated in literature (see [2] and references therein). In all, there are 5 different types of DM particles. Then the total energy density of DM is (see equation 6.3):

$$\Omega_{DM} = 5\Omega_p = 0.24007327 \qquad 6.28$$

which is close to the DM energy density discussed in literature: $\Omega_{DM} = 0.268$ [86]. 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 ≅ 5 [87], [88]. Dark matter can, in principle, be also achieved through extended theories of gravity. It has been shown, for example, that in the framework of R2 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 [89], [90]. The signatures of DM particles annihilation with predicted 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 6.9).

6.6. Macroobjects Cores Built up from Fermionic Dark Matter

The theory of Fermionic Compact Stars (FCS) made up of DMP is well developed in WUM. Scaling solutions are derived for free and an interacting Fermi gas [2]. In addition to fermions (Neutralinos, WIMPs and sterile neutrinos) WUM offers another type of DMP – bosons, consisting of two fermions each. There are two types of DM bosons: DIRACs possessing mass of $m_0 \cong 70\ MeV/c^2$ that are in fact magnetic dipoles, and ELOPs having mass of $\frac{2}{3}m_e$ – preon dipoles. 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 and/or at high temperatures, with subsequent dissociation of dipoles to monopoles and preons. DIRAC breaks into two Dirac's monopoles with mass about $m_0/2$ and charges $\mu = e/2\alpha$. ELOP breaks into two preons with mass about $m_{pr} = \frac{1}{3}m_e$ and charges $e_{pr} = \frac{1}{3}e$ which we took to match the Quark Model. The calculated parameters of FCS show that [2]:

- White Dwarf Shells (WDS) around the nuclei made of strongly interacting WIMPs or Neutralinos compose cores of stars and planets in extrasolar systems;
- Shells of dissociated DIRACs to Dirac's 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.

FCS made up of heavier particles – WIMPs and Neutralinos – could in principle have a density that is much higher than nuclear density. In order for such a star to remain stable and not exceed the nuclear density, WIMPs and Neutralinos must be Majorana fermions and partake in an annihilation interaction. According to WUM the maximum density of neutron stars equals to the nuclear density

$$\rho_{max} = \left(\frac{m_p}{m_0}\right)^4 \rho_0 \qquad 6.29$$

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

Fermionic Compact Stars have the following properties [2]:

- The maximum potential of interaction U_{max} between any object and FCS made up of any fermions with maximum mass M_{max}

$$U_{max} = \frac{GM_{max}}{R_{min}} = \frac{c^2}{6} \quad 6.30$$

  does not depend on the nature of the fermion;

- The minimum radius of FCS made of any fermion

$$R_{min} = 3R_{SH} \quad 6.31$$

  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 $R_{min} \propto \tau^{1/2}$.

Boson stars made up of bosonic DM are discussed in literature (see, for example, the paper by J. Ho, *et al.* [91]) as an alternative to black holes. Phions with mass m_{phi} introduced in Section 6.2. are good candidates for such compact macroobjects. We calculate maximum mass M_{Bmax}, minimum radius R_{Bmin}, and maximum density ρ_{Bmax} for boson stars made of phions:

$$M_{Bmax} \sim \frac{M_P^2}{m_{phi}} = 4\left(\frac{m_p}{m_e}\right)^{1/2} m_0 \times Q^{3/2} \quad 6.32$$

$$R_{Bmin} \sim \frac{h}{m_{phi}c} \propto Q^{1/2} \quad 6.33$$

$$\rho_{Bmax} \sim \frac{m_e}{m_p}\rho_0 \quad 6.34$$

These boson stars are good candidates for the cores of star clusters. They have a constant density in time, similar to fermionic compact stars.

To summarize:

- Macroobjects of the World have cores made up of DM particles.
- The cores are surrounded by shells which consist of DM and baryonic matter.
- No compact stars are made up solely of DM fermionic particles, for instance.

6.7. Stars and Planets

The proposed DM annihilation mechanism in the cores of stars and planets (see Section 6.6) can explain the mysteries of Sun's interior [92] and Jupiter's atmosphere high temperature [93]. Theoretical models of the Sun's interior explain the very low power production density produced by fusion inside of the Sun. The calculations give a power density of approximately 276.5 W/m^3 [92], a value that more nearly approximates reptile metabolism than a thermonuclear bomb. The developed star model [2] explains the very low power production density produced by fusion inside of the Sun the following way: white dwarf shells (WDS) around the nuclei made of strongly interacting neutralinos compose cores of main-sequence stars, like Sun. The fermions, however, have drastically different interaction strength: $\frac{m_N}{m_0} = \alpha^{-2} \approx 18{,}780$ in case of neutralinos annihilation and $\frac{m_p}{m_0} \approx 13.4$ in case of the proton-proton chain reaction. The nucleus 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. New neutralinos freely penetrate through the entire stellar envelope, get absorbed into the core and support neutralino annihilation and proton fusion in the WDS.

Giant planets like Jupiter are measured to be hundreds of degrees warmer than current temperature models predict. Before now, the extremely warm temperatures observed in Jupiter's atmosphere (about 970 degrees C [93]) have been difficult to explain, due to the lack of a known heat source. Previous heat-distribution models suggested that Jupiter's atmosphere should be much cooler, largely because the planet is about fives time further from the Sun than Earth is. WUM gives the following explanation: the heat source of the Jupiter's atmosphere is the core of the planet made up of DMP (neutralinos) which take part in an annihilation process. The amount of energy produced due to this process is sufficiently high to heat up the atmosphere. New DMP freely penetrate through the entire planet envelope, get absorbed into the core and support neutralino annihilation continuously. Planetary cores are reactors fueled by DMP.

In our opinion, all chemical elements, compositions, substances, rocks, etc. are produced by the planets themselves as the result of DMP annihilation. Huge amount of experimental results obtained up to now for planets in our Solar system far away from the Sun proves this approach. The "DMP Reactor" inside of all planets (including Earth) is very efficient to provide enough energy for all geological processes on planets like volcanos, quakes, mountains' formation through tectonic forces or volcanism, tectonic plates' movements, etc. All round objects in hydrostatic equilibrium, down to Mimas in Solar system, should be considered Planets.

6.8. Planck Mass

Recall Dirac's quantization condition:

$$\frac{e\mu}{4\pi\varepsilon_0} = n\frac{hc}{4\pi} \qquad 6.35$$

where n is an integer, ε_0 is the electric constant, 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:

$$\frac{mM}{4\pi\varepsilon_g} = GmM = \frac{hc}{2\pi}\frac{mM}{M_P^2} = n\frac{hc}{4\pi} \qquad 6.36$$

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

$$mM = \frac{1}{2}M_P^2 = 2m_0^2 \times Q = 2.36851 \times 10^{-16}\ kg^2 \qquad 6.37$$

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. Incidentally, in his "Interpreting the Planck mass" paper, B. Hammel showed that the Plank mass is *a lower bound on the regime of validity of General Relativity* [94].

It is important to note that Planck mass in different rational exponents plays the decisive role in Macroobjects of the World:

- Total mass of the World M_W

$$M_W = \frac{3\pi^2}{8}\frac{M_P^4}{m_0^3} \qquad 6.38$$

- Maximum mass of Fermionic Compact Star M_{FCS}

$$M_{FCS} = \frac{\pi}{6}\frac{M_P^3}{m_0^2} \qquad 6.39$$

- Maximum mass of Boson Star M_{BS} made of bosons with mass m_b

$$M_{BS} \sim \frac{M_P^2}{m_b} \qquad 6.40$$

- Mass of BEC drops M_{BEC}

$$M_{BEC} \sim M_P \qquad 6.41$$

In our opinion, BEC drops with masses around M_P are the smallest building blocks that participate in extrasolar systems creation [3].

6.9. 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 DM searches with astroparticle data (see reviews [95-104] 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 with cores built up from fermionic DMP [2] (see Section 6.6). Recall that no Macroobjects (MO) are made up of just a single type of DM particles, since other DMP as well as baryonic matter are present in the shells. It follows that MO 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 MO structure. The models of DM annihilation and decay for various types of MO (galaxy clusters, blazars, quasars, Seyfert galaxies) are well-developed. Physicists working in the field of X-ray and gamma-ray astronomy attempt to determine masses of DM particles that would fit the experimental results with the developed models.

WUM predicts 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, while recognizing that all evidences for DM annihilation at the energies corresponding to the masses of the DMP are based on tentative interpretations. We connect gamma-ray spectra with the structure of MO (core and shells composition).

Neutralino 1.3 TeV. A detailed global analysis on the interpretation of the data of PAMELA, Fermi-LAT, AMS-02, H.E.S.S, and other collaborations in terms of DM annihilation and decay in various propagation models [105-115] showed that for the Fermi-LAT and H.E.S.S. data favor the DM particle mass $m_{\chi} \approx 1.3\, TeV$ [112-115]. The mass of the annihilating DM serves as a cutoff scale of the $e^{\pm}$ spectrum. The lepton spectra must have a cutoff energy at the DMP mass m_{χ}. The found value of DMP mass [112-115] equals to the Neutralino mass in WUM. The data obtained in [116-124] require DMP mass to be around 1 to 1.5 TeV which is in good agreement with the predicted mass of a Neutralino. According to A. A. Abdo, *et al.* pulsars are the most natural candidates for such Very High Energy (VHE) gamma-ray sources.

In frames of 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 [2]. It follows that pulsars might be in fact rotating Neutralino stars or 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 DM particles: 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 WUM.

In our opinion, results obtained by the CALET program are the closest to the ultimate discovery of the first confirmed DMP - Neutralino. In December 2015 China started a new DAMPE program to collect more data with significantly better accuracy. We expect them to prove the existence of Neutralinos.

WIMP 9.6 GeV. In his review, Dan Hooper summarized and discussed the body of evidence which has accumulated in favor of DM in the form of approximately 10 GeV particles [125]. Together with Lisa Goodenough he estimated Dark Matter annihilation in the Galactic Center and found that it fits into 7-10 GeV range [126]. EGRET data on diffuse gamma-ray background show visible peaks around 70 MeV and 10 GeV. The last peak is consistent with annihilation of WIMPs. 70 MeV peak corresponds to annihilation of DIRACs (see below). 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*" [127]. 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 [128], [129].

WUM proposes that cores of blazars are composed of annihilating WIMPs, explaining why no observed radiation extends above 10 GeV. 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.

DIRAC 70 MeV. C. Boehm, P. Fayet, and J. Silk propose a way "*to reconcile the low and high energy signatures in gamma-ray spectra, 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 [131]), and the other one a possibly light spin-0 particle (~ 100 MeV [100]). Both of them would be neutral and also stable as a result of two discrete symmetries (say R and M-parities)*" [130].

According to WUM, the two coannihilating DMP are

- Neutralino (1.3 TeV) – a heavy fermion, and
- DIRAC (70 MeV) – a light spin-0 boson.

Above we discussed the observations of gamma rays in the very high-energy ($>$ 100 GeV) domain [112-124] which are consistent with self-annihilating Neutralino. 70 MeV peak in EGRET data is discussed by S. D. Hunter, *et al.* [132] and by Golubkov and Khlopov [133]. They explain this peak by the decay of π^0-mesons, produced in nuclear reactions. B. Wolfe, *et al.* say that gamma rays at 70 MeV are notably detectable by GLAST and EGRET [134].

R. Yamazaki, *et al.* attribute the 70 MeV peak in the emission spectrum from an old supernova remnant to π^0-decay too [135]. Note that whenever the 70 MeV peak appears in gamma-ray spectra, it is always attributed to pion decay. We claim that π0 decay produces a 67.5 MeV peak, while DIRAC annihilation is responsible for 70 MeV peak. Observation of the two distinct peaks is complicated by the broadness of the observed "pion bump". 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 [136-141]. Note that the mass of DIRAC proposed by WUM – $0.07\ GeV/c^2$ – falls into the mass range of U boson: $M_U = 0.02 - 0.1\ GeV/c^2$.

ELOP 340 keV. An ELOP is a spin-0 boson with 340 keV mass. In our view, there are another two coannihilating DMP at play:

- WIMP (9.6 GeV) – a heavy fermion, and
- ELOP (340 keV) – a light spin-0 boson.

Existence of DMP with mass $m_\chi < 0.42\ MeV$ has been discussed by Y. Rasera, *et al.* [142]. The developed theoretical model is in good agreement with the experimental 100-400 keV "bump" [143] and with annihilating ELOPs with mass 340 keV proposed in WUM. D. E. Gruber, *et al.* describe a wide gamma-ray diapason between 3 keV and 10 GeV as a sum of three power laws: "*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*" [144].

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 $J(E) \propto E^{-\gamma} \exp\{-E/E_{cut}\}$ with the injection 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.

Sterile Neutrino 3.7 keV. The very first signature of the emission around 3.7 keV was found in 1967 by P. Gorenstein, *et al.* [145]. An important result was obtained by S. Safi-Harb and H. Ogelman in

1997. They reported that a broken power-law model gives the best fit to the observations of the X-ray lobes. The power-law indices are 1.9 and 3.6, with the break occurring at 3.7 keV [146]. T. Itoh analyzed the broad-band (3.0–50 keV) spectra of NGC 4388 and found 3.7 keV peak [147]. A. M. Bykov, *et al*. confirm the 3.7 keV peak in the spectra of the supernova remnant IC 443 [148]. R. Fukuoka, *et al.* observed the 3.7 keV peak as well with $\sim 3\sigma$ significance [149]. In 2012, A. Moretti, *et al.* measured the diffuse gamma-ray emission at the deepest level and with the best accuracy available today and found clearly visible emission around 3.7 keV [76].

To summarize:

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 self-interacting 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.

7. World – Universe Model. Principle Points and Predictions

The sciences do not try to explain, they hardly even try to interpret, they mainly make models. By a model is meant a mathematical construct, which, with addition of certain verbal interpretations describes observed phenomena. The justification of such a mathematical construct is solely and precisely that it is expected to work. John von Newmann

7.1. Principle Points

WUM is based on the following Principle Points:

- The World was started by a fluctuation in the Eternal Universe, and the Nucleus of the World, which is a four dimensional 4-ball, was born. The Beginning of the World is a Quantum effect.
- The 3D World is the Hypersphere that is the surface of a 4-ball Nucleus. Hence the World is curved in the fourth spatial dimension.
- The 4-ball is expanding in the Eternal Universe, and its surface, the hypersphere, is likewise expanding so that the radius of the 4-ball R is increasing with speed c that is the gravitoelectrodynamic constant.
- The World consists of the Medium and Macroobjects. The Medium consists of stable elementary particles with lifetimes longer than the age of the World: protons, electrons, photons, neutrinos, and dark matter particles. The Medium is not Aether; it is a mixture of gases composed of elementary particles. The energy density of the Medium is 2/3 of the total energy density in all cosmological times.
- Galaxy clusters, Galaxies, Star clusters, Extrasolar systems, Planets, etc. are made of these particles. The energy density of Macroobjects is 1/3 of the total energy density in all cosmological times. There are no empty space and dark energy in WUM. There is no

accelerated expansion of galaxies. Experimental observations measuring light from supernovae Ia are explained by nonlinear dependence of a distance from a redshift.

- Time, Space and Gravitation are emergent phenomena and have no separate existence from Matter. In WUM, they are closely connected with the Impedance and the Gravitomagnetic parameter of the Medium.
- 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 Worlds' curvature in the fourth spatial dimension.
- WUM holds that there exist relations between all Q-dependent parameters: Newtonian parameter of gravitation and Hubble's parameter; Critical energy density and Fermi coupling parameter; Temperatures of the Microwave Background Radiation and Far-Infrared Background Radiation peak. The calculated values of these parameters are in good agreement with the latest results of their measurements. Model proposes to introduce a new fundamental quantity Q in the CODATA internationally recommended values for calculating all Q-dependent parameters of the World.
- The black-body spectrum of the cosmic Microwave Background Radiation is due to thermodynamic equilibrium of photons with low density Intergalactic Plasma.
- The Far-Infrared Background Radiation is due to the emission of BEC drops created as the result of the Bose-Einstein Condensation (BEC) of Dineutrinos. The BEC drops do not absorb and re-emit starlight. Instead, they absorb energy directly from the Medium of the World provided by dineutrinos and re-emit this energy in FIRB at the stationary temperature T_{FIRB}.
- Model proposes new types of particle interactions (Super Weak and Extremely Weak) with coupling strength $\sim 10^{-10}$ and $\sim 10^{-20}$ times weaker than that of weak interaction.
- Cosmic Neutrino Background consisting of electronic, muonic and tauonic neutrinos has the relative energy density of about 69%.
- Dark Matter (DM) consists of 5 different particles: Neutralinos, WIMPs, DIRACs, ELOPs, and sterile neutrinos and has the relative energy density of about 24%.
- All Macroobjects of the World (galaxy clusters, galaxies, star clusters, extrasolar systems, and planets) possess the following properties: their Cores are made up of DM particles; they contain other particles, including DM and baryonic matter, in shells surrounding the Cores. Annihilation of DMP can give rise to any combination of gamma-ray lines.
- 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.
- Nucleosynthesis of all elements occurs inside stars during their evolution. Stellar nucleosynthesis theory should be enhanced to account for annihilation of heavy DM particles (WIMPs and Neutralinos) inside of the Stars' Cores.
- Macroobjects form from top (the World) down to extrasolar systems in parallel around different Cores made of different DM particles. Formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing.
- Assuming an Eternal 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.

7.2. Predictions

WUM makes the following predictions, which we hope will be supported by experimental data in the near future:

- All Macroobjects of the World (galaxy clusters, galaxies, star clusters, extrasolar systems, and planets) possess Cores that are made up of DM particles. All round objects in hydrostatic equilibrium, down to Mimas in Solar system, should be considered Planets.
- WUM predicts existence of DM particles with 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV masses. Results obtained by the CALET program are the closest to the ultimate discovery of the first confirmed DM particle – Neutralino with mass 1.3 TeV. In December 2015 China started a new DAMPE program to collect more data with significantly better accuracy. We expect them to prove the existence of Neutralinos.
- Model makes predictions pertaining to neutrinos mass eigenstates and photons rest mass:

  $m_{\nu_e} = 3.1250 \times 10^{-4}\ eV/c^2$; $m_{\nu_\mu} = 7.4999 \times 10^{-3}\ eV/c^2$; $m_{\nu_\tau} = 4.5000 \times 10^{-2}\ eV/c^2$ $m_{phi} = 1.8743 \times 10^{-14}\ eV/c^2$ respectively.
- WUM predicts the concentration of Intergalactic plasma: $n_p = n_e = 0.2548$.

The World – Universe Model successfully describes primary parameters and their relationships, ranging in scale from cosmological structures to elementary particles. WUM allows for precise calculation of values that were only measured experimentally earlier and makes verifiable predictions.

WUM does not attempt to explain all available cosmological data, as that is an impossible feat for any one manuscript. Nor does WUM pretend to have built an all-encompassing theory that can be accepted as is. The Model needs significant further elaboration, but in its present shape, it can already serve as a basis for a new Physics proposed by Paul Dirac in 1937. The Model should be developed into the well-elaborated theory by all physical community.

Acknowledgements

I am grateful to the anonymous referee for valuable comments and important remarks that helped me to improve the understanding of the Model. Special thanks to my son Ilya Netchitailo who proposed the idea of cosmological redshift, questioned every aspect of the paper and helped shape it to its present form.

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Burst Astrophysics

Abstract

This article proposes an explanation for Fast Radio Bursts (FRBs) and Gamma Ray Bursts (GRBs) through the frames of Hypersphere World – Universe Model (WUM). WUM predicts that the concentration of protons and electrons in Intergalactic Plasma decreases inversely proportional to time and in present epoch equals to $\mathbf{0.25480}\ \boldsymbol{m^{-3}}$. The energy density of Intergalactic Plasma relative to the critical energy density equals to $\boldsymbol{\Omega_p} \approx \mathbf{0.048}$. Time delay of FRBs is calculated through these characteristics. A number of experimental results, including the redshift for FRB 150418, remarkable brightness for FRB 150807, and transient gamma-ray counterpart for FRB 131104 are explained. The distance to FRB 150807 object is predicted to be $\sim$ 800 Mpc. WUM holds that all Macroobjects (galaxies, stars, and planets) contain a Core composed of Dark Matter Particles. GRBs are explained as a sum of contributions of multicomponent dark matter annihilation. The spectra of such bursts depend on the composition of the Cores.

Keywords. “Hypersphere World – Universe Model”; “Medium of the World”; “Intergalactic Plasma”; “Macroobjects Structure”; “Dark Matter Particles”; “Gamma-Ray Bursts”; “Fast Radio Bursts”; “ FRB Time Delay”

1. Introduction

Fast Radio Bursts (FRBs) are millisecond-duration radio signals originating from distant galaxies that have been discovered in recent years. These signals are dispersed in the Medium of the World. Together with redshift measurements, this dispersion can be used for fundamental physical investigations of Intergalactic Plasma.

There exists a close parallel between FRBs and Gamma Ray Bursts (GRBs). Both manifest themselves as mysterious flashes of energy that were quite challenging to study due to their short durations. Once the technology has advanced to allow rapid follow-up observations, both were found to have afterglows. The characteristics of the afterglows suggest that FRBs and GRBs may have something in common; furthermore, they may indeed be different flavors of the same event.

In Section 2 we present a short summary of experimental results and existent theoretical models in the field of Burst Astrophysics partially adapted from Wikipedia. In Section 3 we propose a new physical approach to FRBs and GRBs based on Hypersphere World – Universe Model (WUM). In section 4 we calculate FRB time delay based on the predicted parameters of Intergalactic Plasma.

2. Burst Astrophysics. Short Summary

Wikipedia has this to say about Burst Astrophysics:

Gamma-ray bursts *(GRBs) are extremely energetic explosions that have been observed in distant galaxies. They are the brightest electromagnetic events known to occur in the World [1]. Bursts can* *last from ten milliseconds to several hours [2], [3]. GRB 111209A is the longest lasting gamma-ray burst (GRB) detected by the Swift Gamma-Ray Burst Mission on December 9, 2011. Its duration is longer than 7 hours* [2].

After an initial flash of gamma rays, a longer-lived "afterglow" is usually emitted at longer wavelengths (X-ray, ultraviolet, optical, infrared, microwave and radio) [4]. GRBs were first detected in 1967. Following their discovery, hundreds of theoretical models were proposed to explain these bursts. Little information was available to verify these models until the 1997 detection of the first X-ray and optical afterglows and direct measurement of their redshifts. The true nature of these objects remains unknown, although the leading hypothesis is that they originate from the mergers of binary neutron stars or a neutron star with a black hole [5].

The means by which gamma-ray bursts convert energy into radiation remains poorly understood [6]. Any successful model of GRB emission must explain the physical process for generating gamma-ray emission that matches the observed diversity of light curves, spectra, and other characteristics [7]. Particularly challenging is the need to explain the very high efficiencies that are inferred from some explosions: some gamma-ray bursts may convert as much as half (or more) of the explosion energy into gamma-rays [8]. Early observations of the bright optical counterparts to GRB 990123 and to GRB 080319B [9], [10], have suggested that inverse Compton may be the dominant process in some events. In this model, pre-existing low-energy photons are scattered by relativistic electrons within the explosion, augmenting their energy by a large factor and transforming them into gamma-rays [11]. There is no theory that has successfully described the spectrum of all gamma-ray bursts [Gamma-ray burst].

Fast Radio Burst *(FRB) is a high-energy astrophysical phenomenon manifested as a transient radio pulse lasting only a few milliseconds. These are bright, unresolved, broadband, millisecond flashes found in parts of the sky outside the Milky Way. The component frequencies of each burst are delayed by different amounts of time depending on the wavelength. This delay is described by a value referred to as a Dispersion Measure (DM) which is the total column density of free electrons between the observer and the source of FRB. Fast radio bursts have DMs which are: much larger than expected for a source inside the Milky Way [12]; and consistent with propagation through ionized plasma [13].*

The first FRB found was FRB 010621. The Lorimer Burst (FRB 010724) was discovered in archived data taken in 2001 by the Parkes radio dish in Australia. The fact that no further bursts were seen in 90 hours of additional observations implies that it was a singular event such as a supernova or merger of relativistic objects [13]. On 19 January 2015, astronomers from Parkes observatory reported that FRB 140514 had been observed for the first time live [14].

In 2007, just after the publication of the e-print with the first discovery, it was proposed that fast radio bursts could be related to hyperflares of magnetars [15]. In 2015 three studies supported the magnetar hypothesis [12], [16], [17]. In 2014 it was suggested that following dark matter-induced collapse of pulsars [18], the resulting expulsion of the pulsar magnetospheres could be the source of fast radio bursts [19].

On 18 April 2015, FRB 150418 was detected by the Parkes observatory and within hours, several telescopes including the Australia Telescope Compact Array caught an "afterglow" of the flash, which took six days to fade [20]. The Subaru telescope was used to find what was thought to be the host *galaxy and determine its redshift and the implied distance to the burst [21]. However, the origin of the burst was soon disputed by P. K. G. Williams and E. Berger who claim that the emission instead originates from an active galactic nucleus that is powered by a supermassive black hole with dual jets blasting outward from the black hole [22]. It was also noted that what was thought to be an "afterglow", never goes away, meaning that it cannot be associated with the fast radio burst [23]* [Fast radio burst]. We will discuss FRB 150418 in Section 4.

On August 2015, FRB 150807 of remarkable brightness was detected by the Parkes observatory. Astronomers report on a mildly dispersed (DM 266.5±0.1 pc cm-3), exceptionally intense (120±30 Jy), linearly polarized, scintillating burst that was directly localized to 9 arcmin². The burst scintillation suggests weak turbulence in the ionized intergalactic medium. The localization of FRB 150807 can be used to estimate the distance at which it was emitted, if it can associated with a star or a galaxy [24]. We will discuss FRB 150807 in Section 4.

The most intriguing result was obtained by J. J. DeLaunay, *et al.* [25]. They report the discovery of a transient gamma-ray counterpart to the fast radio burst FRB 131104, the first such counterpart to any FRB. The transient counterpart has duration $T_{90} \gtrsim 100\, s$ and fluence $S_\gamma \approx 4 \times 10^{-6}\, erg\, cm^{-2}$ (15–150 keV), increasing the energy budget for this event by more than a billion times; at the nominal z ≈ 0.55 redshift implied by its dispersion measure, the burst's gamma-ray energy output is $E_\gamma \approx 5 \times 10^{51}\, erg$. We will discuss this astronomical event in Section 3.

The discovery that some FRBs are accompanied by energetic gamma-ray transients dramatically alters the basic picture of these events. They have modest energy in radio flash ($E_{radio} \sim 4 \times 10^{41}\, erg$ in case of FRB 131104) in comparison with gamma-ray energy that is more than 10^9 times greater, with dramatic implications for source models and a substantial improvement in the prospects for long-lived counterparts, including X-ray and radio afterglows [25].

3. Hypersphere World-Universe Model

Hypersphere World – Universe Model (WUM) discusses the possibility of all Macroobject cores to be composed of Dark Matter Particles (DMP) with predicted masses of 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV. The energy density of all macroobjects in the World Ω_{MO} relative to the critical energy density is $\Omega_{MO} \approx 0.024$ [26].

One of the most important DMP for galaxies is spin-0 boson which we dubbed ELOP that is preon dipole with mass 340 keV [27]. Dissociated ELOPs can only exist at nuclear density or at high temperatures. ELOP breaks into two preons with mass about $m_{pr} = \frac{1}{3} m_e \cong 170\, keV/c^2$ and charges $e_{pr} = \frac{1}{3} e$ which we took to match the Quark Model (m_e and e are mass and charge of electrons). In particle physics, preons are postulated to be "point-like" particles, conceived to be subcomponents of quarks and leptons [28]. ELOPs are analogous to electron-positron pairs with charge $\frac{1}{3} e$.

In addition to ELOP discussed above, we offer another type of DMP – spin-0 boson which we dubbed DIRAC that is in fact magnetic dipole with mass 70 MeV [27]. Dissociated DIRACs can only exist at nuclear densities or at high temperatures. A DIRAC breaks into two Dirac monopoles with mass $\frac{m_e}{2\alpha} \cong 35\, MeV/c^2$ and charge $\mu = \frac{e}{2\alpha}$ (α is fine-structure constant).

In WUM we derive scaling solutions for a free and an interacting Fermi gas. The numerical values for maximum energy of the galaxies' shell made up of preons and monopoles in the present epoch are: $E_{pr} \approx 5.3 \times 10^{54}\, J$ and $E_{mon} \approx 1.3 \times 10^{50}\, J$ respectively [27].

According to WUM cores and shells of all macroobjects are growing in time until they reach the critical stability, at which point they detonate. The energy released during detonation is produced by annihilation of DMP. The detonation process does not destroy the macroobject; it's rather analogous to Solar flares.

In frames of WUM the experimental results for Gamma-Ray Bursts are explained thusly:

- The nature of these objects – cores and shells of galaxies made up from DMP;
- The means by which bursts convert energy into radiation – the annihilation of DMP;
- The very high efficiencies that are inferred from some explosions;
- The burst's gamma-ray energy output $E_\gamma \approx 5 \times 10^{44}\, J$ [25] that is 10 orders of magnitude smaller than the maximum energy of preons' shell $E_{pr} \approx 5.3 \times 10^{54}\, J$ [27];
- The spectrum of all gamma-ray bursts can be explained by the composition of cores and shells made up from DMP;
- A longer-lived "afterglow" that is usually emitted at longer wavelengths (X-ray, ultraviolet, optical, infrared, microwave and radio) is a result of long-lived processes developing in the cores and shells after detonation.

The duration of ultra-long gamma-ray burst 111209A is longer than 7 hours, implying this event has a different kind of progenitor than normal long GRBs. According to the authors of paper [2]: *The host galaxy of GRB 111209A has not been resolved by the Hubble Space Telescope: only the GRB afterglow was visible, and GRB 111209A traces the location of a putative (very) metal poor galaxy at large distance (z=0.677). At this distance, this galaxy would not have been detected without the GRB which occurred in it*.

A. J. Levan, *et al.* have this to say about ultra-long duration gamma-ray bursts: *The long durations may naturally be explained by the engine driven explosions of stars of much larger radii than normally considered for GRB progenitors which are thought to have compact Wolf-Rayet progenitor stars* [29]. It was first proposed that the progenitor of this event was a blue supergiant star with low metallicity [2].

In frames of WUM, this event can be explained by the galaxies' shell made up of monopoles:

- The burst's gamma-ray isotropic energy for GRB 111209A $\mathrm{E_{iso}} \approx 5.8 \times 10^{46}\ \mathrm{J}$ [2] is about 2200 times less than the maximum energy of monopoles' shell $E_{mon} \approx 1.3 \times 10^{50}\, J$ [27]. *This scenario is favored because of the necessity to supply enough mass to the central engine over duration of thousands of seconds* [2];
- Gamma rays with energy in the range 20 keV $<$ E $<$ 1400 keV [3] are a consequence of monopoles and preons' annihilation.

The described picture is consistent with experimental results for Fast Radio Bursts:

- the observations that sources of FRB are old galaxies;

- FRBs are the result of preons' plasma instability triggering shock waves of gigantic electrical currents and generating a huge amount of energy in transient radio pulses lasting only a few milliseconds;
- All other DMP can start annihilation process as the result of preons' shell instability and give rise to the gamma-radiation with different emission lines in spectra of galaxies.
- Gamma rays with energy less than 170 keV are a consequence of preons' annihilation.

In our opinion, the annihilation of DMP is the most probable process that can generate huge amounts of energy in a very short time. The described galaxies bursts are analogous to the solar bursts which are bright emissions of photons with energies in excess of 100 MeV [30].

4. Fast Radio Bursts

One of the most important parts of the Medium is Intergalactic Plasma with the concentration of protons and electrons that is decreasing inversely proportional to time. It has the energy density Ω_p relative to the critical energy density $\Omega_p \approx 0.048$ in the present epoch. In this Section we calculate a time delay of FRB based on these characteristics of the Intergalactic Plasma.

In our Model, protons and electrons have identical concentrations in the Medium of the World [26]:

$$n_p = n_e = \frac{2\pi^2}{a^3}\frac{m_e}{m_p} \times Q^{-1} = 0.25480\ m^{-3} \qquad 4.1$$

where $a = 2\pi a_0$, a_0 being the classical electron radius and Q is a dimensionless time-varying fundamental parameter which equals to: $Q = 0.759972 \times 10^{40}$ in present epoch [26].

A. Mirizzi, *et al.* found that the mean diffuse intergalactic plasma density is bounded by $n_e \lesssim 0.27\ m^{-3}$ [31] corresponding to the WMAP measurement of the baryon density [32]. The Mediums' plasma density (4.1) is in good agreement with the estimated value [31].

Low density intergalactic plasma has plasma frequency ν_{pl} [26]:

$$\nu_{pl} = \frac{c}{a}(\frac{m_e}{m_p})^{1/2} \times Q^{-1/2} = 4.5322\ Hz \qquad 4.2$$

where c is the electrodynamic constant in Maxwell's equations. Photons with energy smaller than $E = h\nu_{pl}$ 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 will name it phion), whose frequency-independent effective "rest energy" E_{phi} equals to [26]:

$$E_{phi} = E_0\left(\frac{m_e}{m_p}\right)^{1/2} \times Q^{-1/2} = 1.8743 \times 10^{-14}\ eV \qquad 4.3$$

where E_0 is the fundamental unit of energy: $E_0 = hc/a$ and h is Planck constant. In WUM, a photon is a constituent phion with rest energy $E_{phi} = h\nu_{pl}$ and total energy $E = h\nu$ ($\nu \gg \nu_{pl}$).

According to WUM, phions are fully characterized by their four-momentum $\left(\frac{E}{c}, \boldsymbol{p}\right)$ that satisfies the following equation:

$$(\frac{E}{c})^2 - \boldsymbol{p}^2 = Inv = (p_{phi})^2 \qquad 4.4$$

where the invariant is, in fact, the gravitoelectrostatic charge p_{phi} squared, and E is the gravitoelectromagnetic charge [26]. Phions are moving in the Medium of the World with a group velocity v_{gr} which can be found from (4.4):

$$\frac{v_{gr}^2}{c^2} = 1 - \frac{E_{phi}^2}{E^2} \quad 4.5$$

Consider a photon with initial frequency ν_{emit} and energy E_{emit} emitted at time τ_{emit} when the Radius of the hypersphere World in the fourth spatial dimension was R_{emit} . The photon is continuously losing kinetic energy as it moves from galaxy to the Earth until time τ_{obsv} when the Radius is $R_{obsv} = R_0$. The observer will measure ν_{obsv} and energy E_{obsv} and calculate a redshift:

$$1 + \mathrm{z} = \frac{\nu_{emit}}{\nu_{obsv}} = \frac{E_{emit}}{E_{obsv}} \quad 4.6$$

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 light travel time distance to a galaxy d_{LLT} equals to

$$d_{LTT} = c(\tau_{obsv} - \tau_{emit}) = ct_{LTT} = R_0 - R_{emit} \quad 4.7$$

Let's calculate photons' traveling time t_{ph} from galaxy to the Earth taking into account that $E_{phi} \ll E$:

$$t_{ph} = \frac{1}{c}\int_{R_{emit}}^{R_0} \frac{dr}{\sqrt{1-\frac{E_{phi}^2}{E^2}}} = t_{LTT} + \Delta t_{ph} \quad 4.8$$

where Δt_{ph} is photons' time delay relative to the light travel time t_{LLT} that equals to:

$$\Delta t_{ph} = \frac{1}{2c}\int_{R_{emit}}^{R_0} \frac{E_{phi}^2}{E^2} dr \quad 4.9$$

All observed FRBs have redshifts $z < 1$. It means that we can use the Hubble's law: $d_{LTT} = R_0 z$. Then

$$R_{emit} = (1 - z)R_0 \quad 4.10$$

Phions' energy squared at Radius R between R_{emit} and R_0 equals to (4.3):

$$E_{phi}^2 = \frac{m_e}{m_p}\frac{a}{R}E_0^2 \quad 4.11$$

According to WUM, photons' energy on the way from galaxy to an observer can be expressed by the following equation:

$$E = zE_{obsv} + (1 - z)\frac{R_0}{R}E_{obsv} = z\frac{R_0}{R}E_{obsv}\left(\frac{1-z}{z} + \frac{R}{R_0}\right) \quad 4.12$$

which reduces to E_{emit} at (4.10) and to E_{obsv} at $R = R_0$. Placing the values of the parameters (4.10), (4.11), (4.12) into (4.9), we have for photons' time delay:

$$\Delta t_{ph} = \frac{1}{2z^2}\frac{c}{a}\frac{m_e}{m_p}\frac{1}{\nu^2}\int_{1-z}^{1} \frac{xdx}{\left(x+\frac{1-z}{z}\right)^2} = \frac{1}{2z^2}\frac{c}{a}\frac{m_e}{m_p}\frac{1}{\nu^2}\int_{\frac{1-z^2}{z}}^{\frac{1}{z}} \frac{\left(y-\frac{1-z}{z}\right)dy}{y^2} =$$

$$= \frac{1}{2z^2}\left[ln\left(\frac{1}{1-z^2}\right) - \frac{z^2}{1+z}\right]\frac{c}{a}\frac{m_e}{m_p} \times \frac{1}{\nu^2} = \frac{4.61}{z^2}\left[ln\left(\frac{1}{1-z^2}\right) - \frac{z^2}{1+z}\right] \times (\frac{\nu}{1GHz})^{-2} \quad 4.13$$

where $x = R/R_0$ and $y = x + \frac{1-z}{z}$. Taking z=0.492 [33] we get the calculated value of photons' time delay

$$\Delta t_{ph}^{cal} = 2.189 \times (\frac{\nu}{1GHz})^{-2} \quad 4.14$$

which is in a good agreement with experimentally measured value [33]

$$\Delta t_{ph}^{exp} = 2.438 \times (\frac{\nu}{1GHz})^{-2} \quad 4.15$$

The difference between these values is 10.2%. It is worth to note that in our calculations there is no need in a dispersion measure (DM) which is the total column density of free electrons between the observer and the source of FRB.

It is important to note that according to WUM the relative energy density of the Intergalactic plasma is 4.8% that is in a very good agreement with experimentally found value $4.9 \pm 1.3\%$ [33]. The developed analysis based on WUM is consistent with all experimental results obtained by authors of [33].

The line-of-sight free electron column density for FRB 150807, measured in units of DM, is 266.5$\pm$0.1 pc cm-3. This substantially exceeds the expected foreground Milky Way DM, predicted to be 70$\pm$20 pc cm-3 along the burst sightline. According to the authors of paper [24]:

"The localization of FRB 150807 can be used to estimate the distance at which it was emitted, if we can associate the FRB with a star or a galaxy. The deepest archival images of the sky localization area contain nine objects brighter than a Ks-band magnitude of 19.2 (11): three stars and six galaxies. The brightest galaxy is at a distance between 1 and 2 Gpc estimated from its photometric redshift. The other galaxies are factors of >6 fainter than the brightest. Through a comparison of their infrared magnitudes with empirical and theoretical distributions of galaxy luminosities at different distances, they are all expected to be >500 Mpc distant".

In our opinion, based on the equation (4.13) and measured value DM, they should look for an old galaxy (not a star) which has the redshift $z = 0.19 \pm 0.02$ and the distance about 800 Mpc. Hopefully the performed calculations will help astronomers to find the right source of FRB 150807.

Very recently, 16 additional bright bursts in the direction of FRB 121102 were detected (see [34] and references inhere). According to the authors of paper [34]: *This repeating FRB is inconsistent with all of the catastrophic event models put forward previously for hypothetically non-repeating FRBs. Here, we propose a different model, in which highly magnetized pulsars travel through the asteroid belts of other stars.*

In frames of WUM, these repeating FRBs can be explained by the galaxy flares analogous to Solar flares as it is described in Section 3.
Transient Astrophysics is a rapidly growing field, now operating across all wavelengths, observed from the ground and in space. Using multi-wavelength observations allows us to study the various components of the World in extraordinary detail. With the high sensitivity and wide-field coverage

of the Square Kilometre Array, large samples of explosive transients are expected to be discovered [35]. Hypersphere World – Universe Model can serve as a basis for Transient Astrophysics.

Acknowledgements

I thank the anonymous referees for useful comments and suggestions that have led to an overall improvement of the manuscript. Special thanks to my son Ilya Netchitailo who helped shape it to its present form.

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Mathematical Overview of Hypersphere World – Universe Model

Abstract

The Hypersphere World – Universe Model (WUM) provides a mathematical framework that allows calculating the primary cosmological parameters of the World that are in good agreement with the most recent measurements and observations. WUM explains the experimental data accumulated in the field of Cosmology and Astroparticle Physics over the last decades: the age of the World and critical energy density; the gravitational parameter and Hubble's parameter; temperatures of the cosmic microwave background radiation and the peak of the far-infrared background radiation; the concentration of intergalactic plasma and time delay of Fast Radio Bursts. Additionally, the Model makes predictions pertaining to masses of dark matter particles, photons, and neutrinos; proposes new types of particle interactions (Super Weak and Extremely Weak); shows inter-connectivity of primary cosmological parameters of the World. WUM proposes to introduce a new fundamental parameter Q in the CODATA internationally recommended values. This paper is the summary of the mathematical results obtained in [1], [2], [3], [4], [5], [6].

Keywords. "Hypersphere World – Universe Model"; "Primary Cosmological Parameters"; "Medium of the World"; "Macroobjects Structure"; "Gravitoelectromagnetism"; "Dark Matter Particles"; "Intergalactic Plasma"; "Microwave Background Radiation"; "Far-Infrared Background Radiation"; "Fast Radio Bursts", "Emergent Phenomena"; "CODATA"

1. Introduction

Hypersphere World – Universe Model (WUM) views the World as a 3-dimensional Hypersphere that expands along the fourth spatial dimension in the Universe. A Hypersphere is an example of a 3-Manifold which locally behaves like regular Euclidean 3-dimensional space: just as a sphere looks like a plane to small enough observers. WUM is based on Maxwell's equations (ME) that form the foundation of Electromagnetism and Gravitoelectromagnetism. According to ME, there exist two measurable physical characteristics: energy density and energy flux density.

WUM makes reasonable assumptions in the main areas of Cosmology. The remarkable agreement of the calculated values of the primary cosmological parameters with the observational data gives us considerable confidence in the Model.

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 3-Manifold at any cosmological time. ρ_{cr} can be found by considering a sphere of radius R_M and enclosed mass M, with a small test mass m on the periphery of the sphere. Mass M can be calculated by multiplication of ρ_{cr} by the volume of the sphere. The equation for ρ_{cr} can be found from the escape speed calculation for test mass m:

$$\rho_{cr} = \frac{3H^2c^2}{8\pi G} \tag{1.1}$$

where G is the gravitational constant, H is Hubble's parameter, and c is the gravitoelectrodynamic constant that is identical to the electrodynamic constant c in Maxwell's equations.
WUM introduces a fundamental dimensionless time-varying parameter Q that is the measure of the curvature of the Hypersphere. Q can be calculated from the average value of the gravitational constant and in present epoch equals to (see Section 2):

$$Q = 0.759972 \times 10^{40} \quad (1.2)$$

WUM develops a mathematical framework that allows for direct calculation of a number of cosmological parameters through Q. The precision of such parameters increases by orders of magnitude (see Section 2). Below we will use the following fundamental constants:

- basic unit of length $a = 2\pi a_0$, a_0 being the classical electron radius;
- Planck constant h;
- basic unit of energy $E_0 = \frac{hc}{a}$ that is the basic gravitoelectrodynamic charge;
- basic unit of energy density $\rho_0 = \frac{hc}{a^4}$;
- basic unit or surface energy density $\sigma_0 = \frac{hc}{a^3} = \rho_0 a$;
- basic unit of mass $m_0 = \frac{h}{ac}$;
- basic unit of frequency $\nu_0 = \frac{c}{a}$;
- Fine-structure constant α.

2. Primary Cosmological Parameters

Equation (1.1) can be rewritten as

$$\frac{4\pi G}{c^2} \times \frac{2}{3}\rho_{cr} = \mu_g \times \rho_M = H^2 \quad (2.1)$$

where μ_g is the gravitomagnetic parameter and ρ_M is the energy density of the Medium. Hubble's parameter H can be expressed: $H = \frac{c}{R}$, where R is the Hubble's radius and is the radius of the Hypersphere in WUM. Introducing the dimensionless parameter Q:

$$Q = \frac{R}{a} = \nu_0 H^{-1} \quad (2.2)$$

we can rewrite (2.1)

$$\frac{8\pi G a^2}{c^4} \times \frac{1}{3}\rho_{cr} = \frac{8\pi G a^2}{c^4} \times \rho_{MO} = \frac{8\pi G a^2 \rho_0}{c^4} \times \frac{\rho_{MO}}{\rho_0} = Q^{-2} \quad (2.3)$$

where ρ_{MO} is the energy density of Macroobjects of the World. Assuming that

$$\rho_{MO} = \rho_0 \times Q^{-1} \quad (2.4)$$

we can find the equation for the critical energy density:

$$\rho_{cr} = 3\rho_0 \times Q^{-1} \quad (2.5)$$

and for the gravitational constant:

$$G = \frac{a^3 c^3}{8\pi hc} H = \frac{a^2 c^4}{8\pi hc} \times Q^{-1} \quad (2.6)$$

We can calculate the value of G based on the value of H. Conversely, we can find the value of the Hubble's parameter based on the value of the gravitational parameter. H and G are interchangeable! Knowing value of one, it is possible to calculate the other.

According to (2.2) we can find the value of dimensionless parameter Q based on the value of H, but the accuracy of its measurements is very poor. We have obtained the value of Q in (1.2) based on the equation (2.6), and value of G that is measured with much better accuracy. Then we can calculate the value of H_0 in present epoch:

$$H_0 = \nu_0 Q^{-1} = 68.7457(83)\ \frac{km/s}{Mpc} \tag{2.7}$$

Thus, calculated value of H_0 is in excellent agreement with experimentally measured value of $H_0 = 69.32 \pm 0.8\ \frac{km/s}{Mpc}$ [7] and proves assumption (2.4).

3. Gravitation

In frames of WUM the parameter G can be calculated based on the value of the energy density of the Medium ρ_M [2]:

$$G = \frac{\rho_M}{4\pi} \times P^2 \tag{3.1}$$

where a dimension-transposing parameter P equals to:

$$P = \frac{a^3}{2h/c} \tag{3.2}$$

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

$$F = G\frac{m \times M}{r^2} = \frac{\rho_M}{4\pi}\frac{\frac{a^3}{2L_{Cm}} \times \frac{a^3}{2L_{CM}}}{r^2} \tag{3.3}$$

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 in (3.3) have a dimension of "Area", which is equivalent to "Energy", with the constant that equals to the basic unit of surface energy density σ_0.

Following the approach developed in [2] we can find the gravitomagnetic parameter of the Medium μ_M:

$$\mu_M = R^{-1} \tag{3.4}$$

and the impedance of the Medium Z_M:

$$Z_M = \mu_M c = H = \tau^{-1} \tag{3.5}$$

where τ is a cosmological time. These parameters are analogous to the permeability μ_0 and impedance of electromagnetic field $Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = \mu_0 c$, where ε_0 is the permittivity of electromagnetic field and $\mu_0 \varepsilon_0 = c^{-2}$.

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. 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.
The second important characteristic of the World is the gravitomagnetic parameter μ_M . Taking its inverse value, we can find the absolute radius of curvature of the World in the fourth spatial dimension. 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 . It means that Time is not a physical dimension and is absolutely different entity than Space. Time is a factor of the World.
It follows that Gravity, Space and Time itself can be introduced only for a 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. Gravity, Space and Time are then emergent phenomena [3].

4. Intergalactic Plasma

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: $n_p = n_e$.

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

$$\omega_{pl}^2 = \frac{4\pi n_e e^2}{4\pi\varepsilon_0 m_e} = 4\pi n_e \alpha \frac{h}{2\pi m_e c} c^2 = 2n_e a c^2 \quad (4.1)$$

where e is the elementary charge. Since the formula calculating the potential energy of interaction of protons and electrons contains the same parameter k_{pe}:

$$k_{pe} = m_p \omega_{pl}^2 = m_e \omega_e^2 = m_e (2\pi\nu_0 \times Q^{-1/2})^2 \quad (4.2)$$

where we assume that ω_e is proportional to $Q^{-1/2}$, then ω_{pl}^2 is proportional to Q^{-1}. Energy densities of protons and electrons are then proportional to Q^{-1}, similar to the critical energy density $\rho_{cr} \propto Q^{-1}$.

We substitute $\omega_{pl}^2 = \frac{m_e}{m_p}(2\pi\nu_0 \times Q^{-1/2})^2$ into (4.1) and calculate concentration of protons and electrons:

$$n_p = n_e = \frac{2\pi^2}{a^3}\frac{m_e}{m_p} \times Q^{-1} = 0.25480\ m^{-3} \quad (4.3)$$

A. Mirizzi, *et al.* found that the mean diffuse intergalactic plasma density is bounded by $n_e \lesssim 0.27\ m^{-3}$ [8] corresponding to the WMAP measurement of the baryon density [9]. The Mediums' plasma density (4.3) is in good agreement with the estimated value [8].

From equation (4.2) we obtain the value of the lowest frequency ν_{pl} :

$$\nu_{pl} = \frac{\omega_{pl}}{2\pi} = (\frac{m_e}{m_p})^{1/2}\nu_0 \times Q^{-1/2} = 4.5322\ Hz \quad (4.4)$$

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. Following the authors of [10] we can call this amount of energy the rest energy of photons that equals to

$$E_{ph} = \left(\frac{m_e}{m_p}\right)^{1/2} \times E_0 \times Q^{-1/2} = 1.8743 \times 10^{-14}\ eV \quad (4.5)$$

The above value is in good agreement with the value $E_{ph} \lesssim 2.2 \times 10^{-14}\ eV$ estimated in [10]. It is more relevant to call E_{ph} the minimum energy of photons which can pass through the Intergalactic plasma.

$\rho_p = n_p E_p$ 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} :

$$\Omega_p = \frac{\rho_p}{\rho_{cr}} = \frac{2\pi^2\alpha}{3} = 0.048014655 \quad (4.6)$$

This value is in good agreement with experimentally found value of 0.049 ± 0.013 [11]. The results obtained in [8], [10] and [11] prove assumption (4.2).

According to WUM, 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. We assume that the energy density of MBR ρ_{MBR} equals to twice the value of ρ_e :

$$\rho_{MBR} = 2\rho_e = 4\pi^2\alpha\frac{m_e}{m_p}\rho_0 \times Q^{-1} = \frac{8\pi^5}{15}\frac{k_B^4}{(hc)^3}T_{MBR}^4 \quad (4.7)$$

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

$$T_{MBR} = \frac{E_0}{k_B}(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p})^{1/4} \times Q^{-1/4} = 2.72518\ K \quad (4.8)$$

Thus, calculated value of T_{MBR} is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\ K$ [12] and proves assumption (4.7).

5. Fast Radio Bursts

Fast Radio Burst (FRB) is a high-energy astrophysical phenomenon manifested as a transient radio pulse lasting only a few milliseconds. These are bright, unresolved, broadband, millisecond flashes found in parts of the sky outside the Milky Way. The component frequencies of each burst are delayed by different amounts of time depending on the wavelength. This delay is described by a value referred to as a Dispersion Measure (DM) which is the total column density of free electrons between the observer and the source of FRB. Fast radio bursts have DMs which are: much larger than expected for a source inside the Milky Way [13]; and consistent with propagation through ionized plasma [14]. In this Section we calculate a time delay of FRB based on the characteristics of the Intergalactic Plasma discussed in [4] (see Section 4).

Consider a photon with initial frequency ν_{emit} and energy E_{emit} emitted at time τ_{emit} when the radius of the hypersphere World in the fourth spatial dimension was R_{emit}. The photon is continuously losing kinetic energy as it moves from galaxy to the Earth until time τ_{obsv} when the radius is $R_{obsv} = R_0$. The observer will measure ν_{obsv} and energy E_{obsv} and calculate a redshift:

$$1 + \mathrm{z} = \frac{\nu_{emit}}{\nu_{obsv}} = \frac{E_{emit}}{E_{obsv}} \tag{5.1}$$

Recall that τ_{emit} and τ_{obsv} are cosmological times (ages of the World at the moments of emitting and observing). A light-travel time distance to a galaxy d_{LLT} equals to

$$d_{LTT} = c(\tau_{obsv} - \tau_{emit}) = ct_{LTT} = R_0 - R_{emit} \tag{5.2}$$

Let's calculate photons' traveling time t_{ph} from a galaxy to the Earth taking into account that the rest energy of photons E_{ph} is much smaller than the energy of photons E_γ: $E_{ph} \ll E_\gamma$.

$$t_{ph} = \frac{1}{c}\int_{R_{emit}}^{R_0} \frac{dr}{\sqrt{1-\frac{E_{ph}^2}{E_\gamma^2}}} = t_{LTT} + \Delta t_{ph} \tag{5.3}$$

where Δt_{ph} is photons' time delay relative to the light-travel time t_{LLT} that equals to:

$$\Delta t_{ph} = \frac{1}{2c}\int_{R_{emit}}^{R_0} \frac{E_{ph}^2}{E_\gamma^2} dr \tag{5.4}$$

All observed FRBs have redshifts $z < 1$. It means that we can use the Hubble's law: $d_{LTT} = R_0 z$. Then

$$R_{emit} = (1 - z)R_0 \tag{5.5}$$

Photons' rest energy squared at radius r between R_{emit} and R_0 equals to (3.5):

$$E_{ph}^2 = \frac{m_e}{m_p}\frac{a}{r}E_0^2 \tag{5.6}$$

According to WUM, photons' energy E_γ on the way from galaxy to an observer can be expressed by the following equation:

$$E_\gamma = zE_{obsv} + (1 - z)\frac{R_0}{r}E_{obsv} = z\frac{R_0}{r}E_{obsv}\left(\frac{1-z}{z} + \frac{r}{R_0}\right) \tag{5.7}$$

which reduces to E_{emit} at (5.5) and to E_{obsv} at $r = R_0$. Placing the values of the parameters (5.5), (5.6), (5.7) into (5.4), we have for photons' time delay:

$$\begin{aligned}\Delta t_{ph} &= \frac{1}{2z^2}\frac{c}{a}\frac{m_e}{m_p}\frac{1}{\nu^2}\int_{1-z}^{1}\frac{xdx}{\left(x+\frac{1-z}{z}\right)^2} = \frac{1}{2z^2}\frac{c}{a}\frac{m_e}{m_p}\frac{1}{\nu^2}\int_{\frac{1-z^2}{z}}^{\frac{1}{z}}\frac{\left(y-\frac{1-z}{z}\right)dy}{y^2} = \\ &= \frac{1}{2z^2}\left[ln\left(\frac{1}{1-z^2}\right) - \frac{z^2}{1+z}\right]\frac{c}{a}\frac{m_e}{m_p} \times \frac{1}{\nu^2} = \\ &= \frac{4.61}{z^2}\left[ln\left(\frac{1}{1-z^2}\right) - \frac{z^2}{1+z}\right] \times \left(\frac{\nu}{1GHz}\right)^{-2}\end{aligned} \tag{5.8}$$

where $x = r/R_0$ and $y = x + \frac{1-z}{z}$. Taking z=0.492 [14] we get the calculated value of photons' time delay

$$\Delta t_{ph}^{cal} = 2.189 \times (\frac{\nu}{1GHz})^{-2} \quad (5.9)$$

which is in good agreement with experimentally measured value [14]

$$\Delta t_{ph}^{exp} = 2.438 \times (\frac{\nu}{1GHz})^{-2} \quad (5.10)$$

It is worth to note that in our calculations there is no need in the dispersion measure.

6. 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. Neutrino oscillations imply that neutrinos have non-zero masses [15], [16].

Let's take neutrino masses m_{ν_e}, m_{ν_μ}, m_{ν_τ} that are near [5]

$$m_\nu = m_0 \times Q^{-1/4} \quad (6.1)$$

Their concentrations n_ν are then proportional to

$$n_\nu \propto \frac{1}{a^3} \times Q^{-3/4} \quad (6.2)$$

and energy densities of neutrinos are proportional to Q^{-1}, since critical energy density ρ_{cr} is proportional to Q^{-1} (see Section 2).

Experimental results obtained by M. Sanchez [17] show $\nu_e \rightarrow \nu_{\mu,\tau}$ neutrino oscillations with parameter Δm_{sol}^2 given by

$$2.3 \times 10^{-5}\ eV^2/c^4 \le \Delta m_{sol}^2 \le 9.3 \times 10^{-5}\ eV^2/c^4 \quad (6.3)$$

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

$$1.6 \times 10^{-3}\ eV^2/c^4 \le \Delta m_{atm}^2 \le 3.9 \times 10^{-3}\ eV^2/c^4 \quad (6.4)$$

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.* [18] for the ratio of the mass splitting:

$$\sqrt{\frac{\Delta m_{sol}^2}{\Delta m_{atm}^2}} \cong 0.16 \approx \frac{1}{6} \quad (6.5)$$

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

$$m_{\nu_\mu} = m_\nu = m_0 \times Q^{-1/4} \cong 7.5 \times 10^{-3}\ eV/c^2 \quad (6.6)$$

From equation (6.5) it then follows that

$$m_{\nu_\tau} = 6 m_\nu \cong 4.5 \times 10^{-2}\ eV/c^2 \quad (6.7)$$

Then the squared values of the muonic and tauonic neutrino masses fall into ranges (6.3) and (6.4):

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

$$m_{\nu_\tau}^2 \cong 2 \times 10^{-3}\ eV^2/c^4 \quad (6.8)$$

Let's assume that electronic neutrino mass equals to

$$m_{\nu_e} = \frac{1}{24} m_\nu \cong 3.1 \times 10^{-4}\ eV/c^2 \quad (6.9)$$

The sum of the calculated neutrino masses

$$\Sigma m_\nu \cong 0.053\ eV/c^2 \quad (6.10)$$

is also in a good agreement with the value of 0.06 eV/c^2 discussed in literature [19].

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

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

$$i = e, \mu, \tau \quad (6.11)$$

we obtain the following neutrino energy densities $\rho_{\nu i}$ in accordance with theoretical calculations made by L. D. Landau and E. M. Lifshitz [20]:

$$\rho_{\nu i} = \frac{8\pi c}{h^3} \int_0^{p_F} p^2 \sqrt{p^2 + m_{\nu i}^2 c^2}\, dp = \frac{2\pi (p_F c)^4}{(hc)^3} \times F(x_{\nu i}) \quad (6.12)$$

where p_F is Fermi momentum,

$$F(x_{\nu i}) = \frac{x_{\nu i}^{1/2}(2x_{\nu i}+1)(x_{\nu i}+1/2)^{1/2} - ln\left[x_{\nu i}^{1/2} + (x_{\nu i}+1)^{1/2}\right]}{2x_{\nu i}^2} \quad (6.13)$$

$$x_{\nu i} = (\frac{p_F}{m_{\nu i} c})^2 \quad (6.14)$$

$$m_{\nu i} = A_i m_0 \times Q^{-1/4} \quad (6.15)$$

$$A_i = \frac{1}{24};\ 1;\ 6 \quad (6.16)$$

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

$$p_F^2 = \frac{h^2}{2\pi^2 a^2} \times Q^{-1/2} = p_{F0}^2 \times Q^{-1/2} \quad (6.17)$$

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 (6.13), we obtain neutrinos relative energy densities $\Omega_{\nu i}$ in the Medium in terms of the critical energy density ρ_{cr}:

$$\Omega_{\nu i} = \frac{\rho_{\nu i}}{\rho_{cr}} = \frac{1}{6\pi^3} F(y_{\nu i}) \quad (6.18)$$

where

$$y_{\nu i} = (2\pi^2 A_i^2)^{-1} \quad (6.19)$$

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:

$$\Omega_\nu = \frac{\rho_\nu}{\rho_{cr}} = \frac{\rho_{\nu e} + \rho_{\nu \mu} + \rho_{\nu \tau}}{\rho_{cr}} = 0.45801647 \quad (6.20)$$

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 [2]:

$$\Omega_p = \frac{2\pi^2\alpha}{3} = 0.048014655 \tag{6.21}$$

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

$$\Omega_\nu = \frac{30}{\pi}\Omega_p = 20\pi\alpha = 0.45850618 \tag{6.22}$$

which is remarkably close to its value calculated in (6.20).

The assumptions made in (6.6), (6.9), (6.17) and (6.22) are further supported by the excellent numerical agreement of calculated and measured value of Fine-structure constant α discussed in Section 11.

7. Cosmic Far-Infrared Background

The cosmic Far-Infrared Background (FIRB), which was announced in January 1998, is part of the Cosmic Infrared Background, 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 [5].

According to [21]-[23], the size of large cosmic grains D_G is roughly equal to the length L_F:

$$D_G \sim L_F = a \times Q^{1/4} = 1.6532 \times 10^{-4}\ m \tag{7.1}$$

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

$$m_G \sim (10^{-9} \Leftrightarrow 10^{-7})\ kg \tag{7.2}$$

The density of grains ρ_G is about:

$$\rho_G \sim \frac{6}{\pi}\frac{M_P}{L_F^3} \approx 9.2 \times 10^3\ kg/m^3 \tag{7.3}$$

According to WUM, Planck mass M_P equals to [5]

$$M_P = 2m_0 \times Q^{1/2} \tag{7.4}$$

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

$$\frac{d}{d\tau}M_P = \frac{M_P}{2\tau} \tag{7.5}$$

A grain of mass $B_1 M_P$ and radius $B_2 L_F$ is receiving energy from the Medium of the World as the result of dineutrinos Bose-Einstein Condensation (see Section 8) at the following rate:

$$\frac{d}{d\tau}(B_1 M_P c^2) = \frac{B_1 M_P c^2}{2\tau} \tag{7.6}$$

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

$$\frac{B_1 M_P c^2}{2\tau} = \sigma_{SB} T_G^4 \times 4\pi B_2^2 L_F^2 \tag{7.7}$$

where σ_{SB} is Stefan-Boltzmann constant:

$$\sigma_{SB} = \frac{2\pi^5 k_B^4}{15h^3c^3} \tag{7.8}$$

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 [6] to a grain:

$$B_1 M_P c^2 = 4\pi B_2^2 L_F^2 \sigma_0 \tag{7.9}$$

where σ_0 is a basic unit of surface energy density:

$$\sigma_0 = \rho_0 a \tag{7.10}$$

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

$$T_G = (\frac{15}{4\pi^5})^{1/4} \frac{hc}{k_B L_F} = 28.955\ K \tag{7.11}$$

This result is in an excellent agreement with experimentally measured value of $29\ K$ [24]-[35] and proves the assumptions (7.1), (7.2) and (7.9).

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:

$$\rho_{FIRB} = \frac{8\pi^5}{15} \frac{k_B^4}{(hc)^3} T_G^4 = \frac{2}{3} \rho_{cr} = \rho_M \tag{7.12}$$

The total flux of the FIRB radiation is the sum of the contributions of all individual grains. Comparing equations (7.11) and (4.8), we can find the relation between the grains' temperature and the temperature of the MBR:

$$T_G = (3\Omega_e)^{-1/4} \times T_{MBR} \tag{7.13}$$

where electron relative energy density Ω_e in terms of the critical energy density equals to

$$\Omega_e = \frac{m_e}{m_p} \Omega_p \tag{7.14}$$

8. Bose-Einstein Condensate

New cosmological models employing the Bose-Einstein Condensates (BEC) have been actively discussed in literature in recent years [36]-[50]. 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

$$T_c = [\zeta(3/2)]^{-2/3} \frac{h^2 n_X^{2/3}}{2\pi m_X k_B} \approx \frac{h^2 n_X^{2/3}}{11.918 m_X k_B} \tag{8.1}$$

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

$$\zeta(3/2) \approx 2.6124 \tag{8.2}$$

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 (7.11)). Let's assume that the energy density of boson particles ρ_X equals to the MBR energy density (see (4.7)):

$$\rho_X = n_X m_X = 2\frac{m_e}{m_p}\rho_p = 4\pi^2\alpha\frac{m_e}{m_p}\frac{hc}{L_F^4} = 1.5690 \times 10^{-4} \times \frac{hc}{L_F^4} \tag{8.3}$$

Taking into account equations (7.11), (8.1) and (8.3), we can calculate the value of n_X :

$$n_X = [47.672\pi^2\alpha\frac{m_e}{m_p}\left(\frac{15}{4\pi^5}\right)^{1/4}]^{3/5} \times L_F^{-3} = 0.011922 \times L_F^{-3} = 2.6386 \times 10^9\ m^{-3} \tag{8.4}$$

and the value of the mass m_X :

$$m_X = \frac{\rho_X}{n_X c^2} = 0.013161 \times m_0 \times Q^{-1/4} = 0.987 \times 10^{-4}\ eV/c^2 \tag{8.5}$$

m_X is about 10 orders of magnitude larger than the rest mass of photon's (see (4.5)) and is in the range of neutrinos masses (see Section 6).

The calculated values of 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 $T_G \approx 29\ K$ (see Section 7).

In WUM the FIRB energy density ρ_{FIRB} equals to [5]

$$\rho_{FIRB} = \frac{1}{5\pi}\frac{m_e}{m_p}\rho_p = \frac{2\pi\alpha}{15}\frac{m_e}{m_p} \tag{8.6}$$

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

$$\rho_{FIRB} = \frac{1}{10\pi}\rho_{MBR} \approx 0.032\rho_{MBR} \tag{8.7}$$

The ratio between FIRB and MBR corresponds to the value of 3.4% calculated by E. L. Wright [51].

9. Multicomponent Dark Matter

Dark Matter (DM) is among the most important open problems in both cosmology and particle physics. Dark Matter problem can be, in principle, achieved through extended theories of gravity, as it is discussed, for example, in [52].

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 – bosons, consisting of two fermions each. There exist two types of DM bosons which we called DIRACs and ELOPs [6]. DIRACs are magnetic dipoles with mass m_0, consisting of two Dirac monopoles with mass about $\frac{m_0}{2}$ and charge $\mu = \frac{e}{2\alpha}$. 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 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 $e_{pr} = \frac{1}{3}e$ which we took to match the Quark Model. 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 [53].

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):

$$m_N = \alpha^{-2}m_0 = 1.3149950 \ TeV/c^2 \tag{9.1}$$

$$m_{WIMP} = \alpha^{-1}m_0 = 9.5959823 \ GeV/c^2 \tag{9.2}$$

DIRACs:

$$m_{DIRAC} = 2\alpha^0 \frac{m_0}{2} = 70.025267 \ MeV/c^2 \tag{9.3}$$

ELOPs:

$$m_{ELOP} = 2\alpha^1 \frac{m_0}{3} = 340.66606 \ keV/c^2 \tag{9.4}$$

WDM particles (sterile neutrinos):

$$m_{\nu_s} = \alpha^2 m_0 = 3.7289402 \ keV/c^2 \tag{9.5}$$

These values fall into the ranges estimated in literature. The role of those particles in macroobject cores built up from fermionic dark matter will be discussed in Section 10.

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 (see (4.6)) In all, there are 5 different types of DMP. Then the total energy density of DMP is

$$\rho_{DM} = 5\rho_p = 0.24007327\rho_{cr} \tag{9.6}$$

which is close to the measured DM energy density: $\rho_{DM} \cong 0.268\,\rho_{cr}$ [54]. 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 $\cong 5$ [55], [56].

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 10). 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 [6].

The assumptions made in (8.3) and (8.6) are further supported by the excellent numerical agreement of calculated and measured value of Fine-structure constant α discussed in Section 11.

10. 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 9. 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.* [57] as follows. We take a scaling solution for a free Fermi gas consisting of fermions with mass m_f in accordance with following equations:

$$\text{Maximum mass: } M_{max} = A_1 M_F; \tag{10.1}$$

$$\text{Minimum radius: } R_{min} = A_2 R_F; \tag{10.2}$$

$$\text{Maximum density: } \rho_{max} = A_3 \rho_0 \tag{10.3}$$

where

$$M_F = \frac{M_P^3}{m_f^2}; \;\; R_F = \frac{M_P}{m_f}\frac{L_{Cf}}{2\pi}; \;\; \rho_0 = \frac{hc}{a^4} \tag{10.4}$$

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.* [57]). 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.* [57]). Then A_3 will equal to

$$A_3 = (\frac{m_f}{m_0})^4 \tag{10.5}$$

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

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
$$M_0 = \frac{4\pi m_0}{3} \times Q^{3/2} \quad (10.6)$$

$$L_g = a \times Q^{1/2} \quad (10.7)$$

$$\beta = \frac{m_p}{m_0} \quad (10.8)$$

A maximum density of neutron stars equals to the nuclear density:

$$\rho_{max} = \beta^4 \rho_0 \quad (10.9)$$

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

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 (10.1), (10.2), (10.3) and the following values of A_1, A_2 and A_3:

$$A_{1max} = \frac{\pi}{6}(\alpha\beta)^{-2} \quad (10.10)$$

$$A_{2min} = \pi(\alpha\beta)^{-2} \quad (10.11)$$

$$A_{3max} = \beta^4 \quad (10.12)$$

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.

In accordance with the paper by G. Narain, *et al.* [57], 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

$$M_{WIMPmax} = \frac{\pi}{6}(\alpha\beta)^{-2}M_F = \frac{1}{\beta^2}M_0 \tag{10.13}$$

down to

$$M_{WIMPmin} = \alpha^4 M_{WIMPmax} \tag{10.14}$$

$M_{WIMPmin}$ 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 [6].

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:

$$A_1 A_2^3 = \pi^4 \tag{10.15}$$

Compare $\pi^4 \cong 97.4$ with the value of 91 used by G. Narain, *et al.* [57].

Minimum mass and maximum radius take on the following values:

$$A_{1min} = \frac{\pi}{6}\sqrt{6}(\alpha\beta)^2 \tag{10.16}$$

$$A_{2max} = \pi\sqrt[6]{6}(\alpha\beta)^{-2/3} \tag{10.17}$$

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 [6].

Scaling solution for interacting neutralinos can be described with the same equations (10.1), (10.2), (10.3) and the following values of A_1^*, A_2^* and A_3^*:

$$A_{1max}^* = \frac{\pi}{6}(\alpha^2\beta)^{-2} \tag{10.18}$$

$$A_{2min}^* = \pi(\alpha^2\beta)^{-2} \tag{10.19}$$

$$A_{3max}^* = \beta^4 \tag{10.20}$$

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

$$M_{Nmax} = \frac{\pi}{6}(\alpha\beta)^{-2}\alpha^2 M_F = \frac{1}{\beta^2}M_0 \tag{10.21}$$

down to

$$M_{Nmin} = \alpha^8 M_{Nmax} \tag{10.22}$$

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 [6].

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^*:

$$A_1^* {A_2^*}^3 = \pi^4 \quad (10.23)$$

Minimum mass and maximum radius take on the following values:

$$A_{1min}^* = \frac{\pi}{6}\sqrt{6}(\alpha^2\beta)^2 \quad (10.24)$$

$$A_{2max}^* = \pi\sqrt[6]{6}(\alpha^2\beta)^{-2/3} \quad (10.25)$$

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.

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

  $$U_{max} = \frac{GM_{max}}{R_{min}} = \frac{c^2}{6} \quad (10.26)$$

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

  $$R_{min} = 3R_{SH} \quad (10.27)$$

  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 $R_{min} \propto \tau^{1/2}$.

11. Energy Density of Dineutrinos, FIRB and the World

Our Model holds that the energy densities of all types of Dark Matter particles (DMP) are proportional to the proton energy density in the World's Medium. In all, there are 5 different types of DMP (see Section 9). Then the total energy density of Dark Matter (DM) Ω_{DM} is

$$\Omega_{DM} = 5\Omega_p \quad (11.1)$$

The total electron energy density Ω_{etot} is:

$$\Omega_{etot} = 1.5\frac{m_e}{m_p}\Omega_p \quad (11.2)$$

The MBR energy density Ω_{MBR} equals to [1]:

$$\Omega_{MBR} = 2\frac{m_e}{m_p}\Omega_p \quad (11.3)$$

We took energy density of dineutrinos $\Omega_{\nu\bar{\nu}}$ and FIRB Ω_{FIRB} (see Section 8):

$$\Omega_{\nu\bar{\nu}} = \Omega_{MBR} = 2\frac{m_e}{m_p}\Omega_p \quad (11.4)$$

$$\Omega_{FIRB} = \frac{1}{5\pi}\frac{m_e}{m_p}\Omega_p = \frac{1}{10\pi}\Omega_{MBR} \approx 0.032\Omega_{MBR} \quad (11.5)$$

Then the energy density of the World Ω_W

$$\Omega_W = \left[\frac{13}{2} + \left(\frac{11}{2} + \frac{1}{5\pi}\right)\frac{m_e}{m_p} + \frac{45}{\pi}\right]\Omega_p = 1 \quad (11.6)$$

Equation (11.6) contains such exact terms as the result of the Models' predictions and demonstrates consistency of WUM. From (11.6) we can calculate the value of α, using electron-to-proton mass ratio $\frac{m_e}{m_p}$

$$\frac{1}{\alpha} = \frac{\pi}{15}\left[450 + 65\pi + (55\pi + 2)\frac{m_e}{m_p}\right] = 137.03600 \quad (11.7)$$

which is in an excellent agreement with the commonly adopted value of 137.035999074(44). It follows that there exists a direct correlation between constants α and $\frac{m_e}{m_p}$ expressed by equation (11.6). As shown above, $\frac{m_e}{m_p}$ is not an independent constant but is instead derived from α.

12. Grand Unified Theory

At the very Beginning ($Q=1$) all extrapolated fundamental interactions of the World – strong, electromagnetic, weak, Super Weak and Extremely Weak (proposed in WUM), and gravitational – had the same cross-section of $(\frac{\pi a}{2})^2$, and could be characterized by the Unified coupling constant: $\alpha_U = 1$. The extrapolated energy density of the World was four orders of magnitude smaller than the nuclear energy density [1]. The average energy density of the World has since been decreasing in time $\rho_W \propto Q^{-1} \propto \tau^{-1}$.

The gravitational coupling parameter α_G is similarly decreasing:

$$\alpha_G = Q^{-1} \propto \tau^{-1} \quad (12.1)$$

The weak coupling parameter α_W is decreasing as follows:

$$\alpha_W = Q^{-1/4} \propto \tau^{-1/4} \quad (12.2)$$

The strong α_S and electromagnetic α_{EM} coupling parameters remain constant in time:

$$\alpha_S = \alpha_{EM} = 1 \quad (12.3)$$

The difference in the strong and the electromagnetic interactions is not in the coupling parameters but in the strength of these interactions depending on the particles involved: electrons with charge e and monopoles with charge $\mu = \frac{e}{2\alpha}$ in electromagnetic and strong interactions respectively.

The super weak coupling parameter α_{SW} and the extremely weak coupling parameter α_{EW} proposed in WUM are decreasing as follows:

$$\alpha_{SW} = Q^{-1/2} \propto \tau^{-1/2} \quad (12.4)$$

$$\alpha_{EW} = Q^{-3/4} \propto \tau^{-3/4} \quad (12.5)$$

According to WUM, the coupling strength of super-weak interaction is $\sim 10^{-10}$ times weaker than that of weak interaction. The possibility of such ratio of interactions was discussed in the developed theoretical models explaining CP and Strangeness violation [58]-[61]. Super-weak and Extremely-weak interactions provide an important clue to Physics beyond the Standard Model.

13. Conclusion

WUM holds that there exist relations between all Q-dependent parameters: Newtonian parameter of gravitation and Hubble's parameter; Critical energy density and Fermi coupling parameter; Temperatures of the Microwave Background Radiation and Far-Infrared Background Radiation peak. The calculated values of these parameters are in good agreement with the latest results of their measurements.

Today, Fermi coupling parameter G_F is known with the highest precision [1]:

$$\frac{G_F}{(\hbar c)^3} = \sqrt{30}(2\alpha \frac{m_e}{m_p})^{1/4} \times \frac{m_p}{m_e}\frac{1}{E_0^2} \times Q^{-1/4} \qquad (13.1)$$

Based on its average value we can calculate and significantly increase the precision of all Q-dependent parameters. We propose to introduce Q as a new Fundamental Parameter tracked by CODATA and use its value in calculation of all Q-dependent parameters.

Acknowledgements

I am grateful to anonymous referees for valuable comments and important remarks that helped me to improve the understanding of the Model. Special thanks to my son Ilya Netchitailo who helped shape the manuscript to its present form.

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Astrophysics: Macroobject Shell Model

Abstract

The model proposes that Nuclei of all macroobjects (Galaxy clusters, Galaxies, Star clusters, Extrasolar systems) are made up of Dark Matter Particles (DMP). These Nuclei are surrounded by Shells composed of both Dark and Baryonic matter. This model is used to explain various astrophysical phenomena: Multiwavelength Pulsars; Binary Millisecond Pulsars; Gamma-Ray Bursts; Fast Radio Bursts; Young Stellar Object Dippers; Starburst Galaxies; Gravitational Waves. New types of Fermi Compact Stars made of DMP are introduced: Neutralino star, WIMP star, and DIRAC star. Gamma-Ray Pulsars are rotating Neutralino and WIMP stars. Merger of binary DIRAC stars can be a source of Gravitational waves.

Keywords. Hypersphere World-Universe Model, Medium of the World, Macroobject Shell Model, Dark Matter Particles, Gamma-Ray Bursts, Fast Radio Bursts, Multiwavelength Pulsars, Binary Millisecond Pulsars, Young Stellar Object Dippers, Starburst Galaxies, Gravitational Waves

1. Introduction

This paper is an elaboration of Hypersphere World-Universe Model published in [1]-[7]. The prospect that Dark Matter Particles (DMP) might be observed in Centers of Macroobjects has drawn many new researchers to the field in the last forty years. Indirect effects in cosmic rays and gamma-ray background from the annihilation of cold Dark Matter (DM) in the form of heavy stable neutral leptons in Galaxies were considered in [8]-[13]. The role of cold DM in the formation of Primordial Luminous Objects is discussed in [14].

A mechanism whereby DM in protostellar halos plays a role in the formation of the first stars is discussed in [15]. Heat from neutralino DM annihilation is shown to overwhelm any cooling mechanism, consequently impeding the star formation process. A "dark star" powered by DM annihilation instead of nuclear fusion may result [15]. Dark stars are in hydrostatic and thermal equilibrium, but with an unusual power source. Weakly Interacting Massive Particles (WIMPs) are among the best candidates for DM [16].

Two-component DM systems consisting of bosonic and fermionic components are proposed for the explanation of emission lines from the bulge of Milky Way galaxy. C. Boehm, P. Fayet, and J. Silk analyze the possibility of two coannihilating neutral and stable DMP: a heavy fermion for example, like the lightest neutralino ($>$100 GeV) and the other one a possibly light spin-0 particle ($\sim$100 MeV) [17].

Conversions and semi-annihilations of DMP in addition to the standard DM annihilations are considered in a three-component DM system [18]. Multicomponent DM models consisting of both bosonic and fermionic components were analyzed in literature (for example, see [19]-[24] and references therein).

Hypersphere World-Universe Model (WUM) proposes five-component DM system consisting of two couples of coannihilating DMP: a heavy fermion—neutralino with mass 1.3 TeV and a light spin-0 boson—DIRAC (dipole of Dirac monopoles) with mass 70 MeV; a heavy fermion—WIMP with mass

9.6 GeV and a light spin-0 boson—ELOP (preons dipole) with mass 340 keV; and a light fermion—sterile neutrino with mass 3.7 keV [2].

The Model 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 DM 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 [2].

In Section 2, we present the numerical values for parameters of Macroobjects' shells made up of different fermions. In Section 3, we discuss Macroobject Shell Model. We give explanations for different astrophysical phenomena: Multiwavelength Pulsars (Section 4); Binary Millisecond Pulsars (Section 5); Young Stellar Object Dippers (Section 6); Long-Term Radio Variability (Section 7); Gamma-Ray Bursts (Section 8); Fast Radio Bursts (Section 9); Starburst galaxies (Section 10); Gravitational Waves (Section 11)—through the frames of Macroobject Shell Model.

2. Macroobjects

According to WUM, Cores of macroobjects of the World (galaxy clusters, galaxies, star clusters, and extrasolar systems) are Fermion Compact Stars (FCS). They have Nuclei made up of strongly interacting WIMPs or neutralinos surrounded by different shells [2]. The theory of FCS made up of DMP is well developed. Scaling solutions are derived for a free and an interacting Fermi gas in [2]. **Table 1** describes the numerical values for maximum mass and minimum

Table 1. Numerical values for masses and radii of FCS made up of different fermions.

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	$\gtrsim0.17$	5.9×10^{37}	2.6×10^{11}	7.8×10^{2}
Monopole	$\gtrsim35$	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}

Macroobjects' Cores consist of Nuclei (neutralinos and WIMPs) and shells made up of various fermions. The shells envelope one another, like a Russian doll. The lighter a fermion—the greater the radius and the mass of its shell. Innermost shells are the smallest and are made up of heaviest fermions; outer shells are larger and consist of lighter particles.

The calculated parameters of the shells show that [2]:

• 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 star 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.

3. Macroobject Shell Model

In our view, Macroobjects of the World possess the following properties [6]:

• Nuclei are made up of DMP. Surrounding shells contain DM and baryonic matter;
• Nuclei and shells are growing in time proportionally to square root of cosmological time $\propto \tau^{1/2}$ until one of them reaches the critical point of its local stability, at which it detonates. The energy released during detonation is produced by the annihilation of DMP. The detonation process does not destroy the Macroobject; instead, Hyper-flares occur in active regions of the shells, analogous to Solar flares;
• All other DMP in different shells can start annihilation process as the result of the first detonation;
• Different emission lines in spectra of bursts are connected to the Macroobjects' structure which depends on the composition of the Nuclei and surrounding shells made up of DMP. Consequently, the diversity of Very High Energy Bursts has a clear explanation;
• Afterglow is a result of processes developing in Nuclei and shells after detonation.

4. Multiwavelength Pulsars

D. J. Thompson in the review "Gamma Ray Pulsars: Multiwavelength Observations" presents the light curves from seven highest-confidence gamma-ray pulsars (in 2003) in five energy bands: radio, optical, soft X-ray (<1 keV), hard X-ray/soft gamma ray (~10 keV − 1 MeV), and hard gamma ray (above 100 MeV). Gamma rays are frequently the dominant component of the radiated power. According to D. J. Thompson, for all known Gamma-Ray Pulsars (GRP), multiwavelength observations and theoretical models based on such observations offer the prospect of gaining a broad understanding of these rotating neutron stars [25].

WUM: FCS made up of strongly interacting neutralinos and WIMPs have maximum mass and minimum size which are equal to parameters of neutron stars (see **Table 1**). It follows that GRP might be in fact rotating Neutralino star or WIMP star. The nuclei 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 other DMP. The GRP multiwavelength radiation depends on the composition of Nucleus and shells.

S. Ansoldi, *et al.* report the most energetic pulsed emission ever detected from the Crab pulsar reaching up to 1.5 TeV. Such TeV pulsed quants require a parent population of electrons with a Lorentz factor of at least 5×10^6. These results strongly suggest Inverse Compton scattering off low energy photons as the emission mechanism [26].

WUM: Very High Energy (VHE) pulsed emission from the Crab pulsar can be explained by active area of rotating Star composed of a mixture of strongly interacting neutralinos (1.3 TeV) and WIMPs (9.6 GeV).

Ge Chen, *et al.* (2015) report hard X-ray observations of the young rotation-powered radio pulsar PSR B1509. The log parabolic model describes the NuSTAR data, as well as previously published gamma-ray data obtained with COMPTEL and AGILE, all together spanning 3 keV through 500 MeV. Astronomers' opinion is that the obtained results support a model in which the pulsar's lack of GeV emission is due to viewing geometry, with the X-rays originating from synchrotron emission from secondary pairs in the magnetosphere [27].

WUM: Multiwavelength emission from pulsar PSR B1509 can be explained by rotating WIMP star with an active area irradiating gamma quants with energy 9.6 GeV which interact with surrounding shells, causing them to glow in X-ray spectrum.

5. Binary Millisecond Pulsars

The properties of the growing class of radio pulsars with low-mass companions are discussed in literature (see [28], [29], [30] and references therein). During a survey of the southern sky for millisecond pulsars, S. Johnston, *et al.* have discovered pulsar PSR J0437-4715 with by far the greatest flux density of any known millisecond pulsar [28].

M. Bailes, *et al.* report the discovery of three binary millisecond pulsars in circular orbits with low-mass companions PSR J0034-0534, PSR J1045-4509, and PSR J2145-0750 that have pulse periods of 1.87, 7.47, and 16.05 ms. PSR J2145-0750 has a spin-down age of approximately greater than 12 Gyr, which raises interesting questions about its progenitor and initial pulse period [29].

IGR~J18245-2452/PSR J1824-2452I is one of the rare transitional accreting millisecond X-ray pulsars, showing direct evidence of switches between states of rotation powered radio pulsations and accretion powered X-ray pulsations, dubbed transitional pulsars. IGR~J18245-2452 is the only transitional pulsar so far to have shown a full accretion episode. V. De Falco, *et al.* have found that the observed spectrum in the energy range 0.4 - 250 keV is the hardest among the accreting millisecond X-ray pulsars [30].

Binary millisecond pulsar PSR J1311-3430 was found via gamma-ray pulsations. The system is explained by a model where mass from a low mass companion is transferred onto the pulsar, increasing the mass of the pulsar and decreasing its period. Pulse-phase-averaged gamma-ray spectral energy distribution for PSR J1311-3430 has cut-off about 10 GeV [31].

WUM: These experimental results can be explained by rotating WIMP star made up of strongly interacting WIMPs (9.6 GeV) with mass (energy) that is growing in time proportionally to the root square of the third power of cosmological time $\propto \tau^{3/2}$ [2]. WIMP star is receiving mass (energy) at the rate $W_r \propto \tau^{1/2}$. In case, when power received W_r is greater than the gamma-ray power irradiated by the active area of the rotating WIMP star, the decreasing of its period will be observed. Then there is no need to introduce a low-mass companion.

6. Young Stellar Object Dippers

The Mysterious Star KIC 8462852 which has large irregular dimmings, is a main-sequence star, with a rotation period $\sim$ 0.88 day, that exhibits no significant Infrared excess. A stellar mass is $M = 1.43M_{\odot}$, luminosity $L = 4.68L_{\odot}$, and radius $R = 1.58R_{\odot}$. While KIC 8462852's age was initially estimated to be hundreds of millions of years old, a number of astronomers have argued that it could be much younger—just like EPIC 204278916. Young stars with protoplanetary disks should emit light in the infrared, and observations with NASA's Infrared Telescope Facility came up empty. The infrared observations also show no evidence for warm dust, which would exist if a planetary collision debris were at play [32].

The obtained in [32] results show that the 0.88-day signal is present in most of the Kepler time series, with the strongest presence occurring around day 1200. Interestingly however, around day 400 and day 1400, T. S. Boyajian, *et al.* observed major contributions at different frequencies, corresponding to 0.96 days and 0.90 days, respectively.

Several hypotheses have been proposed to explain the star's large irregular changes in brightness as measured by its light curve, but none to date fully explain all aspects of the curve. A prominent hypothesis, based on a lack of observed infrared light, posits a swarm of cold, dusty comet fragments in a highly eccentric orbit. However, the notion that disturbed comets from such a cloud could exist in high enough numbers to obscure 22% of the star's observed luminosity has been doubted (see references in [32]).

EPIC 204278916 has been serendipitously discovered from its K2 light curve which displays irregular dimmings of up to 65% for ≈25 consecutive days out of 78.8 days of observations. For the remaining duration of the observations, the variability is highly periodic and attributed to stellar rotation. The star is a young, low-mass pre-main-sequence star about five million years old. The inferred radius of this star is $M = 0.97M_{\odot}$, while the stellar mass is $M{\sim}0.5M_{\odot}$ [33]. S. Scaringi, *et al.* examined the K2 light curve in detail and hypothesize that the irregular dimmings are caused by either a warped inner-disk edge or transiting cometary-like objects in either circular or eccentric orbits. In authors' opinion, the discussed explanations are particularly relevant for other recently discovered young objects with similar absorption dips [34], [35].

M. Ansdell, *et al.* identified ~25 dippers in the young (≲10 Myr), nearby (~120 - 145 Myr) Upper Sco and ρ Oph star-forming regions and proposed alternative mechanisms to explain the dips, namely occulting disk warps, vortices, and forming planetesimals [34]. Most of the proposed mechanisms assume nearly edge-on viewing geometries. However, an analysis of the known dippers by M. Ansdell, *et al.* shows that nearly edge-on viewing geometries are not a defining characteristic of the dippers and that additional models should be explored [35].

M. Sucerquia, *et al.* studied the dynamics of a tilted exoring. They performed numerical simulations and semi-analytical calculations of the evolving ring's properties and their related transit observables and found that tilted ringed structures undergo short-term changes in shape and orientation that are manifested as strong variations of transit depth and contact times [36].

M. A. Sheikh, *et al.* performed a statistical analysis of small dimming events by using methods found useful for avalanches in ferromagnetism and plastic flow. Scaling collapses suggest that this star may be near a nonequilibrium critical point. The large dimming events are interpreted as avalanches marked by modified dynamics. If KIC 8462852 is near a nonequilibrium phase transition, this could also explain the random times at which the large events occur in the light curve. In authors' opinion, " *there is more work to be done in order to verify that KIC 8462852 is near a critical point. A detailed theory of stellar processes is necessary to answer what the key tuning parameters are* . "[37]

WUM: These experimental results can be explained the following way:

• KIC 8462852 and EPIC 204278916 have average density about 3 and 2 times smaller than the average density of Sun respectively;

• In frames of WUM, the Nuclei of these stars made of DMP (neutralinos or WIMPs) have densities smaller than nuclear density (see **Table 1**);
• This relatively low density makes density fluctuations inside of the Nucleus possible;
• An annihilation of neutralinos or WIMPs depends on a concentration of DMP squared $\propto n_{DMP}^2$;
• As the result of the huge density fluctuation, some bulk of the Nucleus can arise in which the annihilation process ceases. It will cause a drop of the star luminosity in this area;
• The Nucleus is rotating (~0.88 days in case of KIC 8462852) and consequently the regular dimming events are observed;
• Change in the position of the huge density fluctuation inside of the Nucleus is responsible for the change of the regular dimming event frequency from ~ 0.88 days (around day 1200) to ~0.96 and ~0.90 days (around day 400 and day 1400) respectively [32].
• Irregular dimming events are the result of random density fluctuations in the bulk of Nucleus.

7. Long-Term Radio Variability

H. K. Vedantham, *et al.* report the discovery of a rare new form of long-term radio variability in the light-curves of active galaxies (AG)—Symmetric Achromatic Variability (SAV)—a pair of opposed and strongly skewed peaks in the radio flux density observed over a broad frequency range. They propose that SAV arises through gravitational milli-lensing when relativistically moving features in AG jets move through gravitational lensing caustics created by macroobject with mass in the range $(10^3 - 10^6)M_{\odot}$ —a range that embraces intermediate-mass black holes, cores of globular clusters, dense molecular cloud cores, and compact dark matter halos [38].

WUM: Potential lens candidates with these properties are the following compact objects (**Table 1**):

• Cores of star clusters with shells built up from Dirac monopoles and masses of about $10^3 M_{\odot}$;
• Cores of galaxies with shells made up of preons and masses of up to $10^7 M_{\odot}$.

8. Gamma-Ray Bursts

Gamma-Ray Bursts (GRBs) status after 50 years of investigations looks as follows [6]:

• The intense radiation of most observed GRBs is believed to be released when a rapidly rotating, high-mass star collapses to form a neutron star, quark star, or black hole;
• Short GRBs appear to originate from merger of binary neutron stars;
• Seven known soft gamma repeaters are not catastrophic astrophysical events.

WUM: The experimental results for GRBs have the following explanation [6]:

• Nature of GRBs—Nuclei and shells of galaxies made up of DMP;

• Gamma-ray bursts convert energy into radiation through annihilation of DMP;
• Spectrum of GRBs depends on composition of Nuclei and shells;
• Afterglow is a result of processes developing in the Nuclei and shells after detonation.

9. Fast Radio Bursts

The Lorimer Burst (FRB 010724) was discovered in 2007 in archived data taken in 2001. Just after the publication of the e-print with the first discovery, it was proposed that Fast Radio Bursts (FRBs) could be related to hyperflares of magnetars. A more likely explanation is a merger of a pair of neutron stars which form a black hole. Later it was suggested that following dark matter-induced collapse of pulsars, the resulting expulsion of the pulsar magnetospheres could be the source of fast radio bursts (see [6] and references therein).

L. G. Spitler, *et al.* [39] and P. Scholz, *et al.* [40] report on simultaneous X-ray, gamma-ray, and radio observations of the repeating Fast Radio Burst FRB 121102. They have detected six additional radio bursts from this source for a total of 17 bursts from this source. This repeating FRB is inconsistent with all the catastrophic event models put forward previously for FRBs.

V. Gajjar, *et al.* detected 15 bursts at 4 - 8 GHz band from FRB 121102 which is the only one known to repeat: more than 150 high-energy bursts have been observed coming from the dwarf galaxy about 3 billion light years from Earth [41]. These are the highest frequency and widest bandwidth detections of bursts from FRB 121102 obtained to-date [42].

Z. G. Dai, *et al.* propose a different model, in which highly magnetized pulsars travel through asteroid belts of other stars and show that a repeating FRB could originate from such a pulsar encountering lots of asteroids in the belt [43].

WUM: At high temperatures, preon dipoles break up into two preons with mass about $m_{pr} = 1/3\, m_e$ and charge $e_{pr} = 1/3\, e$ [6]. FRBs are the result of preons' plasma instability triggering shock waves of gigantic electrical currents and generating huge amount of energy in transient radio pulses. The described picture is consistent with experimental results for FRBs [44]:

• Transient gamma-ray counterpart to FRB 131104 with output energy $E_\gamma \approx 5 \times 10^{44}\, J$ is 10 orders of magnitude smaller than the maximum energy of preons' plasma shell (see **Table 1**);

• Gamma rays in the range 15 - 150 keV are a consequence of preons' annihilation with mass $m_{pr} \cong 170\ keV/c^2$.

Repeating FRBs can be explained by galaxy Hyper-flares analogous to Solar flares [6].

10. Starburst Galaxies

Wikipedia has this to say about Starburst Galaxies:

A starburst galaxy is a galaxy undergoing an exceptionally high rate of star formation. Astronomers typically classify starburst galaxies based on their most distinct observational characteristics. Some of the categorizations include Ultraluminous and Hyperluminous Infrared Galaxies. These galaxies are generally extremely dusty objects. The ultraviolet radiation produced by the obscured star - formation is absorbed by the dust and reradiated in the infrared spectrum at wavelengths of around 100 micrometers [Starburst galaxy].

SDSS J1148 + 5251 is one of the most distant quasar (z = 6.42) with light-travel distance 13 billion light-years. It has been extensively studied at many wavelengths (see [45] and references therein). It is a Hyperluminous Infrared Galaxy [$L_{IR} = (2-3) \times 10^{13} L_\odot$] with the observed maximum rest frame wavelength about 60 microns. A conversion of L_{IR} into star formation rate gives 3500 - 5000 $M_\odot/yr$. Its' dynamical mass is about $5 \times 10^{10} M_\odot$, dust mass is $(1-4) \times 10^8 M_\odot$ and dust temperature 50 - 60 K. In words of F. Galliano, *et al.* "*It challenges our understanding of dust formation in extreme environments: how could such a high mass of dust have formed in only a few 100 Myr?*" [45]

WUM: According to the Model, "dust particles" are Bose-Einstein Condensate (BEC) drops of dineutrinos whose mass is about Planck mass M_P and their temperature is around 29 K in the present epoch [3]. The temperature of BEC drops is decreasing in time proportional to the fourth root of the cosmological time $\propto \tau^{-1/4}$. The ages of the World are about 14.2 and of the SDSS J1148 + 5251 about 1.2 billion years respectively. Then the BEC drops temperature at that time was about 54 K that is in good agreement with the measured value. In our opinion, BEC drops with masses about Planck mass are the smallest building blocks that participate in Macroobjects creation [3]. Observed Ultraluminous (ULIRG) and Hyperluminous Infrared Galaxies (HLIRG) are in fact huge clouds of BEC drops of dineutrinos which are in fact Cradles of Macroobjects.

Chao-Wei Tsai, *et al.* present 20 highly obscured Wide-field Infrared Survey Explorer (WISE)-selected galaxies with bolometric luminosities $L_{bol} > 10^{14} L_{\odot}$, including five with infrared luminosities $L_{IR} \equiv L_{(8-1000\ \mu m)} > 10^{14} L_{\odot}$. WISE J224607.57-052635.0 is an Extremely Luminous Infrared Galaxy which, in 2015, was announced as the most luminous galaxy in Universe ($L = 3.49 \times 10^{14} L_{\odot}$). The light emitted by the quasar with mass $\sim 10^{10} M_{\odot}$ is converted to infrared rays by the galaxy's dust. The galaxy releases 10,000 times more energy than the Milky Way galaxy, although WISE J224607.57-052635.0 is smaller than the Milky Way galaxy. It has a light-travel distance of 12.5 billion light-years away from Earth [46].

WUM: In our opinion, ULIRG and HLIRG are in fact active Cores of galaxy clusters which have the maximum mass of about $1.2 \times 10^{41}\ kg$ in present epoch (see **Table 1**). Mass of galaxy clusters is increasing in time $\propto \tau^{3/2}$. The age of WISE J224607.57-052635.0 is about 1.7 billion years. Then the maximum mass of the galaxy cluster Core at that time was about $0.5 \times 10^{40}\ kg$ that is in good agreement with the evaluated mass. In frames of the developed picture, much higher energy released by WISE J224607.57-052635.0 relatively to the Milky Way galaxy has a reasonable explanation.

The archetype starburst galaxy Arp 220 appears to be a single, odd-looking galaxy, but is in fact a nearby example of the aftermath of a collision between two spiral galaxies with the cores of the parent galaxies 1200 light-years apart. Observations with NASA's Chandra X-ray Observatory have also revealed X-rays in the range 2 - 10 keV coming from both cores [47]. The collision, which began about 700 million years ago, has sparked a cracking burst of star formation, resulting in about 200 huge star clusters in a packed, dusty region about 5000 light-years across [48]. N. Z. Scoville, *et al.* inferred a dynamical mass of $(3-6) \times 10^{10} M_{\odot}$ within $r \cong 1.5\ kpc$ [49].

It is an Ultraluminous Infrared Galaxy (ULIRG), about 250 million light-years away from Earth. Almost 99% of its total energy output is in the infrared with total luminosity of $2 \times 10^{12} L_{\odot}$. IRAS observations of the galaxy Arp 220 give the following data for average Flux Densities (FD) at different wavelengths: $FD_{12\ \mu m} = 0.48$; $FD_{25\ \mu m} = 8.5$; $FD_{60\ \mu m} = 124$; $FD_{100\ \mu m} = 149\ Jy$. It is extremely luminous in the Far-infrared [50].

The heart of Arp 220 is highly obscured by dust that can't be penetrated by the radiation with visible wavelengths. But radio waves can travel through such a dense environment to reach telescopes on Earth. F. Batejat, *et al.* have resolved for the first time, 11 of the 17 detected sources at 2, 8, and 3.6 cm wavelength, and have spotted a record-breaking seven supernovae all found at the same time. Astronomers estimate that the Milky Way galaxy sees only a single supernova every hundred year, on average [51].

Through analysis of 7.5 years of Fermi/LAT observations, Fang-Kun Peng, *et al.* found high-energy gamma-ray emission in the range 0.2 - 100 GeV from Arp 220. This is the first-time detection of GeV emission from an ULIRG. There is a clear positive empirical relation between the γ-ray luminosity $L_{0.1-100\ GeV}$ and total infrared luminosity $L_{8-1000\ \mu m}$ and between the gamma-ray luminosity and radio luminosity [52].

WUM: The observed experimental results testify that Arp220 is the Core of galaxy cluster:

• Two spiral galaxies have already been created;
• There are about 200 huge star clusters in a packed, dusty region ~5,000 light-year across;
• A record-breaking seven supernovae all found at the same time;
• A dynamical mass of $(3-6)\times 10^{10} M_{\odot}$ within $r \cong 1.5\ kpc$ corresponds to the maximum mass of the galaxy cluster Core with a sterile neutrinos shell $\sim 10^{41}\ kg$ (see **Table 1**);
• Maximum flux density of Far-infrared radiation at wavelength 100 μm can be explained by BEC drops of dineutrinos;
• Gamma-rays in the range 2 - 10 keV coming from both spiral galaxies are the result of sterile neutrinos annihilation with mass 3.7 keV;
• High-energy gamma-ray emission in the range 0.2 - 100 GeV is the consequence of neutralinos and WIMPs annihilation in stellar formation processes.

Far-infrared emission (FIR) of the sky is generally thought to originate mainly in cold dust grains distributed in space. The FIR emission of galaxy clusters may be considered therefore as a tracer of the dust constituent of the intracluster medium. Based on IRAS and COBE/DIRBE sky surveys it was found excess FIR emission from the sky area occupied by galaxy cluster ZW5897. Very good positional and extensional coincidence between infrared source and ZW5897 may suggest intracluster origin of the emission which has the highest intensities in the 100, 140 and 240 μm bands. B. Wszołek studied the distribution of stars and galaxies in the cluster area and found that a foreground obscuring cloud, overlapping accidentally the distant cluster ZW5897, may be responsible for some part of the detected FIR emission [53].

WUM: According to the Model, FIR emission with the highest intensities in the 100, 140 and 240 μm bands is originating in the intracluster medium of ZW5897 filled with BEC drops of dineutrinos.

As the conclusion: ULIRG and HLIRG are in fact Starburst Galaxy Clusters.

11. Gravitational Waves

Some cosmological problems like the dark energy and dark matter problems could be solved through extended theories of gravity. In fact, extended gravity is also connected with the recent detections of gravitational waves by the LIGO collaboration [54]. An important work on these issues is published in 2009 [55].

Galaxy/stellar formation in a packed, dense environment of ULIRG and HLIRG can produce many interesting objects and exotic binary systems. Dynamical interactions in Active Galaxy Clusters (AGC) can eject a lot of compact binary systems that could be potential sources of Gravitational Waves (GWs). In frames of WUM, it can be binaries of:

• Neutron stars;
• WIMP stars;
• Neutralino stars;
• White dwarfs with masses about M which are Cores of stellar systems.

It can be also binaries of compact DIRAC stars with shells made of Dirac's monopoles. They have masses up to $10^3 M_\odot$ and sizes about the Earth size (see **Table 1**). DIRAC stars are Cores of stellar clusters in WUM. Binaries of them are the most interesting, because they have masses in the range of the masses of compact binary objects responsible for the observed GWs (30 and up to 60 solar masses [54]).

Due to the packed, dense environment of ULIRG and HLIRG DIRACs binaries can have short gravitational wave merger times. Their merger generates GWs which can penetrate through such a dense environment. The heart of ULIRG and HLIRG is highly obscured by BEC drops that can't be penetrated by radiation with visible wavelengths. In our opinion, a merger of compact DIRAC stars inside of Active Galaxy Clusters like Ultraluminous and Hyperluminous Infrared Galaxies can be a source of Gravitational waves.

Transient Astrophysics is a rapidly growing field, now operating across all wavelengths from gamma-rays to radio waves. Hypersphere World-Universe Model can serve as a basis for Transient Astrophysics.

Acknowledgements

I am grateful to reviewer for the important critical remarks. Many thanks to Prof. F. Giovanelli and all participants of Frascati Workshop 2017 for inspiring discussions of WUM in Palermo, Italy. Special thanks to my son I. Netchitailo who questioned every aspect of the paper and helped shape it to its present form.

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Analysis of Maxwell's Equations. Cosmic Magnetism

Abstract

According to Hypersphere World – Universe Model, dark matter particles DIRACs are magnetic dipoles consisting of two Dirac's monopoles. We conclude that DIRACs are the subject of Maxwell's equations. So-called "auxiliary" magnetic field intensity H is indeed current density of magnetic dipoles. The developed approach to magnetic field can explain a wealth of discovered phenomena in Cosmic Magnetism: a dark magnetic field, the large-scale structure of the Milky Way's magnetic field, and other magnetic phenomena which are only partly related to objects visible in other spectral ranges.

Keywords. "Hypersphere World – Universe Model"; "Maxwell's equations"; "Dirac's Monopole"; "Magnetic Dipole"; "Magnetic Field Intensity"; "Magnetic Dipoles Current Density"; "Cosmic Magnetism"; "Dark Magnetic Field"

1. Introduction

Maxwell's equations (ME) form the foundation of classical electrodynamics. The value of ME is even greater once 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 equation [1].

H. 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 [2]. It allows us to use formal analogies between Electromagnetism and Gravitoelectromagnetism [3] proposed by Oliver Heaviside in 1893. Hypersphere World – Universe Model is based on Maxwell's equations [3].

2. Analysis of Maxwell's Equations

Maxwell's equations vary with the unit system used. We will not rewrite well-known equations, but only provide the relationships between electromagnetic quantities used in ME. **Table 1** gives the definitions of these quantities in SI units. Electrodynamic constant c is defined as the ratio of the absolute electromagnetic unit of charge to the absolute electrostatic unit of charge [3].

In ME, there are two physical sources: the total electric charge density ρ and the total electric current density $\boldsymbol{J}$. According to ME, there are two measurable physical characteristics: energy density ρ_E and energy flux density $\boldsymbol{J}_E$.

It is interesting to proceed with Maxwell's equations for Electromagnetism and Gravitoelectromagnetism when the physical sources are energy density ρ_E and energy flux density $\boldsymbol{J}_E$ which coincide with the same measurable physical characteristics.

To apply ME, it is necessary to specify the constitutive relations:

$$\boldsymbol{D} = \varepsilon_0 \boldsymbol{E}$$

$$\boldsymbol{H} = \frac{1}{\mu_0} \boldsymbol{B}$$

The original equations given by Maxwell included Ohms law in the following form:

$$\boldsymbol{E} = \rho_r \boldsymbol{J}$$

where ρ_r is the resistivity. In ME we can take the value of ρ_r to equal

$$\rho_r = Z_0 \times a$$

where a is the basic unit of size: $a = 2\pi a_0$, a_0 being the classical electron radius. The total electric charge Q enclosed in the volume V is the volume integral over V of the electric charge density ρ :

$$Q = \iiint \rho \, dv$$

Table 1. Electromagnetism

Charge	Impedance of Electromagnetic Field	Magnetic Flux
q, C	$Z_0 = \sqrt{\mu_0 / \varepsilon_0} = \mu_0 c, \Omega$	ϕ, Wb
Electric Current	Magnetic Constant	Electric Potential
I, A	$\mu_{0,} \; Hm^{-1}$	U, V
Magnetic Field Intensity	Electric Constant	Electric Field
$\boldsymbol{H}, Am^{-1}$	$\varepsilon_0 = (\mu_0 c^2)^{-1}, Fm^{-1}$	$\boldsymbol{E}, Vm^{-1}$
Electric Flux Density	Electrodynamic Constant	Magnetic Flux Density
$\boldsymbol{D}, Cm^{-2}$	c, ms^{-1}	$\boldsymbol{B}, Wbm^{-2}$

The net electric current I is the surface integral of the electric current density $\boldsymbol{J}$ passing through a fixed surface S:

$$I = \iint \boldsymbol{J} \, d\boldsymbol{s}$$

Electric potential U is the line integral along a curve L of the electric field $\boldsymbol{E}$:

$$U = \int \boldsymbol{E} \, d\boldsymbol{l}$$

The magnetic flux is the surface integral of the magnetic flux density $\boldsymbol{B}$ passing through a fixed surface S:

$$\phi = \iint \boldsymbol{B} \, d\boldsymbol{s}$$

We emphasize that all these quantities in ME can be calculated based on physical sources ρ and $\boldsymbol{J}$. There are two auxiliary field quantities:

$$\boldsymbol{D} = \varepsilon_0 \boldsymbol{E} + \boldsymbol{P}$$

$$\boldsymbol{H} = \frac{1}{\mu_0} \boldsymbol{B} - \boldsymbol{M}$$

The quantities $\boldsymbol{P}$ and $\boldsymbol{M}$ represent the macroscopically averaged electric dipole and magnetic dipole moment densities of the material medium in the presence of applied fields. Analysis of ME in which all quantities introduced above are arbitrary functions of space and time has been done in literature (see, for example [4], [5]).

Maxwell's equations posit that there is electric charge, but no magnetic charge (magnetic monopole) in the World. K. Brown has this to say about magnetic dipole fields [6]:

There do, however, exist what appear to be magnetic dipoles, analogous to electric dipoles consisting of adjacent positive and negative electric charges. It might seem as if the existence of magnetic dipoles is indirect proof of the existence of individual magnetic charges, assuming the only way to produce a dipole field is by juxtaposing two oppositely charged magnetic monopoles. However, there is an alternative way of creating a magnetic "dipole" field without actually using magnetic charges. The alternative is an electric current loop. It can be shown that a circular loop of electric current produces a magnetic field that is (outside a spherical region enclosing the loop) nearly identical to the field of two adjacent and oppositely charged magnetic monopoles (if such things existed). So, we have two possible classical models for the source of "magnetic dipole" fields, one based on the juxtaposition of two oppositely charged magnetic monopoles, and one based on a loop of electric current. These two models might be called Coulombic and Amperean dipoles respectively.

M. Mansuripur compared two versions of the Poynting vector $\boldsymbol{S} = \frac{1}{\mu_0}\boldsymbol{E} \times \boldsymbol{B}$ and $\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$. He argues *that the identification of one or the other of these Poynting vectors with the rate of flow of electromagnetic energy is intimately tied to the nature of magnetic dipoles and the way in which these dipoles exchange energy with the electromagnetic field. Hidden energy and hidden momentum can be avoided, however, if we adopt* $\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$ *as the true Poynting vector, and also accept a generalized version of the Lorentz force law.* He concludes *that the identification of magnetic dipoles with Amperian current loops, while certainly acceptable within the confines of Maxwell's macroscopic equations, is inadequate and leads to complications when considering energy, force, torque, momentum, and angular momentum in electromagnetic systems that involve the interaction of fields and matter* [4].

K. Brown emphasizes *the difference between the* $\boldsymbol{B}$ *and the* $\boldsymbol{H}$ *fields. Outside any magnetic material,* $\boldsymbol{B}$ *and* $\boldsymbol{H}$ *are strictly proportional to each other, but inside magnetic material they are quite different. The potential energy density of a magnetic field is really* $\frac{1}{2}\boldsymbol{B} \cdot \boldsymbol{H}$ *, and reduces to* $\frac{1}{2\mu_0}\boldsymbol{B}^2$ *only outside of any magnetic material* [6].

According to Hypersphere World – Universe Model (WUM), the Medium of the World consists of the following elementary particles [7]:

- Protons and electrons with mass m_p and m_e and electric charge e;
- Mass-varying neutrinos and photons;
- Dark Matter Particles (DMP) including fermions (neutralinos, WIMPs, and sterile neutrinos) and bosons:

- ELOPs with mass $\frac{2}{3}m_e$ that are electric dipoles of preons with electric charges $\frac{1}{3}e$. They represent the macroscopically averaged electric dipole moment density $\boldsymbol{P}$ of the Medium of the World with energy density about the proton energy density [7].
- DIRACs with mass m_0 which are magnetic dipoles of Dirac's monopoles with magnetic charges $\mu = \frac{e}{2\alpha}$, where $\alpha = \frac{m_e}{m_0}$ (m_0 is the basic unit of mass $m_0 = \frac{h}{ac}$, h is Planck constant) [7].

In our opinion, DIRACs are the Coulombic magnetic dipoles as was discussed by K. Brown [6]. Their energy density in the Medium of the World is about the proton energy density [7]. They represent the macroscopically averaged magnetic dipole moment density $\boldsymbol{M}$ of the Medium in the presence of applied fields.

It is well-known that the dimension of the magnetic field intensity $[\boldsymbol{H}] = Am^{-1}$. We can rewrite it in the following way:

$$[\boldsymbol{H}] = \frac{Cm}{m^2 s} = \frac{[\mathbf{d}_\mathrm{m}]}{m^2 s} = [\boldsymbol{J_m}]$$

where $\boldsymbol{d}_m$ is a magnetic dipole momentum. It looks like magnetic field intensity $\boldsymbol{H}$ is, in fact, the current density $\boldsymbol{J_m}$ of magnetic dipoles d_m . In our opinion, the magnetic field intensity $\boldsymbol{H}$ is not an "auxiliary" field quantity. On the contrary, it is a real magnetic field quantity. That is why $\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$ is the true Poynting vector and $\frac{1}{2}\boldsymbol{B} \cdot \boldsymbol{H}$ is the true potential energy density of a magnetic field.

Let's calculate the value of magnetic dipole momentum $\boldsymbol{d}_m$. We'll start from the original equations. The Dirac's quantization equation introduces the magnetic monopole:

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

where n is an integer, and e and μ are electromagnetic charges. Considering the following well-known equation

$$\frac{e^2}{4\pi\varepsilon_0} = \frac{\alpha hc}{2\pi}$$

for $n = 1$ we obtain the minimum magnetic charge $\mu = \frac{e}{2\alpha}$. Impedance of electromagnetic field Z_0 equals to

$$Z_0 = \frac{1}{\varepsilon_0 c} = \frac{h}{e\mu}$$

Using the equations for Z_0 and μ derived above, we obtain the magnetic parameter μ_0 :

$$\mu_0 = \frac{h}{e\mu c}$$

Using the constitutive relation

$$\boldsymbol{B} = \mu_0 \boldsymbol{H} = \mu_0 \boldsymbol{J}_m$$

we can express the magnetic flux with the following equation:

$$\phi = \mu_0 \iint \boldsymbol{J}_m \, d\boldsymbol{s} = \mu_0 I_m$$

where I_m is the current of magnetic dipoles d_m. Magnetic flux quantum ϕ_0 can then be expressed as follows:

$$\phi_0 = \frac{h}{2e} = \mu_0 I_0 = \frac{h}{e\mu c}\frac{\mu c}{2}$$

and the quant of magnetic dipole current I_0 is:

$$I_0 = \frac{\mu c}{2} = \frac{\frac{\mu a}{2}}{t_0}$$

where t_0 is the basic unit of time [7]:

$$t_0 = \frac{a}{c}$$

It means that the magnetic flux ϕ is the current of the magnetic dipoles:

$$d_m = \frac{\mu a}{2}$$

which are DIRACs in WUM. DIRACs have negligible electromagnetic charges, since the separation between charges μ is very small $a/2$. They do, however, possess a substantial magnetic dipole momentum $\boldsymbol{d}_m$. The same conclusion can be derived for ELOPs – electric dipoles made of two preons with charges $\frac{1}{3}e$.

To summarize, magnetic monopoles are not the subject of Maxwell's equations; instead, magnetic dipoles DIRACs are. So-called "auxiliary" magnetic field intensity $\boldsymbol{H}$ is indeed current density of magnetic dipoles.

3. Cosmic Magnetism

R. Beck and R. Wielebinski have this to say about Cosmic Magnetism:

Most of the visible matter in the Universe is ionized, so that cosmic magnetic fields are quite easy to generate and due to the lack of magnetic monopoles hard to destroy. Magnetic fields have been measured in or around practically all celestial objects, either by in-situ measurements of spacecrafts or by the electromagnetic radiation of embedded cosmic rays, gas or dust. The Earth, the Sun, solar planets, stars, pulsars, the Milky Way, nearby galaxies, more distant (radio) galaxies, quasars and even intergalactic space in clusters of galaxies have significant magnetic fields, and even larger volumes of the Universe may be permeated by "dark" magnetic fields [8].

In frames of WUM, the similarity of field patterns and flow patterns of the diffuse ionized gas [8] can be explained by the flow of DIRACs along with diffuse ionized gas. The large-scale structure of the Milky Way's magnetic field [9], a dark magnetic field [10] and other magnetic phenomena which are only partly related to objects visible in other spectral ranges [8] can be explained by flows of dark matter particles DIRACs. We believe that the developed approach to magnetic field can answer questions on the origin and evolution of magnetic fields such as their first occurrence in young galaxies, or the existence of large-scale intergalactic fields [8]. Hypersphere World – Universe Model can serve as a basis for Cosmic Magnetism.

Acknowledgements

Special thanks to my son Ilya Netchitailo who helped shape this paper.

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Hypersphere World-Universe Model. Tribute to Classical Physics

Abstract

This manuscript summarizes the results of Classical Physics before Quantum Mechanics and Hypotheses proposed by classical physicists from the 17th until the beginning of 21st century. We then proceed to unify these results into a single coherent picture in frames of the developed Hypersphere World-Universe Model (WUM). The Model proposes 5 types of Dark Matter particles and predicts their masses; models the origin, evolution, and structure of the World and Macroobjects; provides a mathematical framework that ties together a number of Fundamental constants and allows for direct calculation of their values.

Keywords. "Classical Physics"; "Hypersphere World–Universe Model"; "Medium of the World"; "Dark Matter Particles"; "Gravitoelectromagnetism"; "Cosmic Neutrino Background" "Macroobjects Structure"; "Emergent Phenomena"; "Q-Dependent Cosmological Parameters"

1. Introduction

This manuscript concludes the series of papers [1] – [9] published by "Journal of High Energy Physics, Gravitation and Cosmology" journal. Many results obtained there are quoted in the current work without a full justification; an interested reader is encouraged to view the referenced papers in such cases. The article does not provide an overview of Hypersphere World-Universe Model (WUM), please refer to manuscripts for that.

In this paper, we show that WUM is a natural continuation of Classical Physics. The Model makes use a number of Hypotheses proposed by classical physicists from the 17th until the beginning of 21st century. The presented Hypotheses are not new, and we don't claim credit for them. In fact, we are developing the existent Hypothesis and proposing new Hypothesis in frames of WUM. The main objective of the Model is to unify and simplify existing results in Classical Physics into a single coherent picture.

WUM is a classical model. It should then be described by classical notions, which define emergent phenomena. 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, simple interactions occur at a microscopic level, and the collective result can be observed at a macroscopic level. WUM introduces classical notions, when the very first ensemble of particles was created at the cosmological time $\cong 10^{-18}\ s$. The World at cosmological times less than $10^{-18}\ s$ is best described by Quantum Mechanics [1].

In **Part 2** we present principal milestones in Classical Physics and show that all the most important Fundamental Physical constants were measured and could be calculated before Quantum Mechanics. Analysis of Hypotheses proposed by classical physicists and developing them in frames of WUM are given in **Part 3**. In **Part 4** we propose Hypotheses of Hypersphere World-Universe Model. In **Part 5** Assumptions, Evidence, Principle Points and Predictions of WUM are discussed.

2. Classical Physics

In this Section we describe principal milestones in Classical Physics. Based on the analysis of measured physical constants we make a conclusion that the most important Fundamental constants could be calculated before Quantum Mechanics.

Kinetic Theory of Gases explains macroscopic properties of gases, such as pressure, temperature, viscosity, thermal conductivity, and volume, by considering their molecular composition and motion. In 1859, James Clerk Maxwell formulated the Maxwell distribution of molecular velocities, which gave the proportion of molecules having a certain velocity in a specific range [10]. This was the first-ever statistical law in Physics that defines macroscopic properties of gases as emergent phenomena.

Maxwell's equations were published by J. C. Maxwell in 1861 [11]. He calculated the velocity of electromagnetic waves from the value of the electrodynamic constant c measured by Weber and Kohlrausch in 1857 [12] and noticed that the calculated velocity was very close to the velocity of light measured by Fizeau in 1849 [13]. This observation made him suggest that light is an electromagnetic phenomenon [14].

Rydberg constant R_∞ is a physical constant relating to atomic spectra. The constant first arose in 1888 as an empirical fitting parameter in the Rydberg formula for the hydrogen spectral series [15]. As of 2012, R_∞ is the most accurately measured Fundamental physical constant. The Rydberg constant can be expressed as in the following equation:

$$R_\infty = \frac{\alpha^3}{2a}$$

where α is Sommerfeld's constant and is, in fact, the ratio of electron mass m_e to the basic unit of mass m_0 : $\alpha = m_e/m_o$ and m_0 equals to: $m_0 = h/ac$, where h is Planck constant, a is the basic unit of length: $a = \alpha\lambda_e$ and λ_e is the Compton wavelength of an electron: $\lambda_e = h/m_e c$.

Electron Charge-to-Mass Ratio e/m_e is a Quantity in experimental physics. It bears significance because the electron mass m_e cannot be measured directly. The e/m_e ratio of an electron was successfully calculated by J. J. Thomson in 1897 [16]. We define it after Thomson: $R_T \equiv e/m_e$.

Planck Constant was suggested by Max Planck as the result of the investigations the problem of black-body radiation. He used Boltzmann's famous equation from Statistical Thermodynamics: $S = k_B \ln W$ that shows the relationship between entropy S and the number of ways the atoms or molecules of a thermodynamic system can be arranged (k_B is the Boltzmann constant).

As the result of his analysis, Planck found that the average resonator entropy must be described by a function which depends on the ratios U/ν and U/E at the same time (U is vibrational energy of vibrating resonator). Planck reconciled those two requirements through $E = h\nu$ in which h represents a factor that converts units of frequency ν into units of energy E. Planck was able to calculate the value of h from experimental data on black-body radiation: his result in 1901, $h = 6.55 \times 10^{-34}\, J \cdot s$, is within 1.2% of the currently accepted value. He was also able to make the first determination of k_B from the same data and theory: his result, $k_B = 1.346 \times 10^{-23}\, J/K$, is about 2.5% lower than today's figure [17]. We emphasize that Planck constant, which is generally associated with the behavior of microscopically small systems, was introduced by Max Planck based on Statistical Thermodynamics before Quantum Mechanics.

Classical Fundamental Physical Constants. Based on the experimentally measured values of the constants R_∞ , R_T , c , h we calculate the most important Fundamental constants as follows:

$$R_T^2 = (\frac{e}{m_e})^2 = \frac{2\alpha hc}{\mu_0 m_e^2 c^2} = \frac{2}{\alpha\mu_0 h/c}(\frac{\alpha h}{m_e c})^2 = \frac{2}{\mu_0 h/c} \times \frac{a^2}{\alpha}$$

where μ_0 is the magnetic constant: $\mu_0 = 4\pi \times 10^{-7}\ H/m$. Then we can find the following equations:

$$R_\infty^2 \times R_T^2 = \frac{\alpha^6}{4a^2} \times \frac{a^2}{\alpha} \times \frac{2}{\mu_0 h/c} = \alpha^5 \times \frac{1}{2\mu_0 h/c}$$

$$R_\infty \times R_T^6 = \frac{\alpha^3}{2a} \times \frac{a^6}{\alpha^3} \times (\frac{2}{\mu_0 h/c})^3 = a^5 \times \frac{4}{(\mu_0 h/c)^3}$$

Now we obtain:

$$\alpha = [2(\mu_0 h/c) R_\infty^2 R_T^2]^{1/5}$$

$$a = [\frac{(\mu_0 h/c)^3 R_\infty R_T^6}{4}]^{1/5}$$

$$m_e = \frac{h}{c}[\frac{8R_\infty}{(\mu_0 h/c)^2 R_T^4}]^{1/5}$$

$$e = (\frac{2\alpha h/c}{\mu_0})^{1/2}$$

All these Fundamental constants, including classical electron radius $a_o = a/2\pi$, were measured and could be calculated before Quantum Mechanics.

3. Hypotheses Revisited by WUM

Hypersphere World-Universe Model is based on classical physics and makes use of a number of hypotheses unknown and forgotten by mainstream scientific community. Below we will describe the Hypotheses belonging to classical physicists such as Le Sage, McCullagh, Riemann, Heaviside, Bjerknes, Tesla, Dirac, and Sakharov, and develop them in frames of WUM. Please pay tribute to these great physicists!

According to WUM, two Fundamental Parameters in various rational exponents define all macro features of the World: Sommerfeld's constant α and dimensionless quantity Q. While α is constant, Q increases with time, and is, in fact, the dimensionless Age of the World. It can be calculated from the value of the gravitational parameter G [4] :

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

Three Fundamental Units define all physical dimensional parameters of the World: momentum $p_0 = h/a$, energy density $\rho_0 = hc/a^4$, and energy flux density $J_0 = hc^2/a^4$. For all particles under consideration we use four-momentum to conduct statistical analysis of particles' ensembles, obtaining the energy density as the result. From classical point of view, we utilize three characteristics: type of particle (fermion or boson), mass, and charge.

3.1. Aether

Physical Aether was suggested as early as 17th century, by Isaac Newton. Following the work of Thomas Young (1804) and Augustin-Jean Fresnel (1816), it was believed that light propagates as a transverse wave within an elastic medium called Luminiferous Aether. At that time, it was realized that Aether could not be an elastic matter of an ordinary type that can only transmit longitudinal waves.

Unique properties of Aether were discussed by James McCullagh in 1846 who proposed a theory of a rotationally elastic medium, i.e. a medium in which every particle resists absolute rotation. 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 [18]. Aether with these properties can transmit transverse waves.

Luminiferous Aether was abandoned in 1905. In later years there have been classical physicists who advocated the existence of Aether:

- Nikola Tesla declared in 1937 in "Prepared Statement on the 81st birthday observance": *All attempts to explain the workings of the universe without recognizing the existence of the aether and the indispensable function it plays in the phenomena are futile and destined to oblivion* [19];
- Paul Dirac stated in 1951 in an article in Nature, titled "Is there an Aether?" that *we are rather forced to have an aether* [20].

WUM introduces the Medium of the World, which is an Aether composed of stable elementary particles: protons, electrons, photons, neutrinos, and Dark Matter particles. The existence of the Medium is a principal point of WUM. It follows from the observations of Intergalactic Plasma; Cosmic Microwave Background Radiation; Far-Infrared Background Radiation; Gamma-ray Background Radiation. According to WUM, inter-galactic voids discussed by astronomers are, in fact, examples of the Medium in its purest. The Medium is the absolute frame of reference [1].

The total energy density of the Medium ρ_M is 2/3 of the total energy density of the World ρ_W in all cosmological times. All Macroobjects (MOs) are built from the same particles. The energy density of MOs adds up to 1/3 of the total energy density throughout the World's evolution [5].

3.2. Le Sage's Theory of Gravitation

Wikipedia summarizes this theory as *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.*

Lyman Spitzer in 1941 calculated that absorption of radiation between two dust particles leads to a net attractive force, which varies proportionally to $1/r^2$ [21]. The Le Sage mechanism also has been identified as a significant factor in the behavior of dusty plasma [22].

Attempts are made to rehabilitate the theory (see, for example references [23] - [30]). In this respect, we would like to stress the importance of extended theories of gravity in the debate about gravitation, as it is clarified by C. Corda in "Interferometric detection of gravitational waves: the definitive test for General Relativity" [31]. A possibility that gravity is not an interaction, but a manifestation of a symmetry based on a Galois field is discussed by F. Lev in "Is Gravity an Interaction?" [32].

WUM introduces the Cosmic Neutrino Background (CNB), which is indeed a space-filling and isotropic flux. CNB has an energy density ρ_{CNB} about 69% of the total energy density of the Medium ρ_M that provides high intensity of CNB [3].

One may wonder – if there are so many neutrinos out there, how come the numerous neutrino detectors do not register them in significant quantities? Calculated Fermi energies for CNB [5] show that it consists of very low-energy neutrinos. Their interaction with matter is 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.

By analogy between Electromagnetism and Gravitoelectromagnetism, we rewrite Dirac's quantization condition for electron and monopole charges for masses m and M [5]:

$$mM = 0.5M_P^2$$

Two particles or microobjects will not exert gravity on one another when both of their masses are smaller than the Planck mass M_P . Planck mass can then be viewed as the mass of the smallest Macroobject (MO) capable of generating the gravitational field and serves as a natural borderline between classical and quantum physics [4]. It means that for the realization of Le Sage's mechanism of gravitation at least one material object must be MO. The validity of this statement follows from the work of L. Spitzer [21] and A. M. Ignatov [22].

To summarize:

- Le Sage's theory of gravitation defines Gravity as emergent phenomenon;
- Gravity is not an interaction but a manifestation of the Medium;
- The proposed mechanism of Gravitation resembles Le Sage's theory.

3.3. Hypersphere Universe

In 1854, Georg Riemann proposed a hypersphere as a model of a finite universe [33]. A hypersphere is the four-dimensional analog of a sphere. A regular three-dimensional sphere has a two-dimensional surface. Similarly, a 4-dimensional sphere has a 3-dimensional surface.

WUM: Before the Beginning of the World there was nothing but an Eternal Universe. About 14.2 billion years ago the World was started by a fluctuation in the Eternal Universe, and the Nucleus of the World, a 4-dimensional ball, was born. An extrapolated Nucleus radius at the Beginning was equal to a , that is chosen to fit the Age of the World. In WUM, a classical notion of "Size" can only be introduced when the very first ensemble of particles was created at the Nucleus radius about $a/\alpha^2 \cong 3 \times 10^{-10}\ m$.

The 3D World is a hypersphere that is the surface of the 4-ball Nucleus. All points of the hypersphere are equivalent; there are no preferred centers or boundary of the World [7]. The extrapolated energy density of the World at the Beginning was four orders of magnitude smaller than the nuclear energy density [5].

The principal point of WUM is that the energy density of the World ρ_W equals to the critical energy density ρ_{cr} , which can be found by considering a sphere of radius R_M and enclosed mass M, with a small test mass m on the periphery of the sphere. Mass M can be calculated by multiplication of ρ_{cr} by the volume of the sphere. The equation for ρ_{cr} can be found from the escape speed calculation for test mass m:

$$\rho_{cr} = \frac{3H^2c^2}{8\pi G} = 3\rho_0 \times Q^{-1} = \frac{3hc}{L_F^4}$$

where H is Hubble's parameter and L_F equals to: $L_F = a \times Q^{1/4}$ [7].

3.4. Gravitoelectromagnetism

Gravitoelectromagnetism (GEM) is the gravitational analog of electromagnetism. The analogy and GEM equations differing from Maxwell's equations by some constants were first published by O. Heaviside in 1893 [34]. WUM follows Heaviside's approach.

3.5. Creation of Matter

In 1964, F. Hoyle and J. V. Narlikar 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"[35]. In 1974, Paul Dirac discussed continuous creation of matter by additive mechanism (uniformly throughout space) and multiplicative mechanism (proportional to the amount of existing matter) [36].

WUM: 3D World is a hypersphere of 4-ball which is expanding in the Eternal Universe, so that its radius in the fourth spatial dimension is increasing with speed c that is the gravitoelectrodynamic constant [5]. The lightspeed expanding hyperspherical topology was proposed in [37], [38].

The surface of the 4-ball is created in a process analogous to sublimation. It is a well-known endothermic process that occurs when surfaces are intrinsically more energetically favorable than the bulk of a material, and hence there is a driving force for surfaces to be created. Continuous creation of matter is the result of a similar process.

Matter arises from the fourth spatial dimension. The Universe is responsible for the creation of Matter. Dark Matter Particles (DMPs) carry new Matter in the World. DMPs are continuously absorbed by Dark Matter Cores of all Macroobjects (galaxy clusters, galaxies, star clusters, stars and planets) [5]. All visible Matter is re-emitted by all MOs as a result of DMPs annihilation.

It is important to emphasize that

- Creation of Matter is a direct consequence of expansion;
- Creation of Dark Matter (DM) occurs homogeneously in all points of the hypersphere World. Visible Matter is a by-product of DM annihilation.

Consequently, the matter-antimatter asymmetry problem discussed in "Characterization of the 1S–2S transition in antihydrogen" [39] does not arise.

3.6. Multi-Component Dark Matter

C. Boehm, P. Fayet, and J. Silk propose a way *to reconcile the low and high energy signatures in gamma-ray spectra, 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* [40].

WUM: There are two couples of coannihilating DMPs: a heavy Dark Matter Fermion 1 (DMF1) with mass 1.3 TeV and a light spin-0 boson – DIRAC with mass 70 MeV; a heavy fermion DMF2 with mass

9.6 GeV and a light spin-0 boson – ELOP with mass 340 keV. Besides, we introduce a light fermion DMF3 with mass 3.7 keV. The values of DM fermion masses fall into ranges estimated in literature for neutralinos, WIMPs, and sterile neutrinos respectively [2].

WUM postulates that masses of DMPs are proportional to a basic unit of mass m_0 multiplied by different exponents of α :

DMF1: $m_{DMF1} = \alpha^{-2} m_0$

DMF2: $m_{DMF2} = \alpha^{-1} m_0$

DIRACs: $m_{DIRAC} = 2\alpha^{0} m_0/2$

ELOPs: $m_{ELOP} = 2\alpha^{1} m_0/3$

DMF3: $m_{DMF3} = \alpha^{2} m_0$

DMF1, DMF2 and DMF3 are Majorana fermions, which partake in the annihilation interaction with strength equals to α^{-2}, α^{-1}, and α^{2} respectively. The signatures of DMPs annihilation with expected masses of 1.3 TeV; 9.6 GeV; 70 MeV; 340 keV; 3.7 keV are found in spectra of the diffuse gamma-ray background and the emission of various macroobjects in the World [2]. The role of those particles in MO Cores built up from fermionic dark matter is discussed in Sections 4.2 and 4.3.

3.7. Macroobjects

The existence of supermassive objects in galactic centers is now commonly accepted. Many non-traditional models explaining the supermassive dark objects observed in galaxies and galaxy clusters, formed by self-gravitating DM composed of fermions or bosons, are widely discussed in literature ([41] - [47]). The first phase of stellar evolution in the history of the World may be Dark Stars, powered by DM heating rather than fusion [48]. E. Ripamonti and T. Abel discuss the role of DM in the formation of Primordial Luminous Objects [49].

The prospect that DMPs might be observed in Centers of MOs has drawn many new researchers to the field. Indirect effects in cosmic rays and gamma-ray background from the annihilation of DM in the form of heavy stable neutral leptons in Galaxies were considered in pioneer articles [50] - [55].

WUM: All Macroobjects of the World have DM Cores surrounded by DM and baryonic shells. Annihilation of DMPs gives rise to any combination of gamma-ray lines [5].

The following facts support the existence of Cores in Macroobjects:

- A rapid rotation of the solar core has been suggested by García, *et al.*, who also gave an approximate estimate of the solar core (below 0.2 solar radius) rotation rate to be between three and five times faster than that of the radiative zone [56]. More accurate results were obtained by Fossat, *et al.*: core rotates 3.8 ± 0.1 faster than the radiative envelope [57];
- By analyzing the minute changes in travel times and wave shapes for earthquake doublets, Zhang, *et al.* concluded that the Earth's inner core is rotating faster than its surface by about 0.3 - 0.5 degrees per year [58];
- T. Guillot, *et al.* found that the deep interior of Jupiter rotates nearly as a rigid body, with differential rotation decreasing by at least an order of magnitude compared to the atmosphere [59].

The analysis of the Sun's heat for planets in Solar System yields the effective temperature of Earth of 255 K [60]. Mean surface temperature of Earth is 288 K [61]. The higher actual temperature of Earth is due to an energy generated internally by the planet itself. According to WUM, this energy is due to annihilation of DMPs in the Core of Earth [7].

The matter creation is occurring homogeneously in all points of the World. It follows that new stars and star clusters can be created inside of galaxies, and new galaxies and galaxy clusters can arise in the World. Structures form in parallel around different cores built from different DMPs. In WUM Dark Matter plays the main role inside of all MOs. Formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing [3].

It is interesting to note that in 1934 Dr. Tesla stated that he *is able to show that all the suns in the universe are constantly growing in mass and heat, so that the ultimate fate of each is explosion* [62].

3.8. Dirac Large Number Hypothesis

Dirac Large Number Hypothesis is an observation made by Paul Dirac in 1937 relating ratios of size scales in the Universe to that of force scales. The ratios constitute very large, dimensionless numbers, some 40 orders of magnitude in the present cosmological epoch. According to Dirac's hypothesis, the apparent equivalence of these ratios might not to be a mere coincidence but instead could imply a cosmology where the strength of gravity, as represented by the gravitational "constant" G, is inversely proportional to the cosmological time τ : $G \propto 1/\tau$ [63].

WUM follows the idea of time-varying G and introduces a dimensionless time-varying quantity Q, that is the Age of the World. G can be calculated from the value of the parameter Q:

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

which in present epoch equals to: $Q = 0.759972 \times 10^{40}$ [4].

3.9. Neutrinos

B. Pontecorvo and Y. Smorodinsky discussed possibility of energy density of neutrinos exceeding that of baryonic matter [64]. Neutrino oscillations imply that neutrinos have non-zero masses [65], [66].

WUM: According to the Model, the total energy density of neutrinos is about 69% of the critical energy density. WUM proposes the values of neutrinos mass eigenstates m_{ν_e}, m_{ν_μ}, m_{ν_τ} [3]:

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

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

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

3.10. Emergent Gravity, Space and Time

C. Barcelo, *et al.* have this to say about emergent gravity: *One of the more fascinating approaches to "quantum gravity" is the suggestion, typically attributed to Sakharov [67], [68] that gravity itself may not be "fundamental physics". Indeed, it is now a relatively common 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* [69].

WUM: Time and space are closely connected with Mediums' impedance and gravitomagnetic parameter. It follows that neither time nor space could be discussed in absence of the Medium. The gravitational parameter G that is proportional to the Mediums' energy density can be introduced only for the Medium filled with Matter. Gravity, Space and Time are all emergent phenomena [4].

In this regard, it is worth to recall the Einstein's quote: *When forced to summarize the theory of relativity in one sentence: time and space and gravitation have no separate existence from matter.*

4. Hypotheses of Hypersphere World-Universe Model

4.1. Dark Matter Bosons

The quantum theory of magnetic charge started with a paper by P. Dirac in 1931 in which he showed that if any magnetic monopoles exist in the universe, then electric charge in the universe must be quantized [70]. The electric charge is, in fact, quantized, which is consistent with (but does not prove) the existence of monopoles.

WUM: We introduce DMPs DIRACs, which are dipoles of magnetic monopoles with magnetic charges $\mu = e/2\alpha$. They possess a substantial magnetic dipole momentum [9]. According to the Model, plasma of magnetic monopoles composes shells of star clusters' cores [6]. Such plasma can exist in a gravitational field of Macroobjects' Core.

In 1979 Haim Harari [71] and Michael A. Shupe [72] proposed a heuristic model, treating leptons and quarks as composites of spin 1/2 fields with charges 0 and $\pm e/3$. In particle physics, preons are point particles, conceived of as subcomponents of quarks and leptons [73].

WUM: We introduce DMPs ELOPs that are dipoles of preons with electric charges $e/3$. They have a substantial electric dipole momentum [9]. Plasma of preons composes shells of galaxies cores. It can exist in a gravitational field of Macroobjects' Core.

4.2. Macroobject Shell Model

According to WUM, Cores of Macroobjects of the World (galaxy clusters, galaxies, star clusters, and extrasolar systems) are Fermion Compact Stars (FCS). They have Nuclei made up of strongly annihilating dark matter fermions DMF1 or DMF2 surrounded by different shells made up of various fermions. The shells envelope one another, like a Russian doll [2]. The lighter a fermion – the greater the radius and the mass of its shell. Innermost shells are the smallest and are made up of heaviest fermions; outer shells are larger and consist of lighter particles.

The calculated parameters of the shells show that [2]:

- White Dwarf Shells around the Nuclei made of strongly annihilating DMF1 or DMF2 compose Cores of stars in extrasolar systems;
- Shells of monopoles around the Nuclei made of strongly annihilating DMF1 or DMF2 form Cores of star clusters;
- Shells of preons around the Nuclei made of strongly annihilating DMF1 or DMF2 constitute Cores of galaxies;
- Shells of DMF3 around the Nuclei made of strongly annihilating DMF1 or DMF2 make up Cores of galaxy clusters.

  In our view, Macroobjects possess the following properties [6], [8]:

- Nuclei are made up of DMPs. Surrounding shells contain DM and baryonic matter;
- Nuclei and shells are growing in time proportionally to square root of cosmological time $\propto \tau^{1/2}$ until one of them reaches the critical point of its local instability, at which it detonates. The energy released during detonation is produced by the annihilation of DMPs. The detonation process does not destroy MO; instead, Hyper-flares occur in active regions of the shells, analogous to Solar flares;
- All other DMPs in different shells can start annihilation process as the result of the first detonation;
- Afterglow is a result of processes developing in Nuclei and shells after detonation;
- Different emission lines in spectra of bursts are connected to the Macroobjects' structure, which depends on the composition of the Nuclei and surrounding shells made up of DMPs. Consequently, the diversity of Very High Energy Bursts has a clear explanation.

In the next Section we give examples of the Macroobject Shell Model realization.

4.3. Multiwavelength Pulsars

In "Gamma Ray Pulsars: Multiwavelength Observations" review D. J. Thompson presents the light curves from seven highest-confidence Gamma-Ray Pulsars (GRPs) in five energy bands: radio, optical, soft X-ray, hard X-ray/soft gamma ray, and hard gamma ray (above 100 MeV). Gamma rays are frequently the dominant component of the radiated power [74].

WUM: Fermi Compact Stars (FCSs) made up of strongly annihilating DMF1 and DMF2 have maximum mass and minimum size which are equal to parameters of neutron stars. It follows that GRPs might be, in fact, rotating DMF1 or DMF2 stars. The nuclei of such pulsars may also be made up of the mixture of DMF1 and DMF2 surrounded by shells composed of other DMPs. The GRP multiwavelength radiation depends on the composition of Nucleus and shells [8].

S. Ansoldi, *et al*. report the most energetic pulsed emission ever detected from Crab pulsar reaching up to 1.5 TeV. Such TeV pulsed quants require a parent population of electrons with a Lorentz factor of at least 5×10^6. These results strongly suggest Inverse Compton scattering of low energy photons as the emission mechanism [75].

WUM: TeV pulsed emission from Crab pulsar can be explained by an active area of rotating FCS composed of strongly annihilating DMF1 with mass 1.3 TeV [8].

Ge Chen, *et al.* (2015) report hard X-ray observations of the rotation-powered radio pulsar PSR B1509. The log parabolic model describes the NuSTAR data spanning 3 keV through 500 MeV. Astronomers opinion is that the obtained results support a model in which the pulsar's lack of GeV emission is due to viewing geometry [76].

WUM: Multiwavelength emission from pulsar PSR B1509 can be explained by rotating DMF2 star with active area irradiating gamma quants with energy 9.6 GeV, which interact with surrounding shells, causing them to glow in X-ray spectrum [8].

Solar flares are explosive phenomena that emit electromagnetic radiation extending from radio to gamma rays. Ackermann, M., *et al.* present the data of 19 solar flares detected in high-energy gamma rays in the range 60 MeV to 6 GeV. They argue that a hadronic origin of the gamma rays is more likely than a leptonic origin [77].

WUM: Multiwavelength emission of solar flares can be explained by the annihilation of dark matter fermions DMF1 and DMF2 in the solar Core. Irradiated gamma quants with energy above 10 GeV interact with surrounding shells, causing them to glow in a broadband spectrum.

4.4. Electromagnetic and Gravitoelectromagnetic Parameters

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. In this Section we will not rewrite well-known equations, but only provide the relationships between physical quantities used for Electromagnetism and Gravitoelectromagnetism in **Tables 1** and **2**.

From these **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): $[q_e] = cm^{3/2}g^{1/2}s^{-1}$ and in CGSM: $[q_m] = cm^{1/2}g^{1/2}$.

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

- Multiply the charge and mass and all physical quantities on the left side of Tables 1 and 2 by an arbitrary parameter P ;
- Divide impedances by P^2 ;
- Divide magnetic fluxes and all physical quantities on the right side of Tables 1 and 2 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.

There are two physical sources in ME: total electric charge density ρ_q and total electric current density $\boldsymbol{J}_q$. According to ME, there are two measurable physical characteristics: energy density ρ_E and energy flux density $\boldsymbol{J}_E$. It is interesting to proceed with ME when physical sources are energy density ρ_E and energy flux density $\boldsymbol{J}_E$, which coincide with the same measurable physical characteristics. It means that electromagnetic and gravitoelectromagnetic charges should have the dimension of "Energy" [9]. Below we make transformations for magnetic parameter of the Medium resulting in the dimension of electromagnetic and gravitoelectromagnetic charges "Area" that is equivalent to "Energy" with a constant σ_0 , that is a basic unit of surface energy density: $\sigma_0 = \frac{hc}{a^3}$.

In frames of WUM, the gravitational parameter G can be calculated based on the value of the energy density of the Medium ρ_M [1]:

$$G = \frac{\rho_M}{4\pi} \times P_g^2$$

where a dimension-transposing parameter P_g equals to: $P_g = \frac{a^3}{2h/c}$.

Table 1. 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 2. 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}	$\boldsymbol{B}_m, s^{-1}$

Using the flexibility of gravitoelectromagnetic charge dimension we replace mass m with

$$m \times P_g = a^3/2L_{Cm}$$

where L_{cm} is Compton length of mass m . The gravitoelectromagnetic charge has a dimension of "Area", which is equivalent to "Energy" with the constant $2\sigma_0$. Then Newton's law of universal gravitation can be rewritten in the following way:

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

where we introduce 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 masses m and M. We took constant $2\sigma_0$ to fit the total energy of masses m and M:

$$\frac{a^3}{2L_{Cm}} \times 2\sigma_0 = \frac{a^3 mc}{2h} \times \frac{2hc}{a^3} = mc^2$$

As the result of this transformation, the gravitomagnetic parameter $\mu_g = \frac{4\pi G}{c^2}$ transforms into μ_{gg} :

$$\mu_{gg} = \rho_M / c^2$$

that is precisely equals to the energy density of the Medium over c^2 [4].

For free electric charges e in the Medium of the World we use a dimension-transposing parameter $P_e = \frac{e_g}{e}$ where e_g equals to: $e_g = 4\pi(\frac{L_F}{2\pi})^2$. e_g has a dimension of “Area”, which is equivalent to “Energy” with the constant $2\sigma_0$. Then magnetic parameter $\mu_0 = \frac{2\alpha h}{ce^2}$ transforms into μ_{0g}:

$$\mu_{og} = \frac{2\alpha h}{ce_g^2} = \frac{2\pi^2\alpha}{3}\frac{\rho_{cr}}{c^2} = \frac{\rho_p}{c^2}$$

μ_{0g} precisely equals to the value of proton energy density in the Medium ρ_p over c^2 [1]. It follows that we can treat the electromagnetic field with constant magnetic parameter μ_0 in the time-varying gravitational Medium with the magnetic parameter $\mu_{0g} \propto \tau^{-1}$ and a time-varying electric charge $e_g \propto \tau^{1/2}$. In this case, free electric charges in the Medium can be treated as the pulsating spheres with the radius $\frac{L_F}{2\pi} \cong 2.63 \times 10^{-5}\, m$.

This approach aligns WUM with Bjerknes mechanism for the attraction and the repulsion between two pulsating spheres. Lord Kelvin and Carl Anton Bjerknes investigated this mechanism between 1870 and 1903. Bjerknes showed that when two spheres immersed in a fluid were pulsating, they exerted a mutual attraction, which obeyed Newton’s inverse square law if the pulsations are in phase. The spheres repelled when the phases differed by a half wave [78].

4.5. Modified Maxwell’s Equations

To apply ME, it is necessary to specify the constitutive relations:

$$\boldsymbol{D} = \varepsilon_0 \boldsymbol{E}$$

$$\boldsymbol{H} = \frac{1}{\mu_0}\boldsymbol{B}$$

$$\boldsymbol{E} = \rho_r \boldsymbol{J}$$

where ε_0 is the electric constant and ρ_r is the electric current resistivity that we propose to take the value of $\rho_r = \mu_0 ca = Z_0 a$. We emphasize that all quantities in ME can be calculated based on physical sources ρ and $\boldsymbol{J}$ [9].

There are two auxiliary field quantities:

$$\boldsymbol{D} = \varepsilon_0 \boldsymbol{E} + \boldsymbol{P}$$

$$\boldsymbol{H} = \frac{1}{\mu_0} \boldsymbol{B} - \boldsymbol{M}$$

The quantities $\boldsymbol{P}$ and $\boldsymbol{M}$ represent the macroscopically averaged electric dipole and magnetic dipole moment densities of the material medium in the presence of applied fields. Analysis of ME in which all quantities are arbitrary functions of space and time has been done in literature ([79], [80]).

K. Brown discusses two classical models for the source of "magnetic dipole" fields: *one based on the juxtaposition of two oppositely charged magnetic monopoles, and one based on a loop of electric current. These two models might be called Coulombic and Amperean dipoles respectively.*

He emphasizes *the difference between $\boldsymbol{B}$ and $\boldsymbol{H}$ fields. Outside any magnetic material, $\boldsymbol{B}$ and $\boldsymbol{H}$ are strictly proportional to each other, but inside magnetic material they are quite different. The potential energy density of a magnetic field is really $(\boldsymbol{B} \cdot \boldsymbol{H})/2$, and reduces to $\boldsymbol{B}^2/2\mu_0$ only outside of any magnetic material* [81].

M. Mansuripur compared two versions of the Poynting vector $\boldsymbol{S} = (\boldsymbol{E} \times \boldsymbol{B})/\mu_0$ and $\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$. He concludes: *the identification of magnetic dipoles with Amperian current loops, while certainly acceptable within the confines of Maxwell's macroscopic equations, is inadequate and leads to complications when considering energy, force, torque, momentum, and angular momentum in electromagnetic systems that involve the interaction of fields and matter* [79].

WUM: The Medium of the World consists of the following elementary particles [7]:

- Protons and electrons with mass m_p and m_e and electric charge e;
- Mass-varying neutrinos and photons;
- DMPs including fermions (DMF1, DMF2, DMF3) and bosons (DIRACs and ELOPs);
- ELOPs with mass $2m_e/3$ that are electric dipoles of preons with electric charges $e/3$. They represent the macroscopically averaged electric dipole moment density $\boldsymbol{P}$ of the Medium in the presence of applied fields with energy density about the proton energy density [7];
- DIRACs with mass m_0 , which are magnetic dipoles of Dirac's monopoles with magnetic charges $\mu = e/2\alpha$. DIRACs are the Coulombic magnetic dipoles. Their energy density in the Medium is about the proton energy density [7]. They represent the macroscopically averaged magnetic dipole moment density $\boldsymbol{M}$ of the Medium in the presence of applied fields.

It is well-known that the dimension of the magnetic field intensity $[\boldsymbol{H}] = Am^{-1}$. We can rewrite it in the following way:

$$[\boldsymbol{H}] = \frac{Cm}{m^2 s} = \frac{[\mathbf{d}_\mathrm{m}]}{m^2 s} = [\boldsymbol{J}_m]$$

where $\boldsymbol{d}_m$ is a magnetic dipole momentum. It looks like magnetic field intensity $\boldsymbol{H}$ is, in fact, proportional to the current density $\boldsymbol{J}_m$ of magnetic dipoles d_m :

$$\boldsymbol{H} = \rho_m \boldsymbol{J}_m$$

where ρ_m is a magnetic dipole current resistivity. In our opinion, the magnetic field intensity $\boldsymbol{H}$ is not an "auxiliary" field quantity. On the contrary, it is a real magnetic field quantity. That is why $\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$ is a true Poynting vector and $(\boldsymbol{B} \cdot \boldsymbol{H})/2$ is a true potential energy density of a magnetic field.

In summary: magnetic monopoles are not the subject of Maxwell's equations; instead, magnetic dipoles DIRACs are. To describe the propagation of electromagnetic signals through the Medium of the World we should modify Maxwell's equations [9]:

- consider the macroscopically averaged electric $\boldsymbol{P}$ and magnetic $\boldsymbol{M}$ dipole moment density of the Medium in the presence of applied fields;
- consider ELOPs and DIRACs current densities induced by the electromagnetic field.

Most articles on electromagnetic theory follow the classical approach of steady state solutions of Maxwell's equations. H. Harmuth and K. Lukin in "Interstellar Propagation of Electromagnetic Signals" point out the deficiencies in Maxwell's theory and present an exciting new way of obtaining transient or signals solutions. A new approach based on microscopic description of the medium and analytical solution of Maxwell equations in time domain has been used to solve the problem [82].

H. Harmuth and K. Lukin analyzed the propagation of electromagnetic signals through a non-conducting medium with very low density of neutral gas considering both electric and magnetic dipole currents [82]. Authors modify Maxwell's equations for "empty space" using both electric and magnetic dipole current densities rather than electric and magnetic flux densities. This implies description of the medium in the frame of microscopic approach using representation of a hydrogen atom as a combination of electric and magnetic dipoles [82]. Those dipoles produce electric and magnetic dipole currents under the electromagnetic field action that is to be calculated in a self-consistent way.

H. Harmuth and K. Lukin created a self-consistent system containing both Maxwell equations and equations for the dipole current densities evolution under the electromagnetic field action in the following form [83]:

$$-rot\boldsymbol{E} = \mu\frac{\partial \boldsymbol{H}}{\partial t} + \boldsymbol{g}_m$$

$$rot\boldsymbol{H} = \varepsilon\frac{\partial \boldsymbol{E}}{\partial t} + \boldsymbol{g}_e$$

$$\varepsilon div\boldsymbol{E} = \mu div\boldsymbol{H} = 0$$

$$\boldsymbol{g}_e + \tau_{mp}\frac{\partial \boldsymbol{g}_e}{\partial t} + \frac{\tau_{mp}}{\tau^2}\int \boldsymbol{g}_e\, dt = \sigma_p\boldsymbol{E}$$

$$\boldsymbol{g}_m + \tau_{mp}\frac{\partial \boldsymbol{g}_m}{\partial t} + \frac{\tau_{mp}}{\tau^2}\int \boldsymbol{g}_e\, dt = 2s_p\boldsymbol{H}$$

$$\sigma_p = \frac{N_0 e^2 \tau_{mp}}{m}$$

$$s_p = \frac{N_0 q_m^2 \tau_{mp}}{m}$$

$$q_m = \frac{\mu m_{m0}}{2r}$$

where σ_p and s_p are electric and magnetic dipole current conductances; $\boldsymbol{g}_e$ and $\boldsymbol{g}_m$ are electric and magnetic dipole current densities induced by the electromagnetic field; ε and μ are electric and magnetic constants; e and m are charge and mass of an electron; m_{m0} and q_m are magnetic dipole moment and fictitious magnet charge; τ_{mp} and τ are the relaxation time and period of eigen-frequency of the dipole-oscillator used as the model for atomic hydrogen.

Authors concluded that *the time delay between the signal precursor and its main lobe evaluated may be used for evaluation of either distance to a pulsar for the known medium parameters or those parameters for a given distance to the pulsar* [83].

R. Beck and R. Wielebinski discuss the omnipresence of Cosmic Magnetism: *Most of the visible matter in the Universe is ionized, so that cosmic magnetic fields are quite easy to generate and due to the lack of magnetic monopoles hard to destroy. Magnetic fields have been measured in or around practically all celestial objects. The Earth, the Sun, solar planets, stars, pulsars, the Milky Way, nearby galaxies, more distant (radio) galaxies, quasars and even intergalactic space in clusters of galaxies have significant magnetic fields, and even larger volumes of the Universe may be permeated by "dark" magnetic fields* [84].

WUM explains the similarity of field patterns and flow patterns of the diffuse ionized gas [85] by the flow of DIRACs along with diffuse ionized gas. The large-scale structure of the Milky Way's magnetic field [85], a dark magnetic field [86] and other magnetic phenomena which are only partly related to objects visible in other spectral ranges [84] can be explained by flows of dark matter particles DIRACs. We believe that the developed approach to magnetic field [9] can answer questions on the origin and evolution of magnetic fields such as their first occurrence in young galaxies, or the existence of large-scale intergalactic fields [84].

In conclusion:

- We should build an all-encompassing theory of Intergalactic propagation of electromagnetic signals considering the content of the Medium proposed in WUM;
- Hypersphere WUM can serve as a basis for Cosmic Magnetism.

4.6. Inter-Connectivity of Primary Cosmological Parameters

The constancy of the universe fundamental constants, including Newtonian constant of gravitation, Fermi coupling constant, Planck mass, is now commonly accepted, although has never been firmly established as a fact. All conclusions on the (almost) constancy of the Newtonian parameter of gravitation are model-dependent [4]. 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. WUM holds that there indeed exist relations between all primary cosmological parameters that depend on dimensionless time-varying quantity Q [5].

The model develops a mathematical framework that allows for direct calculation of the following parameters through Q [7]:

- Newtonian parameter of gravitation G;
- Hubble's parameter H;
- Age of the World A_τ ;
- The Worlds' radius of curvature in the fourth spatial dimension R;
- Critical energy density ρ_{cr} ;
- Temperature of the Microwave Background Radiation T_{MBR} ;
- Temperature of the Far-Infrared Background Radiation peak T_{FIRB} ;
- Electronic neutrino mass m_{ν_e} ;
- Muonic neutrino mass m_{ν_μ} ;
- Tauonic neutrino mass m_{ν_τ} ;

- Fermi coupling parameter G_F ;
- Photons minimum energy E_{phi} .

The precision of their measured values increases by orders of magnitude. In frames of WUM, we calculate the values of these parameters, which are in good agreement with the latest results of their measurements.

For example, calculating the value of Hubble's parameter H_0 based on the average value of the gravitational parameter G we find $H_0 = 68.7457\ km/s\ Mpc$, which is in good agreement with $H_0 = 69.32 \pm 0.8\ km/s\ Mpc$ obtained using WMAP data [87].

The black-body spectrum of the cosmic Microwave Background Radiation (MBR) is due to thermodynamic equilibrium of photons with low density intergalactic plasma [1]. WUM calculates the value of T_{MBR} to be $T_{MBR} = 2.72518\ K$, which is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\ K$ [88].

Based on the thermo-equilibrium of drops of Bose-Einstein-condensed dineutrinos [3] we calculate their stationary temperature that corresponds to the Far-Infrared Background temperature peak T_{FIRB} and obtain $T_{FIRB} = 28.955\ K$, which is in an excellent agreement with experimentally measured value of 29 K ([89] – [100]).

L. Zyga has found that the measured G values from 1980 to 2015 oscillate over time (about $\pm 0.001 \times 10^{-11} m^3 kg^{-1} s^{-2}$) like a sine wave with a period of 5.9 years [101]. In frames of WUM, these results can be explained by variations of the flux of neutrinos emanating from Sun.

Today, Fermi coupling parameter is known with the highest precision. Based on its average value:

$$G_F = 1.1663787 \times 10^{-5}\ GeV^{-2}$$

we can calculate and significantly increase the precision of the values of all Q-dependent parameters. The calculated value of the parameter Q_F based on G_F is [4]:

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

that is much more precise than the value of parameter Q_G calculated based on G:

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

As an example of the increased precision:

- the measured average value of G from CODATA is:

$$G = 6.67408 \times 10^{-11}\ m^3 kg^{-1} s^{-2}$$

- the calculated value of G based on Q_F is:

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

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

WUM makes reasonable assumptions in the main areas of Cosmology. The remarkable agreement of the calculated values of the primary cosmological parameters with the observational data gives us considerable confidence in the Model. We propose to introduce Q as a new Fundamental Parameter tracked by CODATA and use its value in calculation of all Q-dependent parameters.

5. Assumptions, Evidence, Principle Points and Predictions

5.1. Assumptions

WUM is based on the following primary assumptions [1]:

- The universality of physical laws;
- The cosmological principle which states that on a large scale the World is homogeneous and isotropic;
- The World is a finite three-dimensional Hypersphere. All points of the Hypersphere are equivalent; there are no preferred centers or boundary of the World;
- The World is expanding inside the Universe along the fourth spatial dimension with speed equal to the gravitoelectrodynamic constant c;
- Supremacy of Matter and continuous creation of Matter;
- Variable Gravitational parameter;
- Maxwell's equations for Electromagnetism and Gravitoelectromagnetism;
- Elementary particles have the following characteristics: type of particle (fermion or boson), four-momentum, mass and charge;
- The Medium of the World, consisting of protons, electrons, photons, neutrinos, and dark matter particles is an active agent in all physical phenomena in the World.

5.2. Evidence of the Hypersphere World

The physical laws we observe appear to be independent of the Worlds' curvature in the fourth spatial dimension due to small enough observers in comparison with the radius of the curvature. Direct observation of the Worlds' curvature would then appear to be a hopeless goal. One way to prove the existence of the Worlds' curvature 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 curved nature of the World. Unfortunately, the accuracy of the measurements is quite poor. Measurement errors far outweigh any possible "curvature 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 [5]. 4.6 billion years ago the Sun's' output has been only 70 percent as intense during that epoch as it is during the modern epoch [102]. One of the consequences of WUM holds that all stars were fainter in the past. As their cores absorb new DM, size of macroobjects cores 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 [2].

Another effect that has been observed directly is photons' time delay relative to the light travel time $t_{LTT} = \tau_{obsv} - \tau_{emit}$ from the source of Fast Radio Burst (FRB) billions of years away from Earth. τ_{emit} and τ_{obsv} are cosmological times (Ages of the World at the moments of emitting and observing photons), both measured from the Beginning of the World [6]. FRBs are bright, unresolved, broadband, millisecond flashes found in parts of the sky outside Milky Way. Astronomers believe that the pulses are emitted simultaneously over a wide range of frequencies. However, as observed on Earth, the components of each pulse emitted at higher radio frequencies arrive before those emitted at lower frequencies. This delay is described by a value referred to as a Dispersion Measure which depends on the number density of electrons integrated along the path traveled by the photon from the source of FRB to Earth [103], [104].

We propose to calculate a Dispersion Measure based on the calculated electron concentration n_e in the Medium of the World that decreasing in time $n_e \propto Q^{-1} \propto \tau^{-1}$ [1]. The calculated value of photons' time delay for FRB 150418 [6] is in good agreement with experimentally measured value [105]. We emphasize that the described astrophysical phenomenon, Fast Radio Burst, manifests the existence of the Intergalactic plasma.

The proposed approach to the fourth spatial dimension agrees 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 Worlds' curvature in the fourth spatial dimension [1].

5.3. Principle Points

WUM is based on the following Principle Points [5]:

- The World was started by a fluctuation in the Eternal Universe, and the Nucleus of the World, which is a four dimensional 4-ball, was born. The Beginning of the World is a Quantum effect.
- The 3D World is the Hypersphere that is the surface of the 4-ball Nucleus. Hence the World is curved in the fourth spatial dimension.
- The 4-ball is expanding in the Eternal Universe, and its surface, the hypersphere, is likewise expanding so that the radius of the 4-ball is increasing with speed c that is the gravitoelectrodynamic constant.
- The surface of the hypersphere is created in a process analogous to sublimation, which is an endothermic process. Continuous creation of matter is the result of a similar process. The creation of matter is happening homogeneously in all points of the hypersphere World and is a direct consequence of expansion. Visible Matter is a by-product of DM annihilation.
- The World consists of the Medium and Macroobjects. The Medium consists of stable elementary particles with lifetimes longer than the age of the World: protons, electrons, photons, neutrinos, and dark matter particles. The energy density of the Medium is 2/3 of the total energy density in all cosmological times.
- Galaxy clusters, Galaxies, Star clusters, Extrasolar systems, Planets, etc. are made of these particles. The energy density of Macroobjects is 1/3 of the total energy density throughout the World's evolution.
- Time, Space and Gravitation are emergent phenomena and have no separate existence from Matter. In WUM, they are closely connected with the impedance, the gravitomagnetic parameter, and the energy density of the Medium respectively.
- Maxwell's Equations for Electromagnetism and Gravitoelectromagnetism play a principal role in the description of the World.
- Two Fundamental Parameters in various rational exponents define all macro features of the World: Sommerfeld's constant α and dimensionless Quantity Q. While α is constant, Q increases in time, and is, in fact, a measure of the Worlds' curvature in the fourth spatial dimension and the Age of the World.
- WUM holds that there exist relations between all Q-dependent parameters: Newtonian parameter of gravitation and Hubble's parameter; Critical energy density and Fermi coupling parameter; Temperatures of the Microwave Background Radiation and Far-Infrared Background

Radiation peak. The calculated values of these parameters are in good agreement with the latest results of their measurements. Model proposes to introduce a new fundamental quantity Q in the CODATA internationally recommended values for calculating all Q-dependent parameters of the World.

- The black-body spectrum of the cosmic Microwave Background Radiation is due to thermodynamic equilibrium of photons with low density Intergalactic Plasma.
- The Far-Infrared Background Radiation is due to the emission of BEC drops created as the result of the Bose-Einstein Condensation (BEC) of dineutrinos. The BEC drops absorb energy directly from the Medium of the World provided by dineutrinos and re-emit this energy in FIRB at the stationary temperature T_{FIRB}.
- The total energy density of neutrinos is about 69% of the critical energy density.
- Dark Matter (DM) consists of 5 different particles: DMF1, DMF2, DMF3, DIRACs, and ELOPs, and has the relative energy density of about 24% [2].
- All Macroobjects of the World (galaxy clusters, galaxies, star clusters, extrasolar systems, and planets) possess the following properties: their Cores are made up of DMPs; they contain other particles, including DM and baryonic matter, in shells surrounding the Cores. Annihilation of DMPs can give rise to any combination of gamma-ray lines.
- 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 [2].
- Nucleosynthesis of all elements occurs inside stars during their evolution. Stellar nucleosynthesis theory should be enhanced to account for annihilation of heavy DMPs (DMF1 and DMF2) inside of the Stars' Cores [5].
- Macroobjects form from top (galaxy clusters) down to extrasolar systems in parallel around different Cores made of different DMPs. Formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing.
- Assuming an Eternal 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 [5].

5.4. Predictions

WUM makes the following predictions, which we hope will be supported by experimental data [5]:

- All Macroobjects of the World (galaxy clusters, galaxies, star clusters, extrasolar systems, and planets) possess Cores that are made up of DMPs. All round objects in hydrostatic equilibrium, down to Mimas in Solar system, should be considered Planets;
- WUM predicts existence of DMPs with 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, and 3.7 keV masses;
- Model makes predictions pertaining to neutrinos mass eigenstates and photons minimum energy in a present cosmological epoch: $m_{\nu_e} \cong 3.1 \times 10^{-4}\ eV/c^2$; $m_{\nu_\mu} \cong 7.5 \times 10^{-3}\ eV/c^2$; $m_{\nu_\tau} \cong 4.5 \times 10^{-2}\ eV/c^2$ and $E_{phi} \cong 1.9 \times 10^{-14}\ eV$ respectively [5];
- WUM predicts the concentration of Intergalactic plasma in the present cosmological epoch: $n_p = n_e = 0.2548\ m^{-3}$ [1];
- Model proposes new types of particle interactions (Super Weak and Extremely Weak) with coupling strength in the present cosmological epoch: $\sim 10^{-10}$ and $\sim 10^{-20}$ times weaker than that of weak interaction [3].

The Hypersphere World-Universe Model successfully describes primary parameters and their relationships, ranging in scale from cosmological structures to elementary particles. WUM allows for precise calculation of values that were only measured experimentally earlier and makes verifiable predictions. WUM does not attempt to explain all available cosmological data, as that is an impossible feat for any one manuscript. Nor does WUM pretend to have built an all-encompassing theory that can be accepted as is. The Model needs significant further elaboration, but in its present shape, it can already serve as a basis for a new Classical Physics proposed by Paul Dirac in 1937. The Model should be developed into a well-elaborated theory by all physical community.

Acknowledgements

I am a Doctor of Sciences in Physics. I belong to the school of physicists established by Alexander Prokhorov – Nobel Prize Laureate in Physics. I'm an author of more than 150 published papers. I'm very grateful to Prof. A. M. Prokhorov and Prof. A. A. Manenkov whose influence on my scientific life is decisive.

Many thanks to my long-term friend Felix Lev for stimulating discussions of history and philosophy of Physics and important comments on the Model.

Special thanks to my son Ilya Netchitailo, who questioned every aspect of the Model, gave valuable suggestions and helped shape it to its present form.

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