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Cosmic Far-Infrared Background Radiation

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In this manuscript, we discuss mass-varying neutrinos and propose their energy density to exceed that of baryonic and dark matter. We introduce cosmic Large Grains whose mass is about Planck mass, and their temperature is around 29 K. Large grains are in fact Bose-Einstein condensates of proposed dineutrinos, and are responsible for the cosmic Far-Infrared Background radiation.

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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. The hypersphere as a model of finite universe was proposed by Georg Riemann in 1854 [1], [2].

WUM is based on Maxwell's equations that form the foundation of Electromagnetism and Gravitoelectromagnetism that was proposed by O. Heaviside in 1893. Gravitoelectromagnetism is an approximation to the Einstein's field equations for General Relativity in the weak field limit. According to Maxwell's equations, there are two measurable physical characteristics: energy density and energy flux density [3].

WUM introduces a fundamental dimensionless time-varying parameter Q that is the measure of the curvature of the Hypersphere R. It can be calculated from the value of the gravitational constant G and in present epoch equals to [4]:

$$Q = \frac{R}{a} = \nu_0 \tau = \frac{a^2 c^4}{8\pi hc} \times G^{-1} = 0.759972 \times 10^{40} \tag{1.1}$$

where $a = 2\pi a_0$ is a basic unit of length and a_0 is the classical electron radius; $\nu_0 = c/a$ is a basic unit of frequency; c is the gravitoelectrodynamic constant that is identical to the electrodynamic constant c in Maxwell's equations; τ is a cosmological time; and h is Planck constant.

2. Cosmic Neutrinos Background

The existence of the World's Medium is a principal point of WUM. It follows from the observations of Intergalactic Plasma and Cosmic Microwave Background Radiation [5]; Far-Infrared Background Radiation and Cosmic Neutrino Background [6]; Gamma-ray Background Radiation [7]. The Medium consists of stable elementary particles with lifetimes longer than the age of the World: protons with mass m_p, electrons with mass m_e, neutrinos with mass m_ν, photons, and dark matter particles [7].

Cosmic Neutrino Background (CNB) consists of three different types of neutrinos: electronic ν_e, muonic ν_μ, and tauonic ν_τ, and their antiparticles. Pontecorvo and Smorodinskii discussed the possibility of energy density of neutrinos exceeding that of baryonic matter [8]. Neutrino oscillations imply that neutrinos have non-zero masses.

In WUM, neutrino masses are related to and proportional to basic unit of mass $m_0 = h/ac$ multiplied by fundamental parameter $Q^{-1/4}$ and different coefficients. Neutrinos exist in superposition of the following mass eigenstates predicted by WUM [6]:

$$m_{\nu_e} = \frac{1}{24} m_0 \times Q^{-1/4} = 3.1250 \times 10^{-4}\ eV/c^2 \tag{2.1}$$

$$m_{\nu_\mu} = m_0 \times Q^{-1/4} = 7.4999 \times 10^{-3}\ eV/c^2 \tag{2.2}$$

$$m_{\nu_\tau} = 6 m_0 \times Q^{-1/4} = 4.5000 \times 10^{-2}\ eV/c^2 \tag{2.3}$$

The squared values of the muonic and tauonic neutrinos masses fall into the ranges of mass splitting Δm_{sol}^2 and Δm_{atm}^2 for solar and atmospheric neutrinos respectively. 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:

$$\Omega_p = \frac{2\pi^2\alpha}{3} = 0.048014655 \tag{2.4}$$

which depends on the constant $\alpha = m_e/m_0$. Therefore, the total neutrinos relative energy density $\Omega_{\nu tot}$ of the CNB in terms of the critical energy density ρ_{cr} equals to [6]:

$$\Omega_{\nu tot} = \frac{45}{\pi}\Omega_p = 30\pi\alpha = 0.68775927 \tag{2.5}$$

The total neutrinos energy density in the World $\Omega_{\nu tot}$ is almost 15 times greater than the baryonic energy density in the Medium: $\Omega_{\nu tot} \cong 15\Omega_p$. At such a high neutrinos concentration, "neutrinos pairs" $\nu\bar{\nu}$ (dineutrinos) can be created. Bellow we will discuss their role in Far-Infrared Background radiation.

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: 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, such background neutrinos will not be registered by standard neutrino detectors. In fact, we might never be able to directly observe the CNB.

3. 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 [9]. 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 [6].

According to the literature [10], [11], [12], the size of large cosmic grains D_G is roughly equal to the length L_F in WUM:

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

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

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

The calculated density of grains ρ_G is about:

$$\rho_G \sim \frac{6}{\pi}\frac{M_P}{L_F^3} \approx 9.2\times10^3\ kg/m^3 \tag{3.3}$$

According to WUM, Planck mass M_P equals to

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

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

A grain of mass B_1M_P and radius B_2L_F is receiving energy from the Medium of the World as the result of dineutrinos Bose-Einstein condensation at the following rate:

$$\frac{d}{d\tau}(B_1M_Pc^2) = \frac{B_1M_Pc^2}{2\tau} \tag{3.5}$$

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:

$$\frac{B_1M_Pc^2}{2\tau} = \sigma_{SB}T_G^4\times4\pi B_2^2L_F^2 \tag{3.6}$$

where σ_{SB} is Stefan-Boltzmann constant:

$$\sigma_{SB} = \frac{2\pi^5k_B^4}{15h^3c^2} \tag{3.7}$$

With Nikola Tesla's principle at heart – *There is no energy in matter other than that received from the environment* – we get:

$$B_1M_Pc^2 = 4\pi B_2^2L_F^2\sigma_0 \tag{3.8}$$

where $\sigma_0 = \frac{hc}{a^3}$ is a basic unit of surface energy density. We then calculate the grain's stationary temperature T_G to be

$$T_G = (\frac{15}{4\pi^5})^{1/4}\frac{hc}{k_BL_F} = 28.955\ K \tag{3.9}$$

This result is in an excellent agreement with experimentally measured value of $29\ K$. 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. The total flux of the FIRB radiation is the sum of the contributions of all individual grains [6].

4. Bose-Einstein Condensate

New cosmological models employing the Bose-Einstein Condensates (BEC) have been actively discussed in literature in recent years [6]. The transition to BEC occurs below a critical temperature T_c, which for a uniform three-dimensional gas consisting of non-interacting particles is given by [13]:

$$T_c = [\zeta(3/2)]^{-2/3} \frac{h^2 n_X^{2/3}}{2\pi m_X k_B} \approx \frac{h^2 n_X^{2/3}}{11.918 m_X k_B} \tag{4.1}$$

where n_X is the bosons' concentration, m_X is the mass per boson, ζ is the Riemann zeta function: $\zeta(3/2) \approx 2.6124$. 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. Let's assume that the energy density of boson particles ρ_X equals to the Microwave Background Radiation (MBR) energy density ρ_{MBR} [6]:

$$\rho_X = n_X m_X = \rho_{MBR} = 4\pi^2 \alpha \frac{m_e}{m_p} \frac{hc}{L_F^4} = 1.5690 \times 10^{-4} \times \frac{hc}{L_F^4} \tag{4.2}$$

Considering equations (3.9), (4.1) and (4.2), we can calculate the value of n_X:

$$\begin{aligned} n_X &= \left[47.672\pi^2 \alpha \frac{m_e}{m_p} \left(\frac{15}{4\pi^5}\right)^{1/4}\right]^{3/5} \times L_F^{-3} = \\ &= 0.011922 \times L_F^{-3} = 2.6386 \times 10^9\ m^{-3} \end{aligned} \tag{4.3}$$

and the value of the mass m_X:

$$m_X = \frac{\rho_X}{n_X c^2} = 0.013161 \times m_0 \times Q^{-1/4} = 0.987 \times 10^{-4}\ eV/c^2 \tag{4.4}$$

The mass of the dineutrinos m_X is in the range of electronic neutrinos mass (see (2.1)).

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. Dineutrinos stability follows from the calculation of the maximum kinetic energy of tauonic neutrinos in the Cosmic Neutrinos Background which is $144\pi^2$ less than the rest energy of tauonic neutrinos [1]. The stability of BEC drops is provided by the detailed equilibrium between the energy absorption from the Medium of the World (provided by dineutrinos because of their Bose-Einstein condensation) and re-emission of this energy in FIRB at the stationary temperature $T_G \approx 29\ K$.

To summarize,

Bose-Einstein Condensate drops of dineutrinos are responsible for FIRB:

- Drop masses about equal to Planck mass;
- Temperature around 29K.

WUM explanation of FIRB is in good agreement with experimentally measured characteristics.

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