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Dark Matter Particles

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Abstract

Researchers have been able to infer the existence of Dark Matter (DM) only from the gravitational effect. DM seems to outweigh visible matter roughly six to one, making up about 27% of the universe. Here's a sobering fact: The matter we know and that makes up all stars and galaxies only accounts for 5% of the content of universe! But what is DM? [1]. Many experiments to detect and study Dark Matter Particles (DMPs) directly are being actively undertaken, but none have yet succeeded. Indirect detection experiments search for the products of the annihilation or decay of DMPs in outer space [2]. In this paper, we discuss main ideas of the Hypersphere World-Universe Model (WUM) and introduce an additional new DMP "XION" (boson) with the rest energy 10.6 μeV that is an analog of Axion. On June 28, 2023, it was announced the existence of Cosmic Gravitational Background. In frames of WUM, we give an explanation of this discovery based on the analysis of "Gravitoplasma" composed of objects with Planck mass, which were created as the result of Weak Interaction between XIONs and other particles in the Medium.

Keywords

World-Universe Model, Multicomponent Dark Matter, Multiworld, Planck Mass, XION, Cosmic Gravitational Background, Distribution of World's Energy Density

1. Introduction

Galaxy clusters are particularly important for DM studies since their masses can be estimated in two independent ways [2]:

- From the scatter in radial velocities of the galaxies within clusters;
- Gravitational lensing (usually of more distant galaxies) can measure cluster masses without relying on observations of dynamics (e.g., velocity).

In 2017, K. Freese has reviewed the Status of Dark Matter in the Universe [3]:

Most of the mass in the universe is in the form of an unknown type of dark

matter. The need for dark matter has become more and more clear since the 1930*s, with evidence from rotation curves, gravitational lensing, hot gas in clusters, the Bullet Cluster, structure formation, and the cosmic microwave background. A consensus picture has emerged, in which dark matter contributes* 26% *of the overall energy density of the universe. Its nature is still unknown. Dark matter searches for the best motivated candidates, Axions and WIMPs, are ongoing and promising over the next decade.*

In astrophysics and particle physics, Self-Interacting Dark Matter (SIDM) is an alternative class of Cold DM. SIDM particles have strong interactions, in contrast to the standard Cold DMPs [4]. On galactic scales, DM self-interaction leads to energy and momentum exchange between DMPs [5].

WIMPs, or Weakly Interacting Massive Particles, represent a favored class of DM candidates. Some WIMPs may mutually annihilate when pairs of them interact, a process expected to produce gamma rays [6]. A lightest neutralino of rest energy roughly (10 GeV ⇔ 10 TeV) is the leading WIMP DM candidate.

Axion is a hypothetical elementary particle postulated by the Peccei-Quinn theory to resolve the strong CP problem in quantum chromodynamics. With a rest energy $\gtrsim 10^{-11}$ times the electron rest energy about 5 μeV, axions could account for DM, and thus be both DM candidate and a solution to strong CP problem [7].

2. World-Universe Model vs Big Bang Model

WUM and Big Bang Model (BBM) are principally different Models:

1) Instead of the Initial Singularity with the infinite energy density and extremely rapid expansion of spacetime (Inflation) in BBM; in WUM, there was a Fluctuation (4D Nucleus of the World with an extrapolated radius equals to a basic size unit of a, see Section 3.2) in Eternal Universe with finite extrapolated energy density (~10^4 less than nuclear density) and finite expansion of Nucleus in Its fourth spatial dimension with speed c that is a gravitodynamic constant;

2) Instead of alleged practically Infinite Homogeneous and Isotropic Universe around Initial Singularity in BBM; in WUM, 3D Finite Boundless World (Hypersphere of 4D Nucleus) presents Patchwork Quilt of various main Superclusters ($\gtrsim 10^3$), which emerged in different places of the World at different Cosmological times. The Medium of the World, consisting of protons, electrons, photons, neutrinos, and DMPs is Homogeneous and Isotropic. Distribution of Macroobjects is spatially Inhomogeneous and Anisotropic and temporally Non-simultaneous;

3) The Universe is responsible for the creation of DM in 4D Nucleus of the World and is, in fact, the Creator of DM. DMPs carry new DM into the World. Luminous Matter is a byproduct of DMPs self-annihilation;

4) Time, Space and Gravitation are closely connected with the Impedance, Gravitomagnetic parameter, and Energy density of the Medium, respectively. It follows that neither Time, Space nor Gravitation could be discussed in absence of the Medium. WUM confirms the Supremacy of Matter postulated by A. Eins-

tein: "*When forced to summarize the theory of relativity in one sentence: time and space and gravitation have no separate existence from matter*";

5) WUM based on Cosmological Time τ that marches on at the constant pace from the Beginning of the World up to the present Epoch along with time-varying Principal Cosmological Parameters. Gravitational parameter $G \propto \tau^{-1}$. Gravity is not an interaction but a manifestation of the Medium;

6) Gravitation is a result of simple interactions of DMPs XION (see Section 3.5) with Matter which work cooperatively to create a more complex interaction. XIONs are responsible for the Le Sage's "push" mechanism of gravitation that defines Gravity as an emergent phenomenon [8];

7) Thanks to the revealed by WUM Inter-Connectivity of Primary Cosmological Parameters, we show that Gravitational parameter that can be measured directly makes measurable all Cosmological parameters, which cannot be measured directly;

8) In our opinion, the most probable model is the one that built on the minimum number of parameters. BBM is based on six parameters (baryon density, dark matter density, dark energy density, scalar spectral index, curvature fluctuation amplitude, and reionization optical depth), the values of which are mostly not predicted by current theory. WUM is based on two parameters only: dimensionless Rydberg constant α (that later was named Fine-structure constant) and dimensionless quantity Q, which increases in time $Q \propto \tau$, and is, in fact, a measure of the Size and Age of the World.

Most direct observational evidence of validity of WUM are:

1) Microwave Background Radiation and Intergalactic Plasma speak in favor of existence of the **Medium**;

2) Laniakea Supercluster with binding mass $\sim 10^{17} M_{\odot}$ is home to the Milky Way galaxy and ~10^5 other nearby galaxies, which did not start their movement from Initial Singularity;

3) Milky Way is gravitationally bounded with the Virgo Supercluster (VSC) and has an Orbital **Angular Momentum** calculated based on distance of 65 Mly from VSC and orbital speed of ~400 km·s^{-1}, which far exceeds rotational angular momentum of Milky Way;

4) Mass-to-light ratio of VSC is ~300 times larger than that of Solar ratio. Similar ratios are obtained for other superclusters. These ratios are main arguments in favor of presence of significant amounts of **Dark Matter** in the World;

5) Astronomers discovered the most distant galaxy HD1 that is ~13.5 Bly away. WUM predicts discovery of galaxies with distance ~13.8 Bly.

Medium of the World, Dark Matter, and Angular Momentum are main Three Pillars of WUM.

3. Multicomponent Dark Matter

3.1. Existent Models

DM is among the most important open problems in both cosmology and particle

physics. There are three prominent hypotheses on nonbaryonic DM, namely Hot Dark Matter (HDM), Warm Dark Matter (WDM), and Cold Dark Matter (CDM).

The lightest **Neutralino** with the rest energy (>300 GeV) is an excellent candidate to form the universe's CDM [9]. The most widely discussed particles for nonbaryonic CDM are commonly assumed to be **WIMPs**. The Lee-Weinberg limit restricts their rest energy to >2 GeV [10].

It is known that a **Sterile Neutrino** with rest energy in 1.6 ⇔ 10 keV range is a good WDM candidate [11].

HDM is a theoretical form of DM which consists of particles that travel with ultra-relativistic velocities. An example of a HDM particle is a **Neutrino** [12]. In WUM, the particles of HDM are **XION**s (see Section 3.2).

The prospect that DMPs might be observed in Centers of Macroobjects has drawn many new researchers to the field in the last forty six years. Indirect effects in cosmic rays and gamma-ray background from the annihilation of CDM in the form of heavy stable neutral leptons in Galaxies were considered in pioneer articles [13]-[18].

The dark matter problem can be, in principle, achieved in the approach of extended gravity. This is stressed, for example, in the famous paper of Prof. C. Corda [19].

Two-component DM system consisting of bosonic and fermionic components is proposed for the explanation of emission lines from the bulge of the Milky Way galaxy. C. Boehm, P. Fayet, and J. Silk analyze the possibility of two coannihilating neutral and stable DMPs: a heavy fermion for example, like the lightest neutralino (>100 GeV) and the other one a possibly light spin-0 particle (~100 MeV) [20].

Multicomponent DM models consisting of both bosonic and fermionic components were analyzed in literature (for example, see [21]-[27] and references therein). An article by G. Bertone and T. M. P. Tait [28] provides an excellent review of what we have learned about the nature of DM from past experiments, and the implications for planned DM searches in the next decade.

3.2. Basic Ideas

It is the main goal of WUM to develop a Model based on two dimensionless parameters only: the dimensionless Rydberg constant α and the time-varying parameter Q, which is a measure of the Size and Age of the World. In WUM, we often use well-known physical parameters, keeping in mind that all of them can be expressed through the Basic Units. Taking the relative values of physical parameters in terms of the Basic Units we can express all dimensionless parameters of the World through two parameters α and Q in various rational exponents, as well as small integer numbers and π [29].

In our view, there is no way to prevent an occurrence of the Initial Singularity in BBM. A **Finite World** must have gotten started in a principally different

way—a **Fluctuation** in the Eternal Universe with an extrapolated finite size that equals to the basic size unit a [30]:

$$a = 1.7705641 \times 10^{-14} \text{ m}$$

The size of this Fluctuation can increase with a finite speed c (gravitodynamic constant). Then, there is no need to introduce Cosmological Inflation. However, a question about the mechanism of Continuous Creation of Matter in the World arises.

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 ($m_0/2 \cong 35 \text{ MeV}/c^2$) [31]. He noticed that meson masses are even multiplies 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 $m_0 \cong 70 \text{ MeV}/c^2$. During many years M. H. Mac Gregor studied this property extensively [32]. In WUM, we introduce a Basic Energy Unit E_0 that equals to:

$$E_0 = hc/a = 70.025252 \text{ MeV}$$

where h is the Planck constant. It is worth noting that the rest energy of electron E_e equals to: $E_e = \alpha E_0$ and the Rydberg unit of energy is: $Ry = hcR_\infty = 0.5\alpha^3 E_0 = 13.605692 \text{ eV}$ (R_∞ is the Rydberg constant).

According to WUM, the Eternal Universe is the Creator of the World's DM. Ordinary Matter (7.2%) is a byproduct of DMPs self-annihilation. It means that rest energies of DMPs must be constant and proportional to the basic energy unit E_0 [30]. Considering the main goal of WUM—two dimensionless parameters only—the rest energies of DMPs should be proportional to constant α only.

Following the mechanism discussed by C. Boehm, *et al.*, we proposed multi-component DM system consisting of two couples of co-annihilating DMPs: a heavy Dark Matter Fermion (DMF)—DMF1 (1.3 TeV) and a light spin-0 boson—DIRAC (70 MeV) that is a dipole of Dirac's monopoles with charge $\mu = e/2\alpha$ (e is the elementary charge); a heavy fermion—DMF2 (9.6 GeV) and a light spin-0 boson—ELOP (340 keV) that is a dipole of preons with electrical charge $e/3$; DMF3 (3.7 keV), DMF4 (0.2 eV), and boson XION (10.6 μeV).

In frames of WUM, Dark Matter Particles **DMF1**, **DMF2**, and **DMF3** have rest energies, which corresponds to rest energies of Neutralinos, WIMPs, and Sterile Neutrinos discussed in literature (see Section 3.1). **DMF4** constitute the biggest shell of DM Cores of Superclusters [33].

DIRAC, which is a magnetic dipole of Dirac's monopoles, is introduced to explain the Dirac's quantization condition. The quantum theory of magnetic charge started with a paper by P. Dirac in 1931 [34]. In this paper, he showed that if any magnetic monopoles exist in the universe, then all electric charge in the universe must be quantized. The electric charge is, in fact, quantized, which is consistent with (but does not prove) the existence of monopoles. Since Dirac's paper, several systematic monopole searches have been performed but it remains an open question whether monopoles exist [35]. In our opinion, all electric

charges are quantized due to existence of DIRACs—dipoles of Dirac's monopole, which are the smallest building blocks of the structure of constituent quarks and hadrons (mesons and baryons).

ELOP, which is an electric dipole of preons with the rest energy ($E_e/3 = 170.333$ keV), is introduced to explain all subatomic particles with electrical charge $\propto e/3$. Preons are the smallest building blocks of the structure of quarks and leptons. According to I. A. D'Souza and C. S. Kalman "*In particle physics, preons are postulated 'point-like' particles, conceived to be subcomponents of quarks and leptons*" [36].

S. Sukhoruchkin has this to say about "A Role of Hadronic effects in Particle Masses" [37]: *We discuss relations in particle mass spectrum and consider results of analysis of spacing distributions in nuclear spectra which show a distinguished character of intervals related to the electron mass and nucleon mass splitting. Systematic appearance of stable nuclear intervals rationally connected with particle mass splitting* **170**-340-510-1020 *keV… was found in levels of different nuclei including low-spin levels observed in* (γ, γ) *and* (n, γ) *reactions. In this work we show such tuning effect in numerous levels from new compilation for light nuclei. Together with long-range correlations in nuclear binding energies they provide a support for the observed correlation between masses of hadrons and leptons* (*including masses of nucleons and* m_e).

We did not consider binding energies of DIRACs and ELOPs, and thus the values of their rest energies are approximate. They have negligible electrostatic and electromagnetic charges because the separation between charges is very small. They do however possess electrostatic and electromagnetic dipole momentum [38].

XION, which is introduced in the present paper for the first time, is an analog of Axion discussed in literature (see Introduction). It has the value of the rest energy 10.6 μeV that is in reasonable agreement with the value of ≳5 μeV discussed in [7] and with highly-motivated mass range between 5 ⇔ 11 μeV discussed in [39]. In our view, XIONs are responsible for the Le Sage's mechanism of gravitation [30].

The reason for this multicomponent DM system was to explain:

- The diversity of Very High Energy gamma-ray sources in the World [40];
- The diversity of DM Cores of Macroobjects of the World (Superclusters, Galaxies, and Extrasolar Systems (ESS)), which are Fermion Compact Objects and DM Reactors in WUM [30].

WUM postulates that rest energies of DMFs and bosons are proportional to the basic energy unit E_0 multiplied by different exponents of α and can be expressed with the following formulae:

DMF1 (fermion): $E_{DMF1} = \alpha^{-2} E_0 = 1.3149948$ TeV

DMF2 (fermion): $E_{DMF2} = \alpha^{-1} E_0 = 9.5959804$ GeV

DIRAC (boson): $E_{DIRAC} = \alpha^{0} E_0 = 70.025252$ MeV

ELOP (boson): $E_{ELOP} = 2/3\,\alpha^{1} E_0 = 340.66596$ keV

DMF3 (fermion): $E_{DMF3} = \alpha^2 E_0 = 3.7289394$ keV
DMF4 (fermion): $E_{DMF4} = \alpha^4 E_0 = 0.19857107$ eV
XION (boson) $E_{XION} = \alpha^6 E_0 = 10.574179$ μeV

We still do not have a direct confirmation of DMPs' rest energies, but we do have a number of indirect observations. The signatures of DMPs self-annihilation with expected rest energies 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 emissions of various Macroobjects in the World [39]. We connect observed gamma-ray spectra with the structure of Macroobjects (nuclei and shells composition). Self-annihilation of those DMPs 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 this regard, it is worth recalling a story about neutrinos: "*The neutrino was postulated first by W. Pauli in* 1930 *to explain how beta decay could conserve energy*, *momentum*, *and angular momentum* (*spin*). *But we still don't know the values of neutrino masses*". Although we still cannot measure neutrinos' masses directly, no one doubts their existence.

Neutrons serve as another example. The mass of a neutron cannot be directly determined by mass spectrometry since it has no electric charge. But since the masses of a proton and of a deuteron can be measured with a mass spectrometer, the mass of a neutron can be deduced by subtracting proton mass from deuteron mass, with the difference being the mass of the neutron plus the binding energy of deuterium.

DMPs do not possess an electric charge. Their masses cannot be directly measured by mass spectrometry. Hence, they can be observed only indirectly due to their self-annihilation and irradiation of gamma-quants.

3.3. Multiworld [41]

According to A. G. Oreshko, "*P. L. Kapitsa supposed that a ball lightning is a window in another world*". We analyzed the possibility of the existence of other Worlds: Micro-World, Small-World, and Large-World based on the proposed Weak, Super-Weak and Extremely-Weak interaction respectively. It was suggested that Ball Lightning is an object of the Small-World. Below we discuss main characteristics of the proposed new Worlds in the Multiworld.

Macro-World. According to WUM, strength of gravity is characterized by gravitational parameter G [42]:

$$G = G_0 \times Q^{-1}$$

where $G_0 = \dfrac{a^2 c^4}{8\pi hc}$ is an extrapolated value of G at the Beginning of the World ($Q = 1$). Q in the present Epoch equals to: $Q = 0.759972 \times 10^{40}$. The range of gravity equals to the size of the World R:

$$R = a \times Q = 1.34558 \times 10^{26} \text{ m}$$

The total mass of the Macro-World M_{tot} is:

$$M_{tot} = 6\pi^2 m_0 \times Q^2 = 4.26943 \times 10^{53} \text{ kg}$$

where m_0 is a basic mass unit: $m_0 = h/ac$, and average density ρ_{MW}:

$$\rho_{MW} = 3\rho_0 \times Q^{-1} = 8.87794 \times 10^{-27} \text{ kg/m}^3$$

that equals to the critical density.

WUM foresees three additional types of interactions: Weak, Super-Weak, and Extremely-Weak, characterized by the following parameters respectively:

$$G_W = G_O \times Q^{-1/4}$$

$$G_{SW} = G_O \times Q^{-1/2}$$

$$G_{EW} = G_O \times Q^{-3/4}$$

In our view, each type of interaction provides integrity of the corresponding World (see Table 1).

Large-World is characterized by a parameter G_{EW}, which is about 10 orders of magnitude greater than G. The range of the extremely-weak interaction R_{EW} in the present epoch equals to:

$$R_{EW} = a \times Q^{3/4} = 1.44115 \times 10^{16} \text{ m} = 1.5233 \text{ ly} = 96335 \text{ AU}$$

In our view, ESS are Large-World objects with spherical boundary between ESS and Intergalactic Medium. This boundary has a surface energy density $\sigma_0 = \frac{hc}{a^3}$. Maximum total mass of ESS equals to:

$$M_{EW} = M_{ESS} = \frac{4\pi\sigma_0 R_{EW}^2}{c^2} = 4\pi m_0 \times Q^{3/2} = 1.03928 \times 10^{33} \text{ kg} = 522.645 M_\odot$$

and maximum mass of Star M_{Star} that is one third of M_{ESS}:

$$M_{Star} = 3.46427 \times 10^{32} \text{ kg} = 174.215 M_\odot$$

Average density ρ_{EW} equals to:

$$\rho_{EW} = 3\rho_0 \times Q^{-3/4} = 8.28918 \times 10^{-17} \text{ kg/m}^3$$

which is about 10 orders of magnitude greater than the critical density. Extremely-weak interaction between DM Cores and all particles around them provide integrity of ESS.

Table 1. Parameters of Multiworld (ρ_0 is a basic density unit: $\rho_0 = h/ca^4$).

Type of World	Type of Interaction	Rel. Interact. Parameter, G/G_0	Rel. Range of Interact, R_{max}/a	Rel. Mass, $M_{max}/4\pi m_0$	Rel. Density, $\rho/3\rho_0$
Macro-World	Gravity	Q^{-1}	Q	$1.5\pi \times Q^2$	Q^{-1}
Large-World	Extremely-Weak	$Q^{-3/4}$	$Q^{3/4}$	$Q^{3/2}$	$Q^{-3/4}$
Small-World	Super-Weak	$Q^{-1/2}$	$Q^{1/2}$	Q	$Q^{-1/2}$
Micro-World	Weak	$Q^{-1/4}$	$Q^{1/4}$	$Q^{1/2}$	$Q^{-1/4}$

Small-World is characterized by the parameter G_{SW}, which is about 20 orders of magnitude greater than *G*. The range of the super-weak interaction R_{SW} in the present epoch equals to:

$$R_{SW} = a \times Q^{1/2} = 1.54351 \times 10^{6} \text{ m}$$

A maximum total mass of Small-World M_{SW} is:

$$M_{SW} = 4\pi m_0 \times Q = 1.19215 \times 10^{13} \text{ kg}$$

and average density ρ_{SW} equals to:

$$\rho_{SW} = 3\rho_0 \times Q^{-1/2} = 7.73947 \times 10^{-7} \text{ kg/m}^3$$

which is about 20 orders of magnitude greater than the critical density. According to WUM, Ball Lightning is an object of the Small-World.

Micro-World is characterized by the parameter G_W, which is about 30 orders of magnitude greater than *G*. The range of the weak interaction R_W in the present epoch equals to:

$$R_W = a \times Q^{1/4} = 1.65314 \times 10^{-4} \text{ m}$$

that is much greater than the range of the weak nuclear force ($10^{-16} \Leftrightarrow 10^{-17}$ m). The introduced principally new Weak Interaction between DMPs provide integrity of all Macroobjects' Cores, which are 3D fluid balls, made up of different fermions, with a very high viscosity and act as solid-state objects. In our view, weak interaction between particles DMF3 provides integrity of DM Fermi Bubbles [30].

With Nikola Tesla's principle at heart—*There is no energy in matter other than that received from the environment*—we apply to the Micro-World the following equation for a maximum total mass M_W:

$$M_W = \frac{4\pi\sigma_0 R_W^2}{c^2} = 4\pi m_0 \times Q^{1/2} = 1.36752 \times 10^{-7} \text{ kg} = 6.28331 M_{Pl}$$

where M_{Pl} is the Planck mass. The average density of the Micro-World ρ_W is:

$$\rho_W = 3\rho_0 \times Q^{-1/4} = 7.22621 \times 10^{3} \text{ kg/m}^3$$

In our opinion, Micro-World objects with mass about Planck mass (we name them PLANCKs) are the smallest building blocks of all Macroobjects.

3.4. Planck Mass

In WUM, the time-varying Gravitational parameter $G \propto \tau^{-1}$ is proportional to the energy density of the Medium $\rho_M \propto \tau^{-1}$. It is not constant. That is why WUM aligns gravity with the Le Sage's kinetic theory of gravitation, which proposes a mechanical explanation for Newton's gravitational force in terms of streams of tiny unseen particles 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 [43].

In WUM, Gravitation is a result of simple interactions of XIONs with Matter which work cooperatively to create a more complex interaction. XIONs are responsible for the Le Sage's mechanism of gravitation [8]. This theory defines Gravity as an emergent phenomenon. Gravity is not an interaction but a manifestation of the Medium.

The validity of this statement follows from the work of L. Spitzer [44] and A. M. Ignatov [45] who identified Le Sage's mechanism as a significant factor in the behavior of dust particles and dusty plasma.

We emphasize that DMPs do not interact via gravity. 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 gravitomagnetic field and serves as a natural borderline between classical and quantum physics. Incidentally, in his "Interpreting the Planck mass" article [46], B. Hammel showed that the Plank mass is *a lower bound on the regime of validity of General Relativity*.

According to Le Sage theory, Gravitation is a "push" mechanism that depends on the screening effect of XIONs (10.6 μeV) by macroobjects with minimum Planck mass.

3.5. XION

In WUM, XIONs have a high concentration in the World n_{XION} (see Section 4):

$$n_{XION} = 3.013034 \times 10^{14}\ \mathrm{m}^{-3}$$

It means that a distance between XIONs a_{XION} is:

$$a_{XION} = 1.491645 \times 10^{-5}\ \mathrm{m}$$

which is much smaller than the range of the Weak interaction R_W (see Section 3.3):

$$R_W = a \times Q^{1/4} = 1.65314 \times 10^{-4}\ \mathrm{m}$$

Due to the Weak interaction, XIONs can collect into clouds with distances between particles smaller than R_W. As a result, clumps of XIONs will arise. Larger clumps will attract smaller clumps and DMPs and initiate a process of expanding DM clumps up to the Planck mass, which can interact each other gravitationally.

On June 28, 2023, NANOGrav announced:

> Astrophysicists using large radio telescopes to observe a collection of cosmic clocks in our Galaxy have found evidence for gravitational waves that oscillate with periods of years to decades, according to a set of papers published today in The Astrophysical Journal Letters. The gravitational-wave signal was observed in 15 years of data acquired by the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) Physics

Frontiers Center (PFC), a collaboration of more than 190 scientists from the US and Canada who use pulsars to search for gravitational waves. International collaborations using telescopes in Europe, India, Australia and China have independently reported similar results.

While earlier results from NANOGrav uncovered an enigmatic timing signal common to all the pulsars they observed, it was too faint to reveal its origin. The 15-year data release demonstrates that the signal is consistent with slowly undulating gravitational waves passing through our Galaxy.

"This is key evidence for gravitational waves at very low frequencies," says Vanderbilt University's Dr. Stephen Taylor, who co-led the search and is the current Chair of the collaboration. "After years of work, NANOGrav is opening an entirely new window on the gravitational-wave universe."

Unlike the fleeting high-frequency gravitational waves seen by ground-based instruments like LIGO (the Laser Interferometer Gravitational-wave Observatory), this continuous low-frequency signal could be perceived only with a detector much larger than the Earth. To meet this need, astronomers turned our sector of the Milky Way Galaxy into a huge gravitational-wave antenna by making use of exotic stars called pulsars. NANOGrav's 15-year effort collected data from 68 pulsars to form a type of detector called a pulsar timing array. Now, their 15 years of pulsar observations are showing the first evidence for the presence of gravitational waves, with periods of years to decades (15 years equal to 4.734×10^8 s) [47].

In the present paper, we discuss the proposed conjecture in detail. In our analysis, we use analogy between Electromagnetism and Gravitomagnetism. In WUM, the World consists of stable elementary particles with lifetimes longer than the age of the World. Protons with mass m_p and electrons with mass m_e have identical concentrations in the World: $n_p = n_e$. Intergalactic plasma (IGP) consisting of protons and electrons has plasma frequency ω_{pl}:

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

where ε_0 is the permittivity of free space. We emphasize that plasma frequency depends only on the concentration of particles, which constitute the plasma. By analogy between Electromagnetism and Gravitomagnetism, we define an ensemble of the objects with Planck mass (PLANCKs) in the Medium as "Gravitoplasma", a maximum concentration of which can be calculated from Medium's energy density ρ_M:

$$\rho_M = 2\rho_0 \times Q^{-1} = \frac{M_{Pl}}{R_{SW}^3} = \frac{2m_0 \times Q^{1/2}}{a^3 \times Q^{3/2}} = n_{Pl} M_{Pl}$$

where n_{Pl} is a maximum concentration of Gravitoplasma:

$$n_{Pl} = R_{SW}^{-3} = 0.2720 \times 10^{-18}\ \mathrm{m}^{-3}$$

Then, an equation for Gravitoplasma frequency ω_{Pl} is:

$$\omega_{Pl}^2 = 2n_{Pl}ac^2 = 8.655\times10^{-16}\ \mathrm{s}^{-2}$$

$$\omega_{Pl} = 2.942\times10^{-8}\ \mathrm{s}^{-1}$$

$$\nu_{Pl} = 4.682\times10^{-9}\ \mathrm{s}^{-1} = 4.682\ \mathrm{nHz}$$

In our view, the Super-weak interaction between PLANCKs with distance between them equals to R_{SW} provides integrity of Gravitoplasma. Cosmic Gravitational Background is produced by Gravitational interaction between oscillating PLANCKs. Gravitational waves with frequency are smaller than ν_{Pl} cannot propagate in Gravitoplasma. It is worth noting that the calculated value of ν_{Pl} is the maximum value of Gravitoplasma frequency in case when the Medium consists of PLANCKs only. The calculated value of ν_{Pl} is in good agreement with the results obtained in [47].

When a distance between PLANCKs is larger than R_{SW}, then the integrity of Gravitoplasma provides the Extremely-weak interaction between them. In this case, Gravitoplasma frequency is lower than the calculated value ν_{Pl}. Gravitoplasma can be viewed as a cloud of "cosmic dust particles" with the size up to $R_{EW} = 1.44115\times10^{16}\ \mathrm{m} = 1.5233\ \mathrm{ly}$.

PLANCKs can also be responsible for the cosmic Far-Infrared Background, which 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 [48].

4. Distribution of World's Energy Density

Our Model holds that the energy density of all types of self-annihilating DMPs is proportional to proton energy density in the Medium of the World ρ_p in all times that in the present Epoch equals to:

$$\rho_p = \frac{2\pi^2\alpha}{3}\rho_{cr} = 0.048014655\rho_{cr} = 239.1207\ \mathrm{MeV/m}^3$$

where ρ_{cr} is the critical energy density of the World. In all, there are 6 different types of self-annihilating DMPs: DMF1, DMF2, DIRAC, ELOP, DMF3, and DMF4. Then the total energy density of DMPs ρ_{DM} is

$$\rho_{DM} = 6\rho_p = 0.28808793\rho_{cr}$$

that is in good agreement with the results in [1]. The total XION energy density ρ_{XION} is

$$\rho_{XION} = 1.35\pi^2\rho_p = 0.63974563\rho_{cr}$$

The total baryonic energy density ρ_B is:

$$\rho_B = 1.5\rho_p$$

The sum of electron and Microwave Background Radiation energy densities ρ_{eMBR} equals to:

$$\rho_{eMBR} = 1.5\frac{m_e}{m_p}\rho_p + 2\frac{m_e}{m_p}\rho_p = 3.5\frac{m_e}{m_p}\rho_p$$

We take energy density of neutrinos ρ_ν to equal:

$$\rho_\nu = \rho_{MBR}$$

For Far-Infrared Background Radiation energy density ρ_{FIRB} we take

$$\rho_{FIRB} = \frac{1}{40}\frac{m_e}{m_p}\rho_p$$

Then the energy density of the World ρ_W equals to the theoretical critical energy density:

$$\rho_W = \left[1.35\pi^2 + 7.5 + (5.5 + 1/40)\frac{m_e}{m_p}\right]\rho_p = \rho_{cr}$$

From this equation we can calculate the value of $1/\alpha$ using electron-to-proton mass ratio m_e/m_p :

$$\frac{1}{\alpha} = \frac{\pi^2}{60}\left[54\pi^2 + 300 + (220 + 1)\frac{m_e}{m_p}\right] = 137.03600$$

which is in excellent agreement with the commonly adopted value of 137.035999. It follows that there is a direct correlation between constants α and m_e/m_p expressed by the obtained equation. As shown, m_e/m_p is not an independent constant but is instead derived from α [49].

Summary:

- The World's energy density is inversely proportional to a dimensionless time-varying parameter $Q \propto \tau$ in all cosmological times;
- The particles relative energy densities are proportional to constant α.

5. Conclusions

Dark Matter is abundant [29]:

- 2.4% of Ordinary Matter is in Superclusters, Galaxies, Stars, Planets, etc.
- 4.8% of Ordinary Matter is in the Medium of the World;
- The remaining 92.8% is DM.

Dark Matter is omnipresent:

- 2/3 of the total DM is in the Medium of the World;
- 1/3 of the total DM is in Macroobjects of the World;
- Cores of all Macroobjects of the World;
- DM Reactors in Cores of all gravitationally-rounded Macroobjects;
- Coronas of all Macroobjects of the World;
- Fermi Bubbles.

WUM predicts existence of DMPs with 1.3 TeV, 9.6 GeV, 70 MeV, 340 keV, 3.7 keV, 0.2 eV, and 10.6 μeV rest energies. We should concentrate our efforts on the observations of cosmic gamma-rays with spectral lines corresponding to the predicted values of DMP's rest energies.

In our view, great experimental results and observations achieved by Astronomy in the last decades should be analyzed through the prism of a New Paradigm based on WUM. Astronomers should plan new targeted experiments

based on the results of these analyses.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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