Paradigm Shift in Cosmology. Principal Role of Medium & Dark Matter & Angular Momentum

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Abstract

The main objective of a paper is to discuss the most important Concepts for any Cosmological model: Space, Time, and Gravitation; Cosmological principle (homogeneous and isotropic universe); Universality of physical laws; Law of the conservation of angular momentum; Expansion of universe; Content of the World; Formation of galaxies and large-scale structures; Speed of light in vacuum; Origin of cosmic microwave background radiation. The performed analysis shows that Big Bang Model (BBM) fails to account for these Concepts and should be obsolete.

Hypersphere World-Universe Model (WUM) is, in fact, a Paradigm Shift in Cosmology [1]. WUM and BBM are principally different Models: 1) Instead of the Initial Singularity with the infinite energy density and the extremely rapid expansion of the space (Inflation) in BBM; in WUM, there was a Fluctuation (4D Nucleus of the World with an extrapolated radius equals to a basic unit of size a) in the Eternal Universe with a finite extrapolated energy density (four orders of magnitude less than the nuclear density) and a finite expansion of the Nucleus in Its fourth spatial dimension with speed c that is the gravitodynamic constant; 2) Instead of a practically Infinite Homogeneous and Isotropic Universe around the Initial Singularity in BBM; in WUM, the 3D Finite Boundless World (the Hypersphere of the 4D Nucleus) presents a Patchwork Quilt of different Luminous Superclusters (≳10^3), which emerged in different places of the World at different Cosmological times. The Medium of the World is Homogeneous and Isotropic. The distribution of Macroobjects in the World is spatially Inhomogeneous and Anisotropic and temporally Non-simultaneous. The Absolute Age of the entire World (determined by the parameters of the Medium) is 14.22 Gyr. The Medium of the World, Dark Matter, and Angular Momentum are the main Three Pillars of WUM.

1. Introduction

In my opinion, there is a principal difference between Physics and Mathematics. I am convinced that Physics cannot exist without Mathematics, but Mathematics must not replace Physics. It is exactly what has happened for the last one hundred years. Between 1907 and 1912, Albert Einstein wrote: "*Since the mathematicians have invaded the theory of relativity, I do not understand it myself anymore*".

I absolutely agree with John von Neumann who said: "*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*."

In frames of BBM, the Beginning of the Universe is connected with Initial Singularity (infinite energy density) and Cosmological Inflation, which is a theory of an extremely rapid exponential expansion of space (with practically infinite speed) in the early universe up to 93 billion light-years in diameter of the observable universe. The size of the whole universe is unknown, and it might be infinite in extent. The Initial Singularity is a gravitational singularity predicted by General Relativity to have existed before the Big Bang and thought to have contained all the energy and spacetime of the Universe. From a physical point of view, existence of a mathematical singularity is a drawback of any theory. It means that the theoretical model did not consider some significant physical phenomenon, which prevents an occurrence of the singularity.

In our view, there is no way to prevent an occurrence of the initial singularity in BBM. The World must have gotten started in a principally separate way – a Fluctuation in the Eternal Universe with a finite size and energy density.

The size of this Fluctuation can increase with a finite speed. Then, there is no need to introduce the cosmological inflation. However, a question about the mechanism of Continuous Creation of Matter in the World arises. This mechanism was the main challenge of WUM during its development for 20 years.

2. Big Bang Model

The framework for BBM relies on the **General Relativity** and on simplifying assumptions such as homogeneity and isotropy of space. The Lambda Cold Dark Matter (ΛCDM) model is a parametrization of BBM in which the universe contains three major components: a Cosmological constant Λ associated with dark energy; the postulated Cold Dark Matter (CDM); and Ordinary matter. The ΛCDM model 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 these six parameters are mostly not predicted by current theory; other possible parameters are fixed at "natural" values e.g. total density equals to 1.00; neutrino masses are small enough to be negligible. The ΛCDM model can be extended by adding cosmological inflation. It is frequently referred to as the Standard Model of Big Bang cosmology. The Four Pillars of the Standard Cosmology are as follows [2], [3]:

- Expansion of the Universe;
- Origin of the cosmic background radiation;
- Nucleosynthesis of the light elements;
- Formation of galaxies and large-scale structures.

The performed analysis, which we made in [4], shows that the Four Pillars of the Standard Cosmology are model-dependent and not strong enough to support BBM.

3. Analysis of Big Bang Model

In 1905, A. Einstein based a work on **Special Relativity** on two postulates:

- The laws of physics are invariant (i.e., identical) in all inertial systems (i.e., non-accelerating frames of reference);
- The speed of light in a vacuum is the same for all observers, regardless of the motion of the light source.

General Relativity is the geometric theory of gravitation published by A. Einstein in 1915 and is the current description of gravitation in modern physics. General Relativity generalizes Special Relativity and refines Newton's law of universal gravitation, providing a unified description of gravity as a geometric property of space and time or **four-dimensional spacetime**.

In 1983, P. S. Wesson suggested that a fifth dimension might be associated with rest mass m via $x^4 = Gm/c^2 \propto t$, where G is the gravitational constant and c is the speed of light in a vacuum [5]. *The chief effect of this new coordinate on four-dimensional physics was that particle rest mass, usually assumed to be constant, varied with time"*. Moreover, J. M. Overduin and P. S. Wesson postulated that "*Metrics which do not depend on* x^4 *can give rise only to induced matter composed of* (massless) *photons; while those which depend on* x^4 *give back equations of state for fluids composed of massive particles"* [6]. **WUM** supplies the fluid that J. M. Overduin and P. S. Wesson have predicted [7]: it is, in fact, the Medium of the World (see Section 4).

As the conclusion:

- BBM relies on simplifying assumptions such as **homogeneity and isotropy of space** and **laws of physics are invariant** in all inertial systems;
- The **speed of light in a vacuum** is the same for all observers;
- **Massless photons**;
- The existence of **Cold Dark Matter** is a principal point of BBM.

4. Medium of the World

Physical Aether was suggested as early as the 17th century, by I. Newton. Following the work of T. Young (1804) and A. J. Fresnel (1816), it was believed that light propagates as a transverse wave within an elastic medium called Luminiferous Aether, which was abandoned in 1905. In later years there have been classical physicists who advocated the existence of Aether [8]:

- N. Tesla declared in 1937: *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* [9];
- P. Dirac stated in 1951 in an article "Is there an Aether?" that *we are rather forced to have an Aether* [10].

WUM introduces the Medium of the World, which consists of stable elementary particles with lifetimes longer than the age of the World: protons, electrons, photons, neutrinos, and Dark Matter Particles (DMPs). 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. Inter-galactic voids discussed by astronomers are, in fact, examples of the Medium in its purest. Cosmic Microwave Background Radiation is part of the Medium; it then follows that the **Medium is the absolute frame of reference**. Relative to the Cosmic Microwave Background rest frame, the Milky Way galaxy and the Sun are moving with the speed of 552 and $370\ km\ s^{-1}$, respectively [11].

The energy density of the Medium is $2/3$ of the total energy density of the World. Superclusters, Galaxies, Extrasolar systems, planets, moons, *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 [11]. **Cosmological principal is valid for the Homogeneous and Isotropic Medium.** The distribution of Macroobjects is Inhomogeneous and Anisotropic, and therefore, the **Cosmological Principal is not viable for the entire World.**

Intergalactic plasma consisting of protons and electrons is an important part of the Medium. It explains:

- **Missing Baryon problem** related to the fact that the observed amount of baryonic matter did not match theoretical predictions;
- **Black-body spectrum of the Cosmic Microwave Background Radiation** is due to thermodynamic equilibrium of photons with Intergalactic Plasma;
- The predicted by WUM in 2013 value of the **Minimum energy of photons** which can pass through the Intergalactic plasma is in good agreement with the value obtained by L. Bonetti, *et al.* in 2017 [12].

WUM is the classical model, therefore classical notions can be introduced only when the very first ensemble of particles was created at the cosmological time τ_M equals to: $\tau_M = \alpha^{-2} \times t_0 \cong 10^{-18} s$, where α is the dimensionless Rydberg constant: $\alpha = (2aR_\infty)^{1/3}$ (that was later named "Fine-structure constant"); t_0 is a basic unit of time: $t_0 = a/c = 5.9059662 \times 10^{-23}\ s$; a is a basic unit of size $a = 1.7705641 \times 10^{-14}\ m$; and c is a gravitodynamic constant. It is worth noting that the **speed of light in vacuum**, commonly denoted as 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. In WUM, the cosmological principal **Universality of physical laws** is valid at the cosmological times $\tau \geq \tau_M$ because they are determined by the Medium of the World.

Inter-Connectivity of Primary Cosmological Parameters. The constancy of the universe fundamental constants, including Newtonian constant of gravitation, is now commonly accepted, although has never been firmly established as a fact. All conclusions on the constancy of G are model-dependent. A commonly held opinion states that gravity has no established relation to other fundamental forces, so it does not appear possible to calculate it 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 that is a measure of the Size R and Age A_τ of the World [11]:

$$Q = \frac{R}{a} = \frac{A_\tau}{t_0}$$

which in present epoch equals to: $Q = 0.759972 \times 10^{40}$ and is, in fact, the Dirac Large Number.

The Model develops a mathematical framework that allows for direct calculation of the following parameters through Q : Newtonian parameter of gravitation; Age of the World; Size of the World; Hubble's parameter; Critical energy density; Concentration of Intergalactic Plasma; Minimum Energy of Photons; Temperature of the Microwave Background Radiation; Temperature of the Far-Infrared Background Radiation peak; Fermi coupling parameter; Electronic neutrino rest energy; Muonic neutrino rest energy; Tauonic neutrino rest energy. In frames of WUM, we calculate the values of these Primary Cosmological Parameters, which are in good agreement with the latest results of their measurements [11].

WUM is **based on two parameters only** α and Q : the World's energy density is proportional to Q^{-1} in all cosmological times and particles relative energy densities are proportional to α .

In frames of WUM, **Time and Space** are closely connected with the Mediums' impedance (wave resistance) Z_g that equals to the Hubble's parameter H : $Z_g = H = \tau^{-1}$ and the gravitomagnetic parameter μ_g , which equals to: $\mu_g = R^{-1}$. 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. The Gravitation is a result of simple interactions of DMPs with Matter (by the introduced new **Weak Interaction**) that work cooperatively to create a more complex interaction. DMPs are responsible for Le Sage's mechanism of the gravitation. Gravity is not an interaction but a manifestation of the Medium. **Gravity, Space and Time** are all emergent phenomena. In this regard, it is worth recalling A. Einstein quote: "*When forced to summarize the theory of relativity in one sentence: time and space and gravitation have no separate existence from matter*" [11].

It turned out that the abandoning of the Luminiferous Aether in 1905 was crucial for the Classical Physics. It is a great pity that the mainstream physicists at that time did not know (or forgot) a theory developed by J. McCullagh in 1846. He proposed a **Theory of a rotationally elastic medium**, i.e. a medium in which every particle resists absolute rotation [13]. 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 equations. J. 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. **As the conclusion**, the Medium is the Savior of the Classical Physics!

5. Dark Matter

5.1. Early Ideas

The history of the Dark Matter (DM) can be traced back to at least the middle of the 19th century. G. Bertone and D. Hooper provide an excellent review of this history [14]. The principal steps are:

- In 1844, F. Bessel argued that the observed proper motion of the stars Sirius and Procyon could only be explained by the presence of faint companion stars influencing the observed stars through their gravitational pull: *If we were to regard Procyon and Sirius as double stars, their change of motion would not surprise us. The existence of numberless visible stars can prove nothing against the evidence of numberless invisible ones* ;
- Beside dark stars and planets, astronomers in the 19th century also discussed dark matter in the form of dark clouds, or dark "nebulae". In 1877, A. Secchi wrote: *Among these studies there is the interesting probable discovery of dark masses scattered in space, whose existence was revealed thanks to the bright background on*

which they are projected. Until now they were classified as black cavities, but this explanation is highly improbable, especially after the discovery of the gaseous nature of the nebular masses ;

- In 1904, Lord Kelvin was among the first to attempt a dynamical estimate of the amount of dark matter in the Milky Way. His argument was simple yet powerful: if stars in the Milky Way can be described as a gas of particles, acting under the influence of gravity, then one can establish a relationship between the size of the system and the velocity dispersion of the stars: *It is nevertheless probable that there may be as many as* 10^9 *stars (within a sphere of radius* 3.09×10^{16} *km) but many of them may be extinct and 10 dark, and nine-tenths of them though not all dark may be not bright enough to be seen by us at their actual distances. [...] Many of our stars, perhaps a great majority of them, may be dark bodies* ;
- In 1933, F. Zwicky investigated the velocity dispersion of the Coma cluster and found a surprisingly high mass-to-light ratio (~500). He concluded: *if this would be confirmed, we would get the surprising result that dark matter is present in much greater amount than luminous matter* ;
- What did Zwicky think that the dark matter in Coma and other galaxy clusters might be? An illuminating sentence in his 1937 paper provides a rather clear answer to this question: *In order to derive the mass of galaxies from their luminosity we must know how much dark matter is incorporated in nebulae in the form of cool and cold stars, macroscopic and microscopic solid bodies, and gases.*

5.2. Recent Developments

Our article "Astrophysics: Macroobject Shell Model" focuses on more recent developments [15]:

- In 1977-1980, indirect effects in cosmic rays and gamma-ray background from the annihilation of Cold DM in the form of heavy stable neutral leptons in Galaxies were considered in pioneer articles [16]-[21];
- In the wake of the failures of hot DM, it was quickly becoming appreciated that cold DM could do a much better job of accounting for the observed patterns of large-scale structure. In 1984, G. Blumenthal, S. Faber, J. Primack, and M. Rees wrote: "*We have shown that a universe with ~10 times as much cold dark matter as baryonic matter provides a remarkably good fit to the observed universe. This model predicts roughly the observed mass range of galaxies, the dissipational nature of galaxy collapse, and the observed Faber-Jackson and Tully-Fisher relations. It also gives dissipationless galactic halos and clusters. In addition, it may also provide natural explanations for galaxy-environment correlations and for the differences in angular momenta between ellipticals and spiral galaxies*" [14];
- By the end of the 1980s, the conclusion that most of the mass in the Universe consists of cold and non-baryonic particles had become widely accepted, among many astrophysicists and particle physicists alike. Cold dark matter in the form of some unknown species of elementary particle had become the leading paradigm [14];
- Two-component DM systems consisting of bosonic and fermionic components are 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) [22];

5.3. Dark Matter in WUM

WUM proposes multicomponent DM system consisting of two couples of coannihilating 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; a self-annihilating fermion – DMF3 (3.7 keV), and a fermion DMF4 (0.2 eV).

WUM postulates that rest energies of DMFs and bosons are proportional to a basic unit of energy $E_0 = hc/a$ multiplied by different exponents of α and can be expressed with the following formulae [23]:

DMF1 (fermion): $E_{DMF1} = \alpha^{-2}E_0 = 1.3149950\ TeV$
DMF2 (fermion): $E_{DMF2} = \alpha^{-1}E_0 = 9.5959823\ GeV$
DIRAC (boson): $E_{DIRAC} = \alpha^{0}E_0 = 70.025267\ MeV$
ELOP (boson): $E_{ELOP} = 2/3\alpha^{1}E_0 = 340.66606\ keV$
DMF3 (fermion): $E_{DMF3} = \alpha^{2}E_0 = 3.7289402\ keV$
DMF4 (fermion): $E_{DMF4} = \alpha^{4}E_0 = 0.19857111\ eV$

where h is Planck constant; α is the dimensionless Rydberg constant: $\alpha = (2aR_\infty)^{1/3}$ (that was later named "Fine-structure constant"); a is a basic unit of size $a = 1.7705641 \times 10^{-14}\ m$; and c is the **gravitodynamic constant** that is the ratio of the absolute gravitomagnetic unit of charge E_0 to the absolute gravitostatic unit of charge E_0/c. It is worth noting that the **speed of light in vacuum**, commonly denoted as 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. Also note that the rest energy of electron E_e equals to: $E_e = \alpha E_0$ and the Rydberg unit of energy is: $Ry = hcR_\infty = 0.5\ \alpha^3 E_0 = 13.605693\ eV$.

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. 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 WUM.

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.

5.4. Macroobject Shell Model

In WUM, Macrostructures of the World (Superclusters, Galaxies, Extrasolar systems) have Nuclei made up of DMFs, which are surrounded by Shells composed of DM and Baryonic Matter. The shells envelope one another, like a Russian doll. The lighter a particle, the greater the radius and the mass of its shell. Innermost shells are the smallest and are made up of heaviest particles; outer shells are larger and consist of lighter particles. Introduced principally new Weak Interaction of DMPs with Matter provides integrity of all shells. **Table 1** describes the parameters of Macroobjects' Cores, which are 3D fluid balls with a high viscosity and act as solid-state objects [23].

Table 1. Parameters of Macroobjects' Cores made up of different Fermions in present Epoch.

Fermion	Fermion Mass m_f, MeV	Macroobject Mass M_{max}, kg	Macroobject Radius R_{min}, m	Macroobject Density ρ_{max}, kgm^{-3}
DMF1	1.3×10^{6}	1.9×10^{30}	8.6×10^{3}	7.2×10^{17}
DMF2	9.6×10^{3}	1.9×10^{30}	8.6×10^{3}	7.2×10^{17}
Electron-Positron	0.51	6.6×10^{36}	2.9×10^{10}	6.3×10^{4}
DMF3	3.7×10^{-3}	1.2×10^{41}	5.4×10^{14}	1.8×10^{-4}
DMF4	2×10^{-7}	4.2×10^{49}	1.9×10^{23}	1.5×10^{-21}

The calculated parameters of the shells show that [9]:

- Nuclei made up of DMF1 and/or DMF2 compose Cores of stars in Extrasolar Systems;
- Shells of DMF3 and/or Electron-Positron plasma around Nuclei made up of DMF1 and/or DMF2 make up Cores of Galaxies;
- Nuclei made up of DMF1 and/or DMF2 surrounded by shells of DMF3 and DMF4 compose Cores of Superclusters.

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

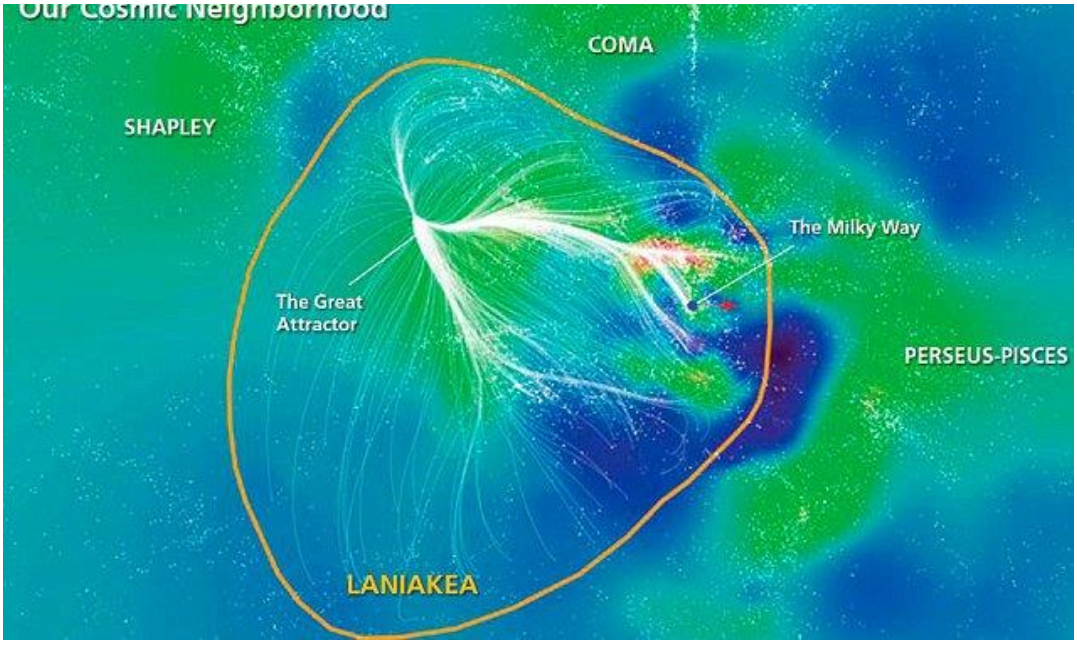
- Nuclei are made up of DMPs. Surrounding shells contain DM and Baryonic matter;
- Nuclei and shells are growing in time proportionally to square root of cosmological time $\propto \tau^{1/2}$ until one of them reaches the critical point of its local stability, at which it detonates. The energy released during detonation is produced by the self-annihilation of DMPs. The detonation process does not destroy the Macroobject; instead, Hyper-flares occur in active areas of the shells, analogous to Solar flares;
- All other DMPs in different shells can start self-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 Nuclei and surrounding shells made up of DMPs. 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.

5.5. Macrostructures

Laniakea Supercluster (LSC) is a galaxy supercluster that is home to Milky Way (MW) and approximately 100,000 other nearby galaxies (see **Figure 1**). It is known as one of the largest superclusters with estimated binding mass $10^{17}\ M_{\odot}$ [25]. The neighboring superclusters to LSC are the Shapley Supercluster, Hercules Supercluster, Coma Supercluster, and Perseus-Pisces Supercluster. Distance from the Earth to the Centre of LSC is 250 Mly. The mass-to-light ratio of the Virgo Supercluster is about three hundred times larger than that of the Solar ratio. Similar ratios are obtained for other superclusters [26]. In 1933, F. Zwicky investigated the velocity dispersion of Coma cluster and found a surprisingly high mass-to-light ratio (~500). He concluded: "*If this would be confirmed, we would get the surprising result that dark matter is present in much greater amount than luminous matter*" [27]. These ratios are one of the **main arguments in favor of presence of significant amounts of Dark Matter in the World**.

We emphasize that about 100,000 nearby galaxies are moving around Centre of Laniakea Supercluster. They belong to LSC. All these galaxies did not start their movement from the "Initial Singularity". The neighboring superclusters have the same structure (see **Figure 2**). It means that the World is, in fact, a Patchwork Quilt of different Luminous Superclusters ($\gtrsim 10^3$) [24].

Figure 1. Laniakea Supercluster. Adapted from [28].



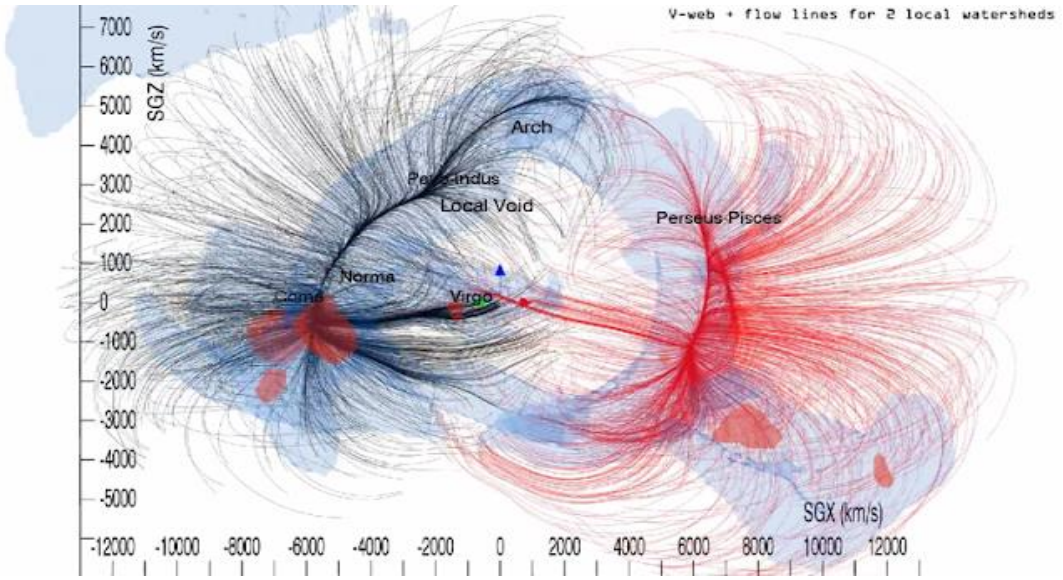


Fig. 2. A representation of structure and flows due to mass within 6,000 km s−1 (~80 Mpc). Surfaces of red and blue respectively represent outer contours of clusters and filaments as defined by the local eigenvalues of the velocity shear tensor determined from the Wiener Filter analysis. Flow threads originating in our basin of attraction that terminate near the Norma Cluster are in black and adjacent flow threads that terminate at the relative attractor near the Perseus Cluster are in red. The Arch and extended Antlia Wall structures bridge between the two attraction basins. Adapted from [28].

According to R. B. Tully, *et al.*, "*Galaxies congregate in clusters and along filaments, and are missing from large regions referred to as voids. These structures are seen in maps derived from spectroscopic surveys that reveal networks of structure that are interconnected with no clear boundaries. Extended regions with a high concentration of galaxies are called 'superclusters', although this term is not precise*" [28].

P. Wang, *et al.* made a great discovery: "*Most cosmological structures in the universe spin. Although structures in the universe form on a wide variety of scales from small dwarf galaxies to large super clusters, the* ***generation of angular momentum across these scales is poorly understood****. We have investigated the possibility that filaments of galaxies - cylindrical tendrils of matter hundreds of millions of light-years across, are themselves spinning. By stacking thousands of filaments together and examining the velocity of galaxies perpendicular to the filament's axis (via their red and blue shift), we have found that these objects too display motion consistent with rotation making them the largest objects known to have angular momentum.* ***These results signify that angular momentum can be generated on unprecedented scales***" [29].

In June 2021, at the "*Giant Arc at the 238th virtual meeting of the American Astronomical Society*", A. Lopez reported about the discovery of "*a giant, almost symmetrical arc of galaxies – the Giant Arc – spanning 3.3 billion light years at a distance of more than 9.2 billion light years away that is* ***difficult to explain in current models of the Universe****. The Giant Arc, which is approximately 1/15th the radius of the observable universe, is twice the size of the striking Sloan Great Wall of galaxies and clusters that is seen in the nearby Universe. This new discovery of the Giant Arc adds to an* ***accumulating set of (cautious) challenges to the Cosmological Principle****. The discovery of the Giant Arc adds to the number of structures on scales larger than those thought to be "smooth," and therefore pushes the boundary size for the Cosmological Principle. The growing number of large-scale structures over the size limit of what is considered theoretically viable is becoming harder to ignore. According to cosmologists, the current theoretical limit is calculated to be 1.2 billion light years, which makes the Giant Arc almost three times larger.* ***Can the standard model of cosmology account for these huge structures in the Universe as just rare flukes or is there more to it than that?"*** [30].

B. Carr, *et al.* "*consider the observational constraints on stupendously large black holes (SLABs) in the mass range* $M > 10^{11} M_{\odot}$ *. These have attracted little attention hitherto, and we are aware of no published constraints on a SLAB population in the range* $(10^{12} - 10^{18})\ M_{\odot}$ *. However, there is already evidence for black holes of up to nearly* $10^{11} M_{\odot}$ *in galactic nuclei , so it is conceivable that SLABs exist, and they may even have been seeded by primordial black holes"* [31].

WUM. These latest observations of the World can be explained in frames of the developed WUM only:

- "*Galaxies* ***do not*** *congregate in clusters and along filaments."* On the contrary, Cosmic Web that is "*networks of structure that are interconnected with no clear boundaries"* is the result of the Rotational Fission of DM Cores of neighbor Superclusters;
- *"Generation of angular momentum across these scales"* provide DM Cores of Superclusters through the Rotational Fission mechanism;
- *"Spinning cylindrical tendrils of matter hundreds of millions of light-years across"* are the result of spiral jets of galaxies generated by DM Cores of Superclusters with internal rotation;
- The Giant Arc is the result of the intersection of the Galaxies' jets generated by the neighbor DM Cores of Superclusters;
- The calculated maximum mass of the supercluster DM Core of 2.1×10^{19} solar mass (see **Table 1**) is in good agreement with the values discussed by L. Bliss [25] and B. Carr, F. Kühnel and L. Visinelli [31]. In the future, these stupendously large compact objects can give rise to new Luminous Superclusters as the result of their DM Cores' rotational fission;
- 13.77 Gyr ago, when the Laniakea Supercluster emerged, the estimated number of DM Supercluster Cores in the World was around $\sim 10^3$ [24]. It is unlikely that all of them gave birth to Luminous Superclusters at the same cosmological time being far away from each other. The 3D Finite Boundless World presents a Patchwork Quilt of different Luminous Superclusters, which emerged at different Cosmological times;
- The main conjecture of BBM: "*Projecting galaxy trajectories backwards in time means that they converge to the Initial Singularity at t=0 that is an infinite energy density state*" is wrong because all Galaxies are gravitationally bound with their Superclusters (see **Fig. 1** and **Fig. 2**). Big Bang never happened.

5.6. Dark Matter Fermi Bubbles

In 2010, the discovery of two Fermi Bubbles (FBs) emitting gamma- and X-rays was announced. FBs extend for about 25 kly above and below the center of the galaxy [32]. The outlines of the bubbles are quite sharp, and the Bubbles glow in nearly uniform gamma rays over their colossal surfaces. Gamma-ray spectrum remains unconstrained up to around 1 TeV [33]. Years after the discovery of FBs, their origin and the nature of the gamma-ray emission remain unresolved.

In **WUM,** FBs are DMPs' clouds containing uniformly distributed Dark Matter Objects (DMOs), in which DMPs self-annihilate and radiate X-rays and gamma rays. FBs made up of DMF3 particles resemble a honeycomb filled with DMF1 and DMF2. Weak interaction between DMF3 particles provides integrity of FBs. Gamma rays up to 1 TeV are the result of the self-annihilation of DMF1 (1.3 TeV) and DMF2 (9.6 GeV) in DMOs, which are macroobjects whose density is sufficient for the self-annihilation of DMPs to occur. On the other hand, DMOs are much smaller than stars in the World, and have a high concentration in FBs to provide nearly uniform gamma ray glow over their colossal surfaces. The Core of MW supplies FBs with new DMPs through the galactic wind, explaining the brightness of FBs remaining constant during the time of observations. In our opinion, FBs are built continuously throughout the lifetime of MW (13.77 Byr) [11].

5.7. Dark Matter Reactors

Sun's DM Core. According to the standard Solar model, the Sun has:

- Core that extends from the center to 20–25% of the solar radius. It produces all of Sun's energy;
- Radiative zone from the Core to about 70% of the solar radius, in which convection does not occur and energy transfer occurs by means of radiation;
- E. Fossat, *et al.* found that Solar Core rotates 3.8 ± 0.1 faster than the surrounding envelope [34];
- Core and Radiative zone contain practically all Sun's mass [35].

The large power output of the Sun is mainly due to the huge size and density of its Core, with only a fairly small amount of power being generated per cubic meter. Theoretical models of the Sun's interior indicate a maximum power density of approximately $276.5\ W/m^3$ at the center of the Core [36], which is about the same power density inside a compost pile [37] and closer approximates reptile metabolism than a thermonuclear bomb. In our view, Core and Radiative zone are the parts of the Sun's DM Core.

Evolution of the Sun. By 1950s, stellar astrophysicists had worked out the physical principles governing the structure and evolution of stars [38]. According to these principles, the Sun's luminosity had to change over time, with the young Sun being about 30% less luminous than today [39], [40], [41]. The long-term evolution of bolometric solar luminosity $L(\tau)$ as a function of cosmological time τ can be approximated by a linear law: $L(\tau) \propto \tau$ [38].

One of the consequences of **WUM** holds that all stars were fainter in the past. As their cores absorb new DMPs, size of MO cores R_{MO} and their luminosity L_{MO} are increasing in time: $R_{MO} \propto \tau^{1/2}$ and $L_{MO}(\tau) \propto R_{MO}^2 \propto \tau$, respectively. Taking the age of the World: $A_W \cong 14.22\ Byr$ and the age of SS: $A_{SS} \cong 4.57\ Byr$, it is easy to find that the young Suns' output was 67% of what it is today. Literature commonly refers to the value of 70% [38].

Earth's Internal Heating. The analysis of Sun's heat for planets in Solar System (SS) yields the effective temperature of Earth of 255 K [42]. The actual mean surface temperature of Earth is 288 K [43]. The higher actual temperature of Earth is due to energy generated internally by the planet itself. According to the standard model, the Earth's internal heat is produced mostly through radioactive decay. The major heat-producing isotopes within Earth are K-40, U-238, and Th-232. The mean global heat loss from Earth is 44.2 TW [44]. The Earth's Uranium has been thought to be produced in one or more supernovae over 6 Gyr ago [45].

Radiogenic decay can be estimated from the flux of geoneutrinos that are emitted during radioactive decay. The KamLAND Collaboration found that decay of K-40, U-238 and Th-232 together contribute about 24 TW to the total heat flux from the Earth to space. Based on the observations they made a conclusion that *heat from radioactive decay contributes about half of Earth's total heat flux* [46].

Plutonium-244 with half-life of 80 million years is not produced by the nuclear fuel cycle, because it needs very high neutron flux environments. Any Plutonium-244 present in the Earth's crust should have decayed by now. Nevertheless, D. C. Hoffman, *et al.* in 1971 obtained the first indication of Pu-244 present existence in Nature [47].

In **WUM**, all chemical products of the Earth including isotopes K-40, U-238, Th-232, and Pu-244, are produced within the Earth as the result of DMF1 self-annihilation [11]. They arrive in the Crust of Earth due to convection currents in the mantle carrying heat and isotopes from the interior to the planet's surface [48].

Planet's Internal Heating. Jupiter radiates more heat than it receives from the Sun [49]. Giant planets like Jupiter are hundreds of degrees warmer than current temperature models predict. Until now, the extremely warm temperatures observed in Jupiter's atmosphere (about 970 degrees C [50]) have been difficult to explain. Saturn radiates 2.5 times more energy than it receives from the Sun [51]; Uranus – 1.1 times [52]; Neptune – 2.6 times [53].

S. Kamata, *et al.* report that "*many icy Solar System bodies possess subsurface oceans. To maintain an ocean, Pluto needs to retain heat inside*." Kamata, *et al.* show that "*the presence of a thin layer of gas hydrates at the base of the ice shell can explain both the long-term survival of the ocean and the maintenance of shell thickness contrasts. Gas hydrates act as a thermal insulator, preventing the ocean from completely freezing while keeping the ice shell cold and immobile. The most likely guest gas is methane*" [54].

According to **WUM**, the internal heating of all gravitationally-rounded objects of the Solar system is due to DMPs self-annihilation in their cores made up of DMF1 (1.3 TeV). The amount of energy produced due to this process is sufficiently high to heat up the objects. New DMF1 freely penetrate through the entire objects' envelope, get absorbed into the cores, and continuously support DMF1 self-annihilation [11].

In WUM, Macroobjects' cores are essentially DM Reactors fueled by DMPs. Chemical elements, compositions, radiations are produced by Macroobjects themselves as the result of DMPs self-annihilation. The diversity of all gravitationally-rounded Macroobjects in the Solar system is explained by the differences in their DM cores (mass, size, density, composition). The DM Reactors at their cores (including Earth) are very efficient and provide enough energy for the internal heating and all their geological processes like volcanos, quakes, mountains' formation through tectonic forces or volcanism, tectonic plates' movements [24].

6. Angular Momentum

Angular Momentum Problem is one of the most critical problem in Standard Cosmology that must be solved. Standard Cosmology does not explain how Galaxies and Extrasolar systems obtained their enormous orbital angular momenta. Any theory of evolution of the Universe that is not consistent with the Law of Conservation of Angular Momentum should be promptly ruled out. To the best of our knowledge, WUM is the only cosmological model in existence that is consistent with this Fundamental Law.

In our opinion, there is the only one mechanism that can provide angular momenta to Macroobjects – Rotational Fission of overspinning (surface speed at equator exceeding escape velocity) Prime Objects. From the point of view of Fission model, the prime object is transferring some of its rotational angular momentum to orbital and rotational momenta of satellites. It follows that the rotational momentum of the prime object should exceed the orbital momentum of its satellite. In frames of WUM, prime objects are DM Cores of Superclusters, which must accumulate tremendous rotational angular momenta before the Birth of the Luminous World. It means that it must be some long enough time in the history of the World, which we named "Dark Epoch" [55].

To be consistent with the Law of Conservation of Angular Momentum we developed a New Cosmology of the World:

- WUM introduces Dark Epoch (spanning from the Beginning of the World for 0.45 billion years) when only DM Macroobjects (MOs) existed, and Luminous Epoch (ever since for 13.77 billion years) when Luminous MOs emerged due to the Rotational Fission of Overspinning DM Superclusters' Cores and self-annihilation of DMPs;
- Proposed Weak Interaction between DMPs provides the integrity of DM Cores, which are 3D fluid balls with a high viscosity and function as solid-state objects;
- The main objects of the World are overspinning DM Cores of Superclusters, which accumulated tremendous rotational angular momenta during Dark Epoch and transferred it to DM Cores of Galaxies during their Explosive Volcanic Rotational Fission. The experimental observations of galaxies in the universe showed that most of them are disk galaxies: about 60% are ellipticals and about 20% are spirals [56]. These results speak in favor of the developed Rotational Fission mechanism;
- Size, mass, density, composition, orbital angular momentum, and rotational angular momentum of satellite cores depend on local density fluctuations at the edge of the overspinning prime DM cores and cohesion of the outer shell. Consequently, the diversity of satellite cores has a clear explanation;
- DM Core of MW was born 13.77 billion years ago as the result of the Rotational Fission of the Virgo Supercluster DM Core;
- DM Cores of Extrasolar systems (including planets and moons) are the result of the repeating Rotational Fissions of MW DM Core in various times (4.57 billion years ago for the Solar System);
- Macrostructures of the World form from the top (superclusters) down to galaxies, extrasolar systems, planets, and moons.
- Gravitational waves can be a product of Rotational Fission of overspinning DM Macroobject Cores.

7. Hypersphere World-Universe Model

7.1. Assumptions

WUM is based on three primary assumptions:

- The World is a finite 3D Hypersphere of a 4D Nucleus of the World that is expanding along the fourth spatial dimension of the Nucleus with speed equals to the gravitodynamic constant c. The Universe serves as an unlimited source of DM, which continuously created in the Nucleus of the World. Ordinary Matter is a byproduct of DMPs self-annihilation;
- The Medium of the World, consisting of protons, electrons, photons, neutrinos, and DMPs, is an active agent in all physical phenomena in the World;
- Two fundamental parameters in various rational exponents define all macro and micro features of the World: dimensionless Rydberg constant α and dimensionless quantity Q that is a measure of the Size R and Age A_τ of the World and is, in fact, the Dirac Large Number.

7.2. Principal Points

WUM is based on the following Principal Points:

The Beginning. The World was started by a Fluctuation in the Eternal Universe, and the Nucleus of the World, which is a 4D ball, was born. An extrapolated Nucleus radius at the Beginning was equal to the basic unit of size a. The extrapolated energy density of the World at the Beginning was four orders of magnitude smaller than the nuclear energy density. The World is a finite 3D Hypersphere that is the surface of the 4D Nucleus. All points of the Hypersphere are equivalent; there are no preferred centers or boundaries of the World. The **Initial Centre of the World** coincides with the center of the 4D Nucleus and located in the fourth spatial dimension of the Nucleus. **The 3D World is curved in the fourth spatial dimension!**

Expansion. The 4D Nucleus is expanding along its fourth spatial dimension and its surface, the 3D Hypersphere, is likewise expanding so that the radius of the Nucleus is increasing with speed c that is the gravitodynamic constant. The expansion of the Hypersphere World can be understood through the analogy with an expanding 3D balloon: imagine an ant residing on a seemingly two-dimensional surface of a balloon. As the balloon is blown up, its radius increases, and its surface grows. The distance between any two points on the surface increases. The ant sees her world expands but does not observe a preferred center.

According to WUM, the World is 3D space filled out with the Medium and Macroobjects. We do not know that our 3D space is curved. We know that it is expanding without center of expansion. By the analogy with the expanding 3D balloon, we introduced the radius of the curvature in the fourth spatial dimension $R = a \times Q$ to give an explanation providing insight into the curved nature of the World.

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 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].

Creation of Matter. The surface of the Nucleus 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. DM is created by the Universe in the 4D Nucleus of the World. DMPs carry new DM into the 3D Hypersphere World. Ordinary Matter is a byproduct of DMPs self-annihilation. Consequently, a Matter-Antimatter Asymmetry problem discussed in literature does not arise (since antimatter does not get created by

DMPs self-annihilation). By analogy with 3D ball, which has 2D spherical surface (that has surface energy), we can imagine that the 3D Hypersphere World has a "Surface Energy" of the 4D Nucleus. The grows of the surface of the 4D Nucleus means the increase of the World's "Surface Energy" [57].

The proposed 4D process is responsible for the Expansion, Creation of Matter, and Arrow of Time. It constitutes the main **Hypothesis of WUM**. In our view, the arrow of the Cosmological Time does not depend on any physical phenomenon in the Medium of the World. It is the result of the Worlds' expansion due to the driving force for surfaces to be created. It is important to emphasize that [57]:

- Creation of Matter is a direct consequence of expansion;
- Creation of DM occurs homogeneously in all points of the 3D Finite Boundless Hypersphere World.

Content of the World. The World consists of the Medium and Macroobjects. Total energy density of the World equals to the critical energy density throughout the World's evolution. The energy density of the Medium is 2/3 of the total energy density and Macroobjects (Superclusters, Galaxies, Extrasolar systems, Planets, Moons, *etc*.) – 1/3 in all cosmological times. The relative energy density of DMF4 particles is about 68.8%, self-annihilating DMPs (DMF1, DMF2, DMF3, DIRACs, and ELOPs) – about 24%, and Ordinary particles (protons, electrons, photons, and neutrinos) – about 4.8% in the Medium of the World and 2.4% in Macroobjects.

Two Fundamental Parameters in various rational exponents define all micro- and macro-features of the World: dimensionless Rydberg constant α and Quantity Q. The World's energy density is proportional to Q^{-1} in all cosmological times. Particles relative energy densities are proportional to α.

Supremacy of Matter. Time, Space and Gravitation have no separate existence from Matter. They are closely connected with the Impedance, Gravitomagnetic parameter, and Energy density of the Medium, respectively.

WUM reveals the **Inter-Connectivity of Primary Cosmological Parameters** and calculates their values, which are in good agreement with the latest results of their measurements.

WUM introduces **Dark Epoch** (spanning from the Beginning of the World for 0.45 billion years) and **Luminous Epoch** (ever since, 13.77 billion years). Transition from Dark Epoch to Luminous Epoch is due to the **Explosive Volcanic Rotational Fission** of Overspinning DM Supercluster's Cores and self-annihilation of DMPs.

Macroobjects Shell Model. Macroobjects of the World possess the following properties: their Cores are made up of DMPs; they contain other particles, including DMPs and Ordinary Particles, in shells surrounding the Cores. Introduced **Weak Interaction** between DMPs and Ordinary particles provides integrity of all shells. Self-annihilation of DMPs can give rise to any combination of gamma-ray lines.

Macroobjects Formation and Evolution. Macroobjects form from superclusters down to galaxies and extrasolar systems in parallel around different Cores made up of different DMPs. Formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing. Assuming the Eternal Universe, numbers of cosmological structures on all levels will increase; new superclusters will form; existing clusters will obtain new galaxies; new stars will be born inside existing galaxies; sizes of individual stars will increase. The temperature of the Medium will asymptotically approach absolute zero.

Nucleosynthesis of all elements occurs inside of Macroobjects during their evolution.

Solar Corona, Geocorona and Planetary Coronas made up of DMPs resemble honeycombs filled with plasma particles (electrons, protons, and multicharged ions), which are the result of DMPs self-annihilation.

Dark Matter Reactors. Macroobjects' cores are essentially Dark Matter Reactors fueled by DMPs. All chemical elements, compositions, radiations are produced by Macroobjects themselves as the result of DMPs self-annihilation in their DM cores.

8. Conclusion

WUM solves a number of physical problems in contemporary Cosmology and Astrophysics through DMPs and their interactions: **Angular Momentum problem** in birth and subsequent evolution of Galaxies and Extrasolar systems; **Missing Baryon problem** related to the fact that the observed amount of baryonic matter did not match theoretical predictions; **Fermi Bubbles** – two large structures in gamma-rays and X-rays above and below Galactic center; **Coronal Heating problem** – temperature of Sun's corona exceeding that of photosphere by millions of degrees; **Cores of Sun and Earth** rotating faster than their surfaces; **Diversity of Gravitationally-Rounded Objects** in Solar System and their **Internal Heating**; **Faint young Sun paradox** describes the apparent contradiction between observations of liquid water early in Earth's history and the astrophysical expectation that the Sun's output would be only 70% as intense during that epoch as it is during the modern epoch. WUM reveals **Inter-Connectivity of Primary Cosmological Parameters** and calculates their values, which are in good agreement with the latest results of their measurements.

In 2013, WUM predicted the values of the following Cosmological parameters: Gravitational, Hubble's, Intergalactic plasma concentration, and Photons minimum energy, which were experimentally confirmed in 2015-2021. "*The Discovery of a Supermassive Compact Object at the Centre of Our Galaxy*" (Nobel Prize in Physics 2020) made by Prof. R. Genzel and A. Ghez is a confirmation of one of the most important predictions of WUM in 2013: "*Macroobjects of the World have cores made up of the discussed DM particles. Other particles, including DM and baryonic matter, form shells surrounding the cores*" [58].

In WUM, **Ball Lightnings** (BLs) are the objects that have cores made up of DMPs surrounded by the electron-positron plasma shells contaminated by chemical elements of soil and air as the result of Terrestrial Gamma-Ray Flash strikes of the ground. The introduced **Super-weak interaction** between DM cores and all particles around them provide integrity of BLs. The core of BL irradiates quants with different energies and attracts new DMPs from Geocorona due to super-weak interaction. It explains the observed result that the brightness of BLs remains fairly constant during their lifetime. It is important to emphasize that the initial energy required for BL creation is insufficient for its sustenance of up to 1200 seconds. Additional energy, therefore, must be consumed by BL once it had been formed. Once we master the creation of BLs in a controlled environment, we can concentrate our efforts on harvesting that energy [59].

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 – Hypersphere World-Universe Model. Astronomers should plan new purposeful experiments based on the results of these analyses.

WUM does not attempt to explain all available cosmological data, as that is an impossible feat for any one article. 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 the entire physical community.

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