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Center of Milky Way Galaxy

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Abstract

In 2013, World-Universe Model (WUM) made one of the most important predictions: "*Macroobjects of the World have cores made up of the discussed DM* (Dark Matter) *particles. Other particles, including DM and baryonic matter, form shells surrounding the cores*" [1]. Prof. R. Genzel and A. Ghez confirmed this prediction: "*The Discovery of a Supermassive **Compact Object** at the Centre of Our Galaxy*" (Nobel Prize in Physics 2020). On May 12, 2022, astronomers, using the Event Horizon Telescope, released the first image of the accretion disk around the Sagittarius A* (Sgr A*) produced using a worldwide network of radio observatories made in April 2017. These observations were obtained by a global array of millimeter wavelength telescopes and analyzed by an international research team that now numbers over 300 people, which claimed that Sgr A* is a Supermassive Black Hole (SBH). In the present paper, we analyze these results in frames of WUM. Based on the totality of all accumulated experimental results for the Center of the Milky Way Galaxy we conclude that Sgr A* is the DM Core of our Galaxy.

Keywords

World-Universe Model, Center of Milky Way Galaxy, Supermassive Compact Object, Event Horizon Telescope, Sagittarius A*, Multi-Component Dark Matter, Macroobjects Shell Model, Angular Momentum Problem

1. Introduction

Sagittarius A* (Sgr A*) is a **supermassive black object** at the Galactic Center of the Milky Way (MW), which was discovered in 1954 by J. D. Kraus, H.-C. Ko, and S. Matt with Ohio State University radio telescope at 250 MHz. It is a **bright and very compact astronomical radio source**. In 1982 R. L. Brown understood that the strongest radio emission from the center of MW appeared to be due to a **compact nonthermal radio object**.

The Sagittarius A* cluster is the cluster of stars in close orbit around Sgr A* (see **Figure 1**). The individual stars are often listed as "S-stars". One of the most studied stars is S2, a relatively bright star that also passes close by Sgr A* [2]. As of 2020, S14 is the record holder of the closest approach to Sgr A*, at about 12.6 AU (1.88×10^{12} m), almost as close as Saturn gets to the Sun. Its orbital period is 12 years, but an extreme eccentricity of 0.985 gives it a close approach and high velocity of about 8% of the speed of light.

In 2005, F. Eisenhauer, *et al.* reported the results (with 75 milli-arcsec resolution) of near-IR imaging spectroscopy within the central 30 light days of the Galactic Center, taken with the new adaptive optics assisted, integral field spectrometer SINFONI on the ESO-VLT (see **Figure 1**).

In 2018, S. D. von Fellenberg, *et al.* reported the first detection of the Galactic Centre in the far infrared. Their measurements were obtained with PACS on board the Herschel satellite at 100 μm and 160 μm [3].

In 2019, the observations of several stars orbiting Sgr A*, particularly S2, have been used to determine the mass and upper limits on the radius of the object. Based on mass and increasingly precise radius limits [4], astronomers have found that the enclosed mass of Sgr A* is 4.154 ± 0.014 million solar masses. A calculated Schwarzschild radius of its mass 1.227×10^{10} m is about two orders of magnitude smaller than the minimum distance of S14 from Sgr A*: 1.88×10^{12} m.

In May 2022, the Event Horizon Telescope Collaboration presented Event Horizon Telescope (EHT) 1.3 mm measurements of the radio source located at the position of the supermassive black object Sgr A*, collected during the 2017 April campaign (see **Figure 2**) [5]. A deciphered image of Sgr A* is depicted in **Figure 3**.

The observations were conducted with eight facilities at six locations across the globe. Novel calibration methods are employed to account for Sgr A*'s flux variability. The majority of the 1.3 mm emission arises from horizon scales where intrinsic structural source variability is detected on timescales of minutes to hours. The effects of interstellar scattering on the image and its variability are found to be subdominant to intrinsic source structure. The calibrated visibility amplitudes, particularly the locations of the visibility minima, are broadly consistent with a blurred ring with a diameter of (51.8 ± 2.3) μas (6.337×10^{10} m) [5] as determined in later works in this series (distance to Sgr A* is 26.673 kly [4]).

Contemporaneous multiwavelength monitoring of Sgr A* was performed at 22, 43, and 86 GHz and at near-infrared and X-ray wavelengths. Several X-ray flares from Sgr A* are detected by Chandra, one at low significance jointly with Swift on 2017 April 7 and the other at higher significance jointly with NuSTAR on 2017 April 11. The brighter April 11 flare is not observed simultaneously by the EHT but is followed by a significant increase in millimeter flux variability immediately after the X-ray outburst, indicating a likely connection in the emission physics near the event horizon. The Collaboration compared Sgr A*'s broadband flux during the EHT campaign to its historical spectral energy distribution and find that both the quiescent emission and flare emission are consistent with its long-term behavior.

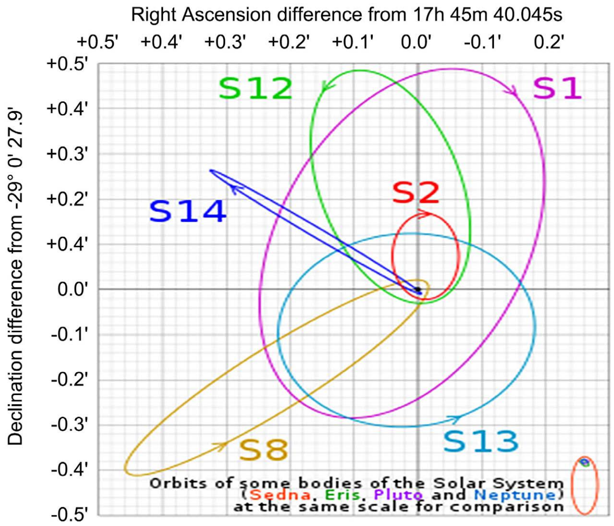

Figure 1. Inferred orbits of 6 stars around SBH **candidate** Sgr A* at MW center [2].

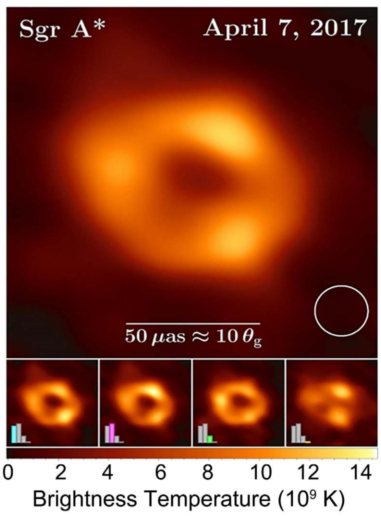

Figure 2. Sagittarius A* imaged by the Event Horizon Telescope in 2017, released in 2022 [5].

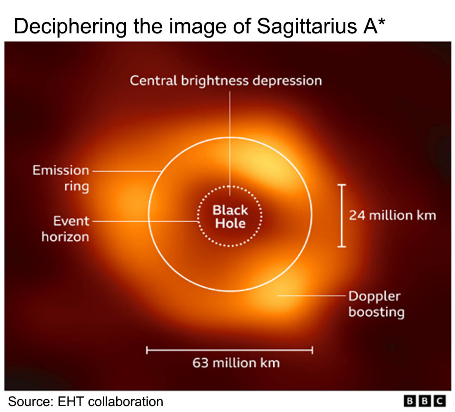

Figure 3. The Milky Way's monster black hole seen for the FIRST time [6].

Astronomers of the Collaboration have made a first comparison of the EHT 2017 Sgr A* data to a state-of-the-art library of ideal time-dependent General Relativistic Magnetohydrodynamics simulations models. The models assume that the mass and distance to Sgr A* are known and that the central object is a SBH described by the Kerr metric. The model parameters are as follows: whether the horizon magnetic field is strong or weak; the SBH spin a^*; and the inclination angle i between the line of sight and the accretion flow orbital angular momentum vector.

None of the fiducial models survive the full gauntlet of 11 constraints. The astronomers set aside both variability constraints and got two fiducial models that pass the remaining nine constraints in all simulation pipelines. These models in the "best-bet region" are strongly magnetized and have positive spin and low inclination, with (a^* , i) = (0.5, 30˚) and (0.94, 10˚) [5].

Based on the obtained results the Event Horizon Telescope Collaboration claimed that Sgr A* is SBH. Below we will analyze the obtained experimental results in frames of WUM [7].

2. Hypersphere World-Universe Model

2.1. Multi-Component Dark Matter

There are three prominent hypotheses on nonbaryonic Dark Matter (DM), namely Hot Dark Matter (HDM), Warm Dark Matter (WDM), and Cold Dark Matter (CDM). The most widely discussed models are based on the CDM hypothesis, and the corresponding particles are most commonly assumed to be Weakly Interacting Massive Particles (WIMPs). A neutralino with mass in 100 ⇔ 10,000 GeV/c^2 range is the leading CDM candidate. It is known that a sterile neutrino with mass in 1 ⇔ 10 keV/c^2 range is a good WDM candidate. The best candidates for the identity of HDM are neutrinos and axions.

In 1952, Y. Nambu (Nobel Prize Laureate in Physics) proposed an empirical mass spectrum of elementary particles with a mass unit close to one quarter of the mass of a pion (about $m_0/2 \cong 35\,\mathrm{MeV/c^2}$) [8]. He noticed that meson masses are even multiples of a mass unit $m_0/2$, baryon (and also unstable lepton) masses are odd multiples, and mass differences among similar particles are quantized by $m_0 \cong 70\,\mathrm{MeV/c^2}$.

In WUM, we introduced a basic energy unit E_0 that equals to:

$$E_0 = hc/a = 70.025267\ \mathrm{MeV}$$

where h is Planck constant, c is the electrodynamic constant, and a is the basic size unit. It is interesting that the rest energy of electron E_e equals to:

$$E_e = \alpha \times E_0$$

where dimensionless Rydberg constant α equals to: $\alpha = \left(2aR_\infty\right)^{1/3}$; R_∞ is Rydberg constant and Rydberg energy Ry is:

$$Ry = hcR_\infty = \alpha^3 \times E_0/2 = 13.605693\ \mathrm{eV}$$

It is worth noting that the constant α was later named "Fine-structure constant."

In 2012, D. Hooper in the article "The Empirical Case For 10 GeV Dark Matter" *summarized and discussed the body of evidence which has accumulated in favor of dark matter in the form of approximately* 10 *GeV particles. This evidence includes the spectrum and angular distribution of gamma rays from the Galactic Center, the synchrotron emission from the Milky Way's radio filaments, the diffuse synchrotron emission from the Inner Galaxy (the "WMAP Haze") and low-energy signals from the direct detection experiments DAMA/LIBRA, CoGeNT and CRESST-II* [9].

In our view, 10 GeV particles can be DMPs with the following rest energy:

$$E_{Hooper} = \alpha^{-1} \times E_0 = 9.6\ \text{GeV}$$

In 2009, A. Bykov, *et al.* investigated *the nature of the extended hard X-ray source XMMU J*061804.3 + 222,732 *and its surroundings using XMM-Newton, Chandra, and Spitzer observations. A feature at* 3.7 *keV was found in the X-ray spectrum of Src* 3 *at the* 99% *confidence level* [10]. In 2012, A. Moretti, *et al.* measured the diffuse gamma-ray emission at the deepest level and with the best accuracy available at that time. An emission line around 3.7 keV is clearly visible in the obtained spectrum [11].

In frames of WUM, 3.7 keV emission can be a result of a self-annihilation of DMPs with the following rest energy:

$$E_{Moretti} = \alpha^2 \times E_0 = 3.7\ \text{keV}$$

In addition to Fermions discussed above, we offer another type of Dark Matter particles—Bosons. The quantum theory of magnetic charge started with a paper by P. Dirac in 1931 m in which he showed that if any magnetic monopoles exist in the universe, then electric charge in the universe must be quantized [12]. The electric charge is, in fact, quantized, which is consistent with (but does not prove) the existence of monopoles.

WUM introduces spin-0 boson—DIRAC with the rest energy $E_{DIRAC} = \alpha^0 \times E_0 = 70\ \text{MeV}$, that is a dipole of Dirac's monopoles with magnetic charges $\mu = e/2\alpha$ (e is an elementary charge). They possess a substantial magnetic dipole momentum. In our view, DIRACs are responsible for the electric charge quantization.

In 1979 H. Harari [13] and M. A. Shupe [14] proposed a heuristic model, treating leptons and quarks as composites of spin 1/2 fields with charges of 0 and $\pm e/3$. In particle physics, preons are postulated to be "point-like" particles, conceived to be subcomponents of quarks and leptons [15].

In 2009, S. Sukhoruchkin has this to say about "A Role of Hadronic effects in Particle Masses" [16]: *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 le-*

vels of different nuclei including low-spin levels observed in (γ, γ) *and* (n, γ) *reactions*.

WUM introduces spin-0 boson—ELOP with the rest energy $E_{ELOP} = 2/3\alpha^1 E_0 = 340\ \text{keV}$, that is a dipole of preons with electric charges $e_{preon} = e/3$. They possess a substantial electric dipole momentum.

In 2003, C. Boehm, P. Fayet, and J. Silk proposed two-component DM system consisting of bosonic and fermionic components for the explanation of emission lines from the bulge of the Milky Way galaxy. They analyzed a way *to reconcile the low and high energy signatures in gamma-ray spectra*, *even if both of them turn out to be due to Dark Matter annihilations*. *One would be a heavy fermion for example*, *like the lightest neutralino* (>100 *GeV*), *and the other one a possibly light spin*-0 *particle* (~100 *MeV*). *Both of them would be neutral and also stable* [17].

Based on the discussed ideas and experimental results, in 2013 we proposed a multicomponent DM system consisting of two couples of coannihilating DMPs: a heavy DM fermion—DMF1 (1.3 TeV) and a light spin-0 boson—DIRAC (70 MeV); a heavy fermion—DMF2 (9.6 GeV) and a light spin-0 boson—ELOP (340 keV); fermions—DMF3 (3.7 keV) and DMF4 (0.2 eV) named DION in 2019 [18].

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): $E_{DMF1} = \alpha^{-2} E_0 = 1.3149950\ \text{TeV}$

DMF2 (fermion): $E_{DMF2} = \alpha^{-1} E_0 = 9.5959823\ \text{GeV}$

DIRAC (boson): $E_{DIRAC} = \alpha^{0} E_0 = 70.025267\ \text{MeV}$

ELOP (boson): $E_{ELOP} = 2/3\alpha^{1} E_0 = 340.66606\ \text{keV}$

DMF3 (fermion): $E_{DMF3} = \alpha^{2} E_0 = 3.7289402\ \text{keV}$

DMF4 (fermion): $E_{DMF4} = \alpha^{4} E_0 = 0.19857111\ \text{eV}$

These values fall into ranges estimated in literature. The reason for this multicomponent DM system was to explain:

- The diversity of Very High Energy gamma-ray sources in the World;
- The diversity of DM Cores of Macroobjects of the World (superclusters, galaxies, and extrasolar systems), which are Fermion Compact Objects in WUM (see Section 2.2).

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 (cores 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 [19].

In this regard, it is worth recalling about the study of 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 do not 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 (expressed as a positive emitted energy). The latter can be directly measured by measuring the energy of a single 0.7822 MeV gamma photon emitted when a deuteron is formed by a proton capturing a neutron (this is exothermic and happens with zero-energy neutrons). The small recoil kinetic energy of the deuteron (about 0.06% of the total energy) must also be accounted for.

The energy of the gamma ray can be measured to high precision by X-ray diffraction techniques, as was first done by Bell and Elliot in 1948. The best modern (1986) values for neutron mass obtained using this technique are provided by Greene, *et al.*: $m_{neutron} = 1.008644904 Da$ (the Dalton is unified atomic mass unit). The value for the neutron mass in MeV is less accurately known, due to smaller accuracy in the known conversion of Da to MeV/c^2:
$m_{neutron} = 939.56563(28)\ \text{MeV}/\text{c}^2$ [20].

DM particles 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.

2.2. Macroobjects Shell Model

The existence of Supermassive Objects (SMOs) in galactic centers is now commonly accepted. Many non-traditional models explaining SMOs observed in galaxies and galaxy clusters are widely discussed in literature [21]-[27]. The prospect that DMPs might be observed in Centers of Macroobjects has drawn many new researchers to the field. Indirect effects in cosmic rays and gamma-ray background from the annihilation of DM in the form of heavy stable neutral leptons in Galaxies were considered in pioneer articles [28]-[33].

According to **WUM**, Macroobjects of the World (Superclusters, Galaxies, Extrasolar systems) have Cores 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 the heaviest particles; outer shells are larger and consist of lighter particles. **Weak Interaction** between DMPs provides integrity of all shells. Self-annihilation of DMPs can give rise to any combination of gamma-ray lines [34].

WUM provides a mathematical framework that allows calculating the primary cosmological parameters of the World that are in good agreement with the most recent measurements and observations [35]. **Table 1** describes the parameters of Macroobjects Cores in the present Epoch made up of different fermions: self-annihilating DMF1, DMF2, DMF3, DMF4, and Electron-Positron plasma.

The calculated parameters of the shells show that [35]:

- 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.

Macroobjects' Cores have the following properties:

- The minimum radius of Core $R_{\min}$ made up of any fermion equals to three Schwarzschild radii;
- Core density does not depend on $M_{\max}$ and $R_{\min}$ and does not change in time while $M_{\max} \propto \tau^{3/2}$ and $R_{\min} \propto \tau^{1/2}$ (where τ is a cosmological time [36]);
- DM cores of superclusters and galaxies are responsible for the gravitational lensing effect.

In WUM, the calculated maximum stellar mass $M_S \cong 174 M_\odot$ [1] is in good agreement with the mass of one of the most massive known stars R136a1: $M_S = 222^{+29}_{-28} M_\odot$ [37].

K. Mehrgan, *et al.* observed a supergiant elliptical galaxy Holmberg 15A. It has been alleged that the primary component of the galactic core is SBH with a mass of $4\times 10^{10} M_\odot$ [38].

TON 618 is a very distant and extremely luminous quasar. It possesses one of the most massive SBHs ever found, with a mass of $6.6\times 10^{10} M_\odot$ at the center of TON 618 [39].

How SBHs initially formed is one of the biggest problems in the study of galaxy evolution today. SBHs have been observed as early as 690 million years after the Big Bang [40]. How they could grow so quickly remains unexplained.

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 $\rho_{\max}$, 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}

C. R. Argüelles, *et al.* propose a novel mechanism for the creation of SBHs from DM without requiring prior star formation or needing to invoke seed black holes with unrealistic accretion rates. The authors investigate a potential existence of stable galactic cores made up of fermionic DM, and surrounded by a diluted DM halo, finding that the centers of these structures could become so concentrated that they could also collapse into SBHs once a critical threshold is reached. They analyzed this mechanism with DM haloes mass up to $5.9\times10^{10} M_{\odot}$ [41].

According to **WUM**, Cores of Galaxies are DM Compact Objects made up of DMF1 and/or DMF2 with shells consisting of DMF3 with the calculated maximum mass of $6\times10^{10} M_{\odot}$ (see **Table 1**). This value is in good agreement with the experimental values [38] [39] and with the analyzed values by C. R. Argüelles, *et al.* [41].

Laniakea Supercluster (LS) is a galaxy supercluster that is home to the Milky Way and approximately 10^5 other nearby galaxies. It is known as the largest supercluster with estimated binding mass of $10^{17} M_{\odot}$ [42]. The mass-to-light ratio of the LS is about 300 times larger than that of the Solar ratio. Similar ratios are obtained for other superclusters [43].

In 1933, Fritz 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*" [44]. **These ratios are one of the main arguments in favor of presence of large amounts of Dark Matter in the World.**

In frames of **WUM**, LS emerged 13.77 billion years ago due to Rotational Fission of the Supercluster Overspinning (surface speed at equator exceeding escape velocity) DM Core and self-annihilation of DMPs. The Core was created during Dark Epoch (spanning from the Beginning of the World for 0.45 billion years) when only DM Macroobjects existed [34].

B. Carr, F. Kühnel, and L. Visinelli "*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 $\left(10^{12} - 10^{18}\right) M_{\odot}$. However, there is already evidence for black holes of up to nearly $10^{11} M_{\odot}$ in galactic nuclei* [39], *so it is conceivable that SLABs exist, and they may even have been seeded by primordial black holes*" [45].

According to **WUM**, the calculated maximum mass of supercluster DM Core of 2.1×10^{19} solar mass (see **Table 1**) is in good agreement with the estimated value by L. Bliss [42] and discussed values by B. Carr, *et al.* [45]. In the future, these stupendously large compact objects can give rise to new Luminous Superclusters as the result of their DM Cores' rotational fission.

It is unlikely that all of them gave birth to Luminous Superclusters at the same cosmological time, given how far away from each other they are located. In our view, there were many Beginnings for different Luminous Superclusters. It means that the World is, in fact, a Patchwork Quilt of different Luminous Superclusters [46].

2.3. Angular Momentum Problem

Angular Momentum Problem is one of the most critical problems in Standard Cosmology (SC) that must be solved. SC does not explain how Galaxies and Extra Solar 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 be consistent with this Law a Model must answer the following questions:

- How did Galaxies and Extra Solar systems obtain their substantial orbital and rotational angular momenta;
- Why are all Macroobjects rotating;
- How did Milky Way (MW) give birth to different Extra Solar systems in different times;
- The beginning of MW galaxy was about 13.77 billion years. The age of MW is about the Age of the World. What is the origin of the MW huge orbital angular momentum? We must discuss the Beginning of MW;
- The oldest star in MW (named Methuselah) is nearly as old as the universe itself. How did it happen?
- The beginning of the Solar System (SS) was 4.57 billion years ago. What is the origin of SS orbital angular momentum? We must discuss the Beginning of SS.

In our opinion, there is the only one mechanism that can provide angular momenta to Macroobjects—**Rotational Fission** of overspinning 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 satellites [18].

In frames of **WUM**, Prime Objects are DM Cores of Superclusters, which must accumulate tremendous angular momenta before the Birth of the Luminous World. It follows that a long enough time period must elapse. We name this period “Dark Epoch” [18]. 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 Rotational Fission of Superclusters’ Cores and self-annihilation of DMPs;
- The main players of the World are Superclusters’ Cores, which accumulated tremendous rotational angular momenta during Dark Epoch and transferred it to DM Cores of Galaxies during their Rotational Fission. The experimental observations of galaxies in the universe show that most of them are disk galaxies. These results speak in favor of the developed Rotational Fission mechanism;

- DM Core of MW was born 13.77 billion years ago as the result of the Rotational Fission of Virgo DM Core;
- DM Cores of Extrasolar systems, planets and moons were born as the result of the Rotational Fissions of the Milky Way DM Core in different 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 Macroobjects Cores.

2.4. Milky Way Center

MW is a barred spiral galaxy with an estimated visible diameter of 100 - 200 kly. MW is a part of the Local Group of galaxies that form part of the Virgo Supercluster, which is itself a component of LS. It is estimated to contain 100 - 400 billion stars. The galactic center is an intense radio source known as Sgr A*. In 2008, A. M. Ghez, *et al.* found the enclosed mass of it: $(4.1 \pm 0.6) \times 10^6 M_{\odot}$ [47].

Several teams of researchers have attempted to image Sgr A* in the radio spectrum using very-long-baseline interferometry. The current highest-resolution (approximately 30 μas) measurement, made at a wavelength of 1.3 mm, indicated an overall angular size for the source of 50 μas [48]. At a distance of 26.673 kly this yields a diameter of 6.337×10^{10} m.

E. A. C. Mills in her "Journey to the Center of the Galaxy: Following the gas to understand past and future activity in galaxy nuclei" wrote [49]: "*The **young stars in the central lightyear**, the innermost of whose orbits are famously used to determine parameters of central supermassive black hole, are suggested to have formed in-situ in one of the most extreme environments imaginable: in an incredibly dense gas disk a fraction of a light year from the black hole. Even allowing for recent activity in the past few hundred years which we can detect from the X-ray light of these outbursts reflecting off of clouds a few hundred light years from the black hole…our black hole is no AGN*" (Active Galactic Nucleus).

On January 5, 2015, NASA reported observing an X-ray flare 400 times brighter than usual, a record-breaker, from Sgr A*. The unusual event may have been caused by the breaking apart of an asteroid falling into SBH or by the entanglement of magnetic field lines within gas flowing into Sgr A*, according to astronomers [50].

On May 2021, NASA published new images of the galactic center, based on surveys from Chandra X-ray Observatory. Astronomers present a catalogue of the detected X-ray sources in the 0.3 - 7 keV band. NASA has released a stunning new picture of our galaxy's violent, super-energized "**downtown**." The image, a composite of 370 observations made over the past two decades by the orbiting Chandra X-ray observatory, depicts billions of stars in the center of the Milky Way. The author of this investigations D. Wang of the University of Massachusetts Amherst said: "*What we see in the picture is a violent or energetic* *ecosystem in our galaxy's downtown*" [51].

Prof. R. Genzel and A. Ghez were awarded the 2020 Nobel Prize in Physics for their discovery that Sgr A* is a **supermassive compact object**, for which SBH was the only accepted explanation.

In 2013, we proposed a principally different explanation of supermassive compact objects: "*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*" [1].

In frames of **WUM** (see **Table 1**):

- The calculated value of the radius of the Electron-Positron shell 2.9×10^{10} m is in excellent agreement with the experimentally measured value of the radio source 3×10^{10} m [47];
- The calculated value of the mass of the Electron-Positron shell 6.6×10^{36} kg is in good agreement with the experimentally measured value of the supermassive compact object 8.5×10^{36} kg [47];
- The additional mass of the DMF3 shell of 1.9×10^{36} kg is much smaller than the maximum mass of it: 1.2×10^{41} kg;
- X-ray flare 400 times brighter than usual can be explained by the detonation of DMF3 particles (3.7 keV) and their self-annihilation [50];
- The excess of gamma-ray emission with energy about 10 GeV reported by D. Hooper from the Galactic Center [52] can be explained by DMF2 particles (9.6 GeV) self-annihilation;
- DM Fermi Bubbles can be explained based on DMF1, DMF2, and DMF3 particles (see Section 2.5).

The oldest known star HD 140283 (Methuselah star) is a subgiant star about 190 light years away from Earth for which a reliable age has been determined [53]. H. E. Bond, *et al.* found its age to be 14.46 ± 0.8 Byr that does not conflict with the Age of the Universe, 13.77 ± 0.06 Byr, based on the microwave background radiation and Hubble constant [54]. It means that this star must have formed between 13.66 and 13.83 Byr, an amount of time that is too short for formation of the second generation of stars according to prevailing theories. In our Model, this discovery can be explained by generation of HD 140283 by overspinning Core of MW 13.77 billion years ago.

In frames of the developed Rotational Fission model, it is easy to explain hyper-runaway stars unbound from the Milky Way with speeds of up to ~700 km/s [55]: they were launched by overspinning DM Core of the Large Magellanic Cloud with the speed higher than the escape velocity.

S. E. Koposov, *et al.* present the discovery of the fastest Main Sequence hyper-velocity star S5-HVS1 with mass of about 2.3 solar mass that is located at a distance of ~9 kpc from the Sun. When integrated backwards in time, the orbit of the star points unambiguously to the Galactic Centre, implying that S5-HVS1 was kicked away from Sgr A* with a velocity of ~1800 km/s and travelled for 4.8 Myr to its current location. So far, this is the only hyper-velocity star confidently associated with the Galactic Centre [56]. In frames of the developed Model, this discovery can be explained by Gravitational Burst (GB) of the overspinning Core of the Milky Way 4.8 million years ago, which gave birth to S5-HVS1 with the speed higher than the escape velocity of the Core.

C. J. Clarke, *et al.* observed CI Tau, a young 2 million year old star. CI Tau is located about 500 light years away in a highly-productive stellar "*nursery*" region of the galaxy. They discovered that the Extrasolar system contains four gas giant planets that are only 2 million years old [57], an amount of time that is too short for formation of gas giants according to the prevailing theories. In frames of the developed Rotational Fission model, this discovery can be explained by GB of the MW Core 2 million years ago, which gave birth to the CI Tau system with all the planets generated at the same time.

2.5. 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 [58]. The outlines of the bubbles are quite sharp, and the bubbles themselves glow in nearly uniform gamma rays over their colossal surfaces. Gamma-ray spectrum at Galactic latitude ≤ 10˚, without showing any sign of cutoff up to around 1 TeV, remains unconstrained [59]. Years after the discovery of FBs, their origin and the nature of the gamma-ray emission remain unresolved.

WUM explains FBs the following way [34]:

- Core of the Milky Way is made up of DMPs: DMF1 (1.3 TeV), DMF2 (9.6 GeV), and DMF3 (3.7 keV). The second component (DMF2) explains the excess GeV emission reported by Dan Hooper from the Galactic Center [52]. Core rotates with surface speed at equator close to the escape velocity between Gravitational Bursts (GBs), and over the escape velocity at the moments of GBs;
- Bipolar astrophysical jets (which are astronomical phenomena where outflows of matter are emitted as the extended beams along the axis of rotation [60]) of DMPs are ejected from the rotating Core into the Galactic halo along the rotation axis of the Core;
- Due to self-annihilation of DMF1 and DMF2, these beams are gamma-ray jets [61]. The prominent X-ray structures on intermediate scales (hundreds of parsecs) above and below the plane (named the Galactic Centre "*chimneys*" [62]) are the result of the self-annihilation of DMF3 particles;
- FBs are bubbles whose boundary with the Intergalactic Medium has a basic surface energy density $\sigma_0 = hc/a^3$. These bubbles are filled with DMPs: DMF1, DMF2, and DMF3. The calculated diameter D_{FB} of FBs: $D_{FB} = 28.6$ kly is in good agreement with the measured size of the FBs 25 kly [58] and 32.6 kly [34]. **FBs made up of DMF3 particles resemble a honeycomb filled with DMF1 and DMF2**;
- With Nikola Tesla's principle at heart—"*There is no energy in matter other*

than that received from the environment"—we calculate mass M_{FB} of FBs: $M_{FB} = 3.6 \times 10^{41}$ kg. Recall that the mass of Milky Way M_{MW} is about: $M_{MW} = (1.6 - 3.2) \times 10^{42}$ kg;

- FBs radiate X-rays due to the self-annihilation of DMF3 (3.7 keV). Gamma rays up to 1 TeV [63] are the result of self-annihilation of DMF1 (1.3 TeV) and DMF2 (9.6 GeV) particles in Dark Matter Objects (DMOs) 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 [34];
- The total flux of the gamma radiation from FBs is the sum of the contributions of all individual DMOs, which irradiate gamma quants with different energies and attract new DMF1 and DMF2 particles from FBs. The Core of the Milky Way supplies FBs with new DMPs through the galactic wind, explaining the brightness of FBs remaining fairly constant during the time of observations. In our opinion, FBs are built continuously throughout the lifetime of the Milky Way galaxy.

In our view, **FBs are DMPs' clouds containing uniformly distributed Dark Matter Objects,** in which DMPs self-annihilate and radiate X-rays and gamma rays. DM Fermi Bubbles constitute a principal proof of WUM.

3. Analysis of Event Horizon Telescope Results

The Event Horizon Telescope Collaboration presented the outstanding Event Horizon Telescope 1.3 mm measurements of the radio source located at the position of the supermassive black object Sgr A* [5]. Contemporaneous multiwavelength monitoring of Sgr A* was performed at 22, 43, and 86 GHz and at near-infrared and X-ray wavelengths. Using the Event Horizon Telescope, astronomers released the first image of the accretion disk around the Sgr A*. Based on the obtained results the Event Horizon Telescope Collaboration claimed that Sgr A* is a Supermassive Black Hole.

In our opinion, the results obtained by Collaboration are model-dependent and not sufficient to support this claim. Astronomers should answer some principal questions:

- The age of MW is similar to the Age of the World. The oldest star in MW (named Methuselah) is nearly as old as the World itself. If Sgr A* is a SBH, then how it could grow so quickly?
- What is the origin of the alleged SBH positive spin?
- Their models in the "best-bet region" have low inclination 30˚ and 10˚ that contradicts the disk shape of the MW galaxy and bipolar astrophysical jets, which are astronomical phenomena where outflows of matter are emitted as the extended beams along the axis of rotation;
- The MW galaxy (including Sgr A*) is gravitationally bounded with Virgo Supercluster (VS) and has a huge orbital angular momentum calculated

based on the distance of 65 million light-years from VS and orbital speed of about 400 km/s [64]. How did MW galaxy obtain this substantial orbital angular momentum?

- What is the mechanism of gamma rays emission from the Galactic Center?
- What is the mechanism of Gamma- and X-rays emissions from the Fermi Bubbles?

In frames of WUM Macroobjects Shell Model, the results obtained by the Event Horizon Telescope Collaboration can be explained in the following way:

- The image is dominated by the bright, thick ring with the diameter of 6.337×10^{10} m. The ring has a comparatively dim Interior that is made up of DM Fermions DMF1 (1.3 TeV) and DMF2 (9.6 GeV), which are responsible for the excess of gamma-ray emission from Sgr A* due to their self-annihilation;
- DMPs are continuously absorbing by the Interior of the Sgr A*. Ordinary Matter is a byproduct of DMPs self-annihilation. It is re-emitted by the Interior continuously into the Shell around it;
- Very powerful gamma quants with energy of at least 1.02 MeV in the vicinity of atomic nuclei of the Shell produce electron-positron pairs with high concentration;
- The bright, thick area with the diameter of 6.337×10^{10} m consists of Ordinary Matter and Electron-Positron plasma with the radius of 2.9×10^{10} m that is a compact nonthermal radio object responsible for the strongest radio emission from the center of MW;
- The area from the radius of 3.17×10^{10} m to 1.88×10^{12} m is filled out with DM Fermions DMF3 (3.7 keV), which are responsible for X-rays from the center of MW due to their self-annihilation. The 400 times brighter than usual X-ray flare reported by NASA is the result of the detonation process inside of this shell, which does not destroy it; instead, Hyper-flare occurred in active region of the shell, analogous to Solar flares;
- The enclosed mass of Supermassive Compact Object of $4.154 \times 10^6 M_\odot$ is the mass of the MW DM Core made up of DMF1 and DMF2 with the Ordinary Matter and Electron-Positron Shell and DMF3 shell;
- Sgr A* has gotten the rotational and orbital angular momenta as the result of the rotational fission of the DM Core of the Virgo supercluster;
- The inclination angle between the line of sight and the rotational angular momentum vector of Sgr A* is about 90˚.

4. Conclusion

The totality of all obtained experimental results testifies in favor of the existence of the supermassive compact object made up of Dark Matter particles at the Milky Way Center.

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Conflicts of Interest

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

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