Development of Hypersphere World-Universe Model. Narrative

Part I. World-Universe Black-Hole Model

We can't solve problems by using the same kind of thinking we used when we created them.

Albert Einstein

World-Universe Model

ABSTRACT

World – Universe Model is based on three primary assumptions:

1) The World is finite and is expanding inside the Universe with speed equal to the electrodynamic constant c. The Universe serves as an unlimited source of energy that continuously enters into the World from the boundary.

2) Medium of the World, consisting of protons, electrons, photons, neutrinos, and dark matter particles, is an active agent in all physical phenomena in the World.

3) Two fundamental parameters in various rational exponents define all macro and micro features of the World: Fine-Structure Constant α, and dimensionless quantity Q. While α is constant, Q increases with time, and is in fact a measure of the size and the age of the World.

The World – Universe Model explains experimental data accumulated in the field of Cosmology over the last decades: the size and age of the World; critical energy density and the gravitational parameter; temperatures of the cosmic microwave background radiation and black body radiation of cosmic dust; fractal structure of the World and its evolution; observed expansion of the World and cosmological redshift. Additionally, the Model makes predictions pertaining to masses of dark matter particles, photons, axions, and neutrinos; proposes new types of particle interactions (Super Weak and Extremely Weak) and the fundamental physical parameters of the World; gives a new "low density small white dwarf" model of Ball Lightning and dineutrino model of Extreme Ball Lightning based on super weak interaction; explains "Pioneer Anomaly"; and resolves paradoxes like "Matter – Antimatter Asymmetry" and "Faint Young Sun". The Model proposes to introduce a new fundamental parameter Q in the CODATA internationally recommended values for calculating time dependent parameters of the World.

Keywords: World – Universe Model, Fractal Cosmology, Fine-Structure Constant, Dark Matter, Microwave Background Radiation, Maxwell-Lorentz Equations, Dirac's Equations, Fractal Particle Structure, Grand Unified Theory, Ball Lightning, CODATA

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1. Introduction

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

I am a Doctor of Sciences in Laser Physics, specializing in interaction of laser radiation with matter. I belong to the school of physicists established by Alexander Prokhorov, Nobel Prize Laureate in Physics and co-inventor of masers and lasers. Most of my past papers were published under V.S. Nechitailo alias.

Today, a growing feeling of stagnation is shared by a large number of researchers. In his "The Twilight of the Scientific Age" (2013), Martin Lopez Corredoira outlines everything that is wrong with Physics today: increasingly expensive experiments that yield less and less, lack of outstanding results, lack of openness to new ideas exhibited by scientific journals and community as a whole.

In some respects, the situation today is similar to that at the end of 19th century, when the common consensus held that the body of Physics is nearly complete. Discoveries of special and general relativity, quantum mechanics and elementary particles shook that belief and led to a new renaissance in Physics that lasted for a century. The genius of Einstein, Bohr, Dirac, Heisenberg, and Schrödinger allowed them to propose fundamentally new theories with very little experimental data to back them up.

During the 20th century, their theories were validated and elaborated with newly acquired experimental results. The pendulum may, however, have swung too far: today, all results must be made fit into the existing framework. The frameworks get adjusted when necessary, particularly inconvenient results may even get discarded at times. The time may be ripe to propose new fundamental models that will be both simpler than the current state of the art, as well as open up new areas of research.

In 1937, Paul Dirac proposed a new basis for cosmology: the hypothesis of a variable gravitational "constant"; and later added the notion of continuous creation of matter in the World. My World – Universe Model follows these ideas, albeit introducing a different mechanism of matter creation. World – Universe Model calculates the primary parameters of the World and proposes new types of particle interactions (Super Weak and Extremely Weak) that occur when neutrinos interact with dark matter, dark matter particles with matter, photons with dark matter, neutrinos oscillate, etc.

A number of ideas presented in this paper are not new, and I don't claim credit for them. In fact, several ideas belonging to classical physicists such as Tesla, Dirac, McCullagh, and Bjerknes, are revisited in a new light.

In the present Review I am attempting to describe the World while unifying and simplifying existing models and results in Cosmology into a single coherent picture. The World – Universe Model (WUM) is proposed as an alternative to the prevailing Bing Bang Model (BBM) of standard physical cosmology. The main difference is the source of the World's energy.

According to Wikipedia, *The Big Bang theory depends on two major assumptions: the universality of physical laws and the cosmological principle. The cosmological principle states that on large scales the Universe is homogeneous and isotropic.* [Wikipedia, Big Bang]. The World – Universe Model is built on the same major assumptions. Similarly, to the Bing Bang, the World – Universe Model envisions an expansion of the World.

Let's proceed to compare the origin, evolution, structure, ultimate fate, and parameters of the World speculated by the BBM and WUM.

1.1. Chronology of the World-Universe

The Beginning

BBM: *In 1927 Georges Lemaitre proposed that the universe began with the "explosion" of a "primeval atom" – which was later called the Big Bang* [Wikipedia, Physical Cosmology]. *About 13.772 billion years (Byr) ago a tremendous explosion started the expansion of the universe. This explosion is known as the Big Bang. At the point of this event all of the matter and energy of space was contained at one point (*singularity*). What existed prior to this event is completely unknown and is a matter of pure speculation. This occurrence was not a conventional explosion but rather an event filling all of space with all of the particles of the embryonic universe rushing away from each other. The Big Bang actually consisted of an explosion of space within itself unlike an explosion of a bomb where fragments are thrown outward* [1].

WUM: About 14.226 billion years ago the World was started by a fluctuation in the Universe, and the Nucleus of the World was born. The radius of the World's Nucleus at the Beginning was

$$a = 2\pi a_0 = 1.7705645 \times 10^{-14}\, m$$

where a_0 is the classical electron radius (Section 2.3). The extrapolated energy density of the World at the Beginning was

$$\rho_{cr0} = 6.0638901 \times 10^{30}\ \frac{J}{m^3}$$

which is four orders of magnitude smaller than the nuclear energy density (Section2.4).

At the Beginning of the World, the extrapolated value of Microwave Background Radiation temperature T_{MBR0} was (Section 2.5):

$$T_{MBR0} = 2.1927\ \text{MeV} = 2.5445\times10^{10}\ \text{K}$$

Prior to this event, there was nothing but the Universe – unlimited source of energy. The World has since been expanding through the Universe, consuming energy as the World – Universe boundary advances (Section 2.1).

Plank Epoch

Plank Epoch is the period from zero to approximately $\mathbf{10^{-43}}$ seconds after the Big Bang.

BBM: *During this period gravitation is believed to have been as strong as the other fundamental forces, and all the forces may have been unified. This has also been theorized to be the earliest moment of time that can be meaningfully described. Modern cosmology now suggests that the Planck epoch may have inaugurated a period of unification, known as the grand unification epoch* [Wikipedia, Planck epoch].

WUM: At the very Beginning all extrapolated fundamental interactions of the World – strong, electromagnetic, weak, super weak and extremely weak (proposed in the World – Universe model), and gravitational – had the same cross-section of $\frac{a^2}{4}$, and were characterized by the Unified coupling constant (Section 3.7):

$$\alpha_U = \alpha_S = \alpha_{EM} = \alpha_W = \alpha_{SW} = \alpha_{EW} = \alpha_G = 1$$

Grand Unification Epoch

Grand Unification Epoch lasted from 10^{-43} to approximately 10^{-36} seconds after the Big Bang.

BBM: *The grand unification epoch was the period in the evolution of the early universe, in which the temperature of the universe was comparable to the characteristic temperatures of grand unified theories. If the grand unification energy is taken to be* 10^{15} *GeV, this corresponds to temperatures higher than* 10^{27} *K. During this period, three of the four fundamental interactions – electromagnetism, the strong interaction, and the weak interaction – were unified as the electronuclear force. Gravity had separated from the electronuclear force at the end of Planck era. During the grand unification epoch, physical characteristics such as mass, charge, flavour and colour charge were meaningless.*

At the end of this epoch the strong force separated from the other fundamental forces. The temperature fell below the threshold at which X and Y bosons could be created, and the remaining X and Y bosons decayed. It is possible that some part of this decay process violated the conservation of baryon number and gave rise to a small excess of matter over antimatter [Wikipedia, Grand unification epoch].

At some point an unknown reaction called baryogenesis violated the conservation of baryon number, leading to a very small excess of quarks and leptons over antiquarks and antileptons – of the order of one part in 30 million. This resulted in the predominance of matter over antimatter in the present Universe [Wikipedia, Big Bang].

WUM: Generation of particle – antiparticle pairs is occurring at the Front (the moving World – Universe boundary) due to high surface energy density of the Universe. Antiparticles remain at the Front, and particles continue on into the World. In other words, all antimatter is concentrated at the Front, and equal amount of matter exists in the World, resolving the long-standing “Matter – Antimatter Asymmetry” paradox (Section 2.1).

Inflationary Epoch

Inflationary Epoch lasted from 10^{-36} to approximately 10^{-32} seconds after the Big Bang.

BBM: *Universe underwent an extremely rapid exponential expansion. This rapid expansion increased the linear dimensions of the early universe by a factor of at least* 10^{26} *(and possibly a much larger factor), and so increased its volume by a factor of at least* 10^{78}*. This expansion explains various properties of the current universe that are difficult to account for without such an inflationary epoch* [Wikipedia, Inflationary epoch].

Inflation resolves several problems in the Big Bang cosmology that were pointed out in the 1970s – Magnetic-monopole problem, Horizon problem, and Flatness problem*.*

The magnetic-monopole problem says that if the early universe were very hot, a large number of very heavy, stable magnetic monopoles would be produced. This is a problem with Grand Unified theories, which proposes that at high temperatures the electromagnetic force, strong and weak nuclear forces are not actually fundamental forces but arise due to spontaneous symmetry breaking from a single gauge theory. Monopoles are expected to be copiously produced in Grand Unified Theories at high temperature. But all searches for them have so far turned out fruitless, placing stringent limits on the density of relic magnetic monopoles in the universe.

The horizon problem is the problem of determining why the universe appears statistically homogeneous and isotropic in accordance with the cosmological principle. In the big bang model without inflation gravitational expansion does not give the early universe enough time to equilibrate. In a big bang with only the matter and radiation known in the Standard Model, two widely separated regions of the observable universe cannot have equilibrated because they move apart from each other faster than the speed of light – thus have never come in to causal contact: in the history of the universe, back to the earliest times, it has not been possible to send a light signal between the two regions. Because they have no interaction, it is difficult to explain why they have the same temperature (are thermally equilibrated) [Wikipedia, Inflation (cosmology)].

Current interpretations of astronomical observations indicate that the age of the Universe is 13.772 Byr (the Hubble radius equals to 13.772 billion light years) *and that the diameter of the observable universe is at least 93 billion light years. According to general relativity, space can expand faster than the speed of light, although we can view only a small portion of the universe due to the limitation imposed by light speed. Since we cannot observe space beyond the limitations of light (or any electromagnetic radiation), it is uncertain whether the size of the Universe is finite or infinite* [Wikipedia, Universe]. *Following the inflationary period, the universe continued to expand, but at a slower rate* [Wikipedia, Inflation (cosmology)].

WUM: The World is expanding with speed equal to the electrodynamic constant c for time t, and has the radius of $R = ct$ (Section 2.1).

In his "Modeling The Expansion Of The Universe By A Steady Flow Of Space-Time" [51], Juan Casado Gimenez and later Juan Casado in "A Steady Flow Cosmological Model from a Minimal Large Numbers Hypothesis" [52] outlined different linear expansion models with $R \propto t$.

The principal idea of the World – Universe model is that the energy density of the World ρ_W equals to the critical energy density ρ_{cr} necessary for a flat World (Section 2.2).

The World is a closed structure whose radius equals to the Hubble radius. Hence the Horizon problem does not arise (Section 2.4).

The World – Universe model introduces dark matter particles named DIRACs that possess mass of $m_0 \cong 70\ MeV/c^2$ and are in fact magnetic dipoles. Dissociated DIRACs (magnetic monopoles) can exist only at nuclear densities or at high temperatures. These monopoles are the smallest building blocks of fractal structure of constituent quarks and hadrons (Sections 2.9, 3.2). DIRACs dissociated into monopoles form cores of star clusters (Section 2.11).

Electroweak Epoch

Electroweak Epoch lasted from 10^{-32} to approximately 10^{-12} seconds after the Big Bang.

BBM: *The electroweak epoch began when the strong force separated from the electroweak interaction. Particle interactions in this phase were energetic enough to create large numbers of exotic particles, including W and Z bosons and Higgs bosons. As the universe expanded and cooled, interactions became less energetic and when the universe was about* 10^{-12} *seconds old, W and Z bosons ceased to be created. The remaining W and Z bosons decayed quickly, and the weak interaction became a short-range force in the following quark epoch.*

The physics of the electroweak epoch is less speculative and much better understood than the physics of previous periods of the early universe. The existence of W and Z bosons has been demonstrated, and other predictions of electroweak theory have been experimentally verified [Wikipedia, Electroweak epoch].

WUM: The very first ensemble of particles, including protons, electrons, photons, neutrinos, and dark matter particles, was generated at approximately 10^{-20} seconds after the Beginning (Section 3.3).

Quark Epoch, Hadron Epoch, Lepton Epoch

Lasted from 10^{-12} to approximately 10 seconds after the Big Bang.

Photon epoch

Photon epoch lasted from 10 seconds to approximately 380,000 years after the Big Bang.

BBM: *After most leptons and antileptons are annihilated at the end of the lepton epoch the energy of the universe is dominated by photons. These photons are still interacting frequently with charged protons, electrons and (eventually) nuclei, and continue to do so for the next 380,000 years.*

During the photon epoch the temperature of the universe falls to the point where atomic nuclei can begin to form. Protons and neutrons begin to combine into atomic nuclei in the process of nuclear fusion. Free neutrons combine with protons to form deuterium. Deuterium rapidly fuses into helium-4. Nucleosynthesis only lasts for about seventeen minutes (between 3 and 20 minutes after the Big Bang), since the temperature and density of the universe has fallen to the point where nuclear fusion cannot continue. By this time, all neutrons have been incorporated into helium nuclei. This leaves about three times more hydrogen than helium-4 (by mass) and only trace quantities of other nuclei [Wikipedia, Chronology of the universe].

The measured abundances all agree at least roughly with those predicted by the Big Bang model from a single value of the baryon-to-photon ratio. The agreement is excellent for deuterium, close but formally discrepant for ^{4}He*, and off by a factor of two for* ^{7}Li*; in the latter two cases there are substantial systematic uncertainties. Nonetheless, the general consistency with abundances predicted by Big Bang nucleosynthesis is strong evidence for the Big Bang* [Wikipedia, Bing Bang].

It is now known that the elements observed in the Universe were created in either of two ways. Light elements (namely deuterium, helium, and lithium) were produced in the first few minutes of the Big Bang, while elements heavier than helium are thought to have their origins in the interiors of stars which formed much later in the history of the Universe. Both theory and observation lead astronomers to believe this to be the case [Wikipedia, Big Bang Nucleosynthesis].

About 380,000 years after the Big Bang the temperature of the universe fell to the point where nuclei could combine with electrons to create neutral atoms. As a result, photons no longer interacted frequently with matter, the universe became transparent and the cosmic microwave background radiation was created and then structure formation took place [Wikipedia, Photon epoch].

This cosmic event is usually referred to as decoupling. The photons present at the time of decoupling are the same photons that we see in the cosmic microwave background radiation, after being greatly cooled by the expansion of the Universe [Wikipedia, Chronology of the universe].

The photons that existed at the time of photon decoupling have been propagating ever since, though growing fainter and less energetic, since the expansion of space causes their wavelength to increase over time [Wikipedia, Cosmic microwave background radiation].

The stretching of space also accounts for the apparent paradox that two galaxies can be 40 billion light years apart, although they started from the same point 13.7 billion years ago and never moved faster than the speed of light [Wikipedia, Universe].

WUM: Nucleosynthesis of all elements occurs inside stars during their evolution (Stellar nucleosynthesis). The theory of this process is well developed, starting with the publication of a celebrated B^2FH review paper in 1957 [2].

With respect to the World – Universe model, stellar nucleosynthesis theory should be enhanced to account for annihilation of heavy dark matter particles (WIMPs and neutralinos). The amount of energy produced due to this process is sufficiently high to produce all elements inside stellar cores. Annihilation of dark matter particles inside the stars accelerates with time, as stars gain mass (Section 2.14).

The black body spectrum of the cosmic microwave background radiation is due to thermodynamic equilibrium of photons with low density intergalactic plasma consisting of protons and electrons (Section 2.5). The calculated value of microwave background radiation temperature $T_{MBR} = 2.7250\ K$ is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\ K$ [Wikipedia, Cosmic microwave background radiation].

Reionization

Reionization lasted from 380,000 years to approximately 1 billion years after the Big Bang, including ***Dark Ages*** *which are currently thought to have lasted between 150 million to 800 million years after the Big Bang* [Wikipedia, Chronology of the universe].

Formation and Evolution of Large-Scale Structures

BBM: Understanding the formation and evolution of the largest and earliest structures (i.e., quasars, galaxies, clusters and superclusters) is one of the largest efforts in cosmology. Cosmologists study a model of hierarchical structure formation in which structures form from the bottom up, with smaller objects forming first, while the largest objects, such as superclusters, are still assembling. *One way to study structure in the universe is to survey the visible galaxies, in order to construct a three-dimensional picture of the galaxies in the universe and measure the matter power spectrum. This is the approach of the Sloan Digital Sky Survey and the 2dF Galaxy Redshift Survey. Another tool for understanding structure formation is simulations, which cosmologists use to study the gravitational aggregation of matter in the universe, as it clusters into filaments, superclusters and voids* [Wikipedia, Physical cosmology].

A combination of observations and theory suggest that the first quasars and galaxies formed about a billion years after the Big Bang, and since then larger structures have been forming, such as galaxy clusters and superclusters. Populations of stars have been aging and evolving, so that distant galaxies (which are observed as they were in the early Universe) appear very different from nearby galaxies (observed in a more recent state). Moreover, galaxies that formed relatively recently appear *markedly different from galaxies formed at similar distances but shortly after the Big Bang* [Wikipedia, Big Bang].

Recently, the UDFj-39546284 galaxy was found to be around 380 million years after the Big Bang [Wikipedia, Chronology of the universe].

HD 140283 *is the oldest known star for which a reliable age has been determined* [3]. *HD 140283, informally nicknamed* ***Methuselah star****, is a metal-poor subgiant star about 190 light years away from the Earth in the constellation Libra* [Wikipedia, HD 140283].

One recent study used the Fine Guidance Sensors at NASA's Hubble Space Telescope to measure a precise parallax (and therefore distance and luminosity) for the star [3], *and employ this information to estimate an age for the star of* 14.46 ± 0.8 *billion years. Due to uncertainty in the value, this age for the star does not conflict with the age of the Universe determined by the Planck satellite,* 13.798 ± 0.037 *. The star "must have formed soon after the Big Bang",* [3] *and it has perhaps the largest age purported to any star.*

The first stars are thought to have been born a few hundred million years after the Big Bang, and they died in supernova explosions after only a few million years. A second generation of stars, the generation in which HD 140283 is theorized to have been born, could not have coalesced until gas, heated from the supernova explosions of the earlier stars, cooled down. The age of HD 140283 indicates that the time it took for the gases to cool was likely only a few tens of millions of years [Wikipedia, HD 140283].

WUM: All macroobjects of the World (galaxy clusters, galaxies, star clusters, and stars) have cores made up of different dark matter particles (Section 2.11). The theory of fermion compact stars made up of dark matter particles is well developed. Scaling solutions are derived for a free and an interacting Fermi gas in Section 2.10.

The calculated parameters of fermion compact stars show that

- White Dwarf Shells around the nuclei made of strongly interacting WIMPs or neutralinos (Section 2.14) compose the cores of stars in extrasolar systems;
- Dissociated DIRACs to Monopoles form cores of star clusters;
- Dissociated ELOPs to Preons constitute cores of galaxies;
- Sterile neutrinos make up cores of galaxy clusters;
- Tauonic neutrinos reside in the cores of galaxy superclusters.

The energy consumption rates are greater for galaxies relative to extrasolar systems, and for the World relative to galaxies. It follows that new stars and star clusters can be created inside of a galaxy, and new galaxies and galaxy clusters can arise in the World. Structures form from top (the World) down to extrasolar systems in parallel around different cores made of different dark matter particles. Formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing (Section 2.13).

The very first objects built from dark matter particles, protons, electrons, photons, and neutrinos, were generated at approximately 10^{-18} seconds after the Beginning. Nuclei of main-sequence stars and red stars were initiated at that time (Section 3.3).

Age of HD 140283 (14.46 ± 0.8 Byr) aligns better with the age of the World calculated by WUM (14.226 Byr) than with the commonly accepted age of the Universe (13.798 ± 0.037 Byr) . According to WUM, the World is some 428 million years older than commonly accepted. This additional period helps explain the rise of second-generation stars.

Ultimate Fate of the Universe

BBM: *There's a growing consensus among cosmologists that the universe is flat and will continue to expand forever. The preponderance of evidence to date, based on measurements of the rate of expansion and the mass density, favors a universe that will continue to expand indefinitely, resulting in the "big freeze" scenario below. However, observations are not conclusive, and alternative models are still possible.*

The Big Freeze is a scenario under which continued expansion results in a universe that asymptotically approaches absolute zero temperature. A related scenario is heat death, which states that the universe goes to a state of maximum entropy in which everything is evenly distributed, and there are no gradients – which are needed to sustain information processing, one form of which is life [Wikipedia, Ultimate fate of the universe].

There are some other main possibilities:

- *Big Crunch: 100+ billion years from now;*
- *Big Rip: 20+ billion years from now;*
- *Big Bounce;*
- *Vacuum metastability event;*
- *Heat death: 10^{150}+ years from now;*
- *Multiverse: no complete end* [Wikipedia, Chronology of the universe].

WUM: The World is continuously receiving energy from the Universe that envelopes it. Assuming an unlimited Universe, the numbers of cosmological structures on all levels will increase: new galaxy clusters will form; existing clusters will obtain new galaxies; new stars will be born inside existing galaxies; sizes of individual stars will increase, etc. The temperature of the Medium of the World will asymptotically approach absolute zero (Section 2.5).

In 1934 *Dr. Tesla disclosed that he has lately perfected instruments which flatly disprove the present theory of the high physicists that the sun is destined to burn itself out until it is a cold cinder floating in space. Dr. Tesla stated that he is able to show that all the suns in the universe are constantly growing in mass and heat, so that the ultimate fate of each is explosion* [45].

Observational Evidence

The earliest and most direct kinds of observational evidence are the Hubble-type expansion seen in the redshifts of galaxies, the detailed measurements of the cosmic microwave background, the relative abundances of light elements produced by Big Bang nucleosynthesis, and today also the large scale distribution and apparent evolution of galaxies predicted to occur due to gravitational growth of structure in the standard theory. These are sometimes called "the four pillars of the Big Bang theory" [Wikipedia, Big Bang].

Is the standard Big Bang theory the only model consistent with these evidences? No, it's just the most popular one. Internationally renowned Astrophysicist George F. R. Ellis explains: "People need to be aware that there is a range of models that could explain the observations… For instance, I can construct you a spherically symmetrical universe with earth at its center, and you cannot disprove it based on observations… You can only exclude it on philosophical ground. What I want to bring into *the open is the fact that we are using philosophical criteria in choosing our models. A lot of cosmology tries to hide that"* [4].

1.2. Related issues in physics

Parameters of the World-Universe

BBM: *The **Lambda-CDM** model is a parameterization of the Big Bang cosmological model in which the universe contains a cosmological constant, denoted by Lambda, and cold dark matter. It is frequently referred as the **standard model** of Big Bang cosmology.*

Λ (Lambda) stands for the cosmological constant which is currently associated with a vacuum energy or dark energy inherent in empty space that explains the current accelerating expansion of space against the attractive (collapsing) effects of gravity from matter. A cosmological constant has negative pressure. The cosmological constant is denoted as Ω_Λ , which is interpreted as the fraction of the total mass-energy density of a flat universe that is attributed to dark energy.

Cold dark matter is a form of matter necessary to account for gravitational effects observed in very large scale structures. Dark matter is described as being cold (i.e. its velocity is non-relativistic [far below the speed of light] at the epoch of radiation-matter equality), non-baryonic (consisting of matter other than protons and neutrons), dissipationless (cannot cool by radiating photons) and collisionless (i.e. the dark matter particles interact with each other and other particles only through gravity and possibly the weak force). The dark matter component is currently estimated to constitute about 23% of the mass-energy density of the universe.

The remaining 4.5% comprises all ordinary matter observed as atoms, chemical elements, gas and plasma, the stuff of which visible planets, stars and galaxies are made.

Also, the energy density includes a very small fraction (~0.01%) in cosmic microwave background radiation, and not more than 0.5% in relic neutrinos. While very small today, these were much more important in the distant past, dominating the matter at redshift > 3200.

The ΛCDM model is based on six parameters: baryon density Ω_B , dark matter density Ω_{DM} , dark energy density Ω_Λ , scalar spectral index, curvature fluctuation amplitude and reionization optical depth. In accordance with Occam's razor, six is the smallest number of parameters needed to give an acceptable fit to current observations; other possible parameters are fixed at "natural" values e.g. total density = 1.00, dark energy equation of state = -1, neutrino masses are small enough to be negligible.

The values of these six parameters are mostly not predicted by current theory (though, ideally, they may be related by a future "Theory of everything"); except that most versions of cosmic inflation predict the scalar spectral index should be slightly smaller than 1, consistent with the estimated value 0.96. The parameter values, and uncertainties, are estimated using large computer searches to locate the region of parameter space providing an acceptable match to cosmological observations. From these six parameters the other model values, including the Hubble constant and age of the universe, can be readily calculated [Wikipedia, Lambda-CDM model].

Martin Lopez-Corredoira has this to say about current cosmology [5]:

The number of independent measurements relevant to current cosmology and the number of free parameters of the theory are of the same order (Disney 2007): the "Big Bang" was in the 50s a theory with three or four free parameters to fit the few numbers of observational cosmology (basically, *Hubble's constant and the helium abundance), and the increase of cosmological information from observations, with the CMBR anisotropies and others, has been accompanied by an increase in free parameters and patches (dark matter, dark energy, inflation) in the models to fit those new numbers, until becoming today a theory with around 20 free parameters (apart from the initial conditions and other boundary conditions introduced in the simulations to reproduce certain structures of the Universe). The independent cosmological numbers extracted from observations are of the same order. Even so, there are some numbers which cannot be fitted.*

Regarding CMBR anisotropies, the power spectrum is just a curve with two or three clear peaks that could be parameterized with ~ 10 parameters (three parameters/peak: central position, width, height). If we allow certain range or errors [each peak has important relative error bars, which are very large in the 2nd, 3rd and beyond (indeed, after the 3rd peak the noise dominates)], it is possible to parameterize a curve like this with somewhat fewer parameters within the errors. Standard concordance cosmology reproduces the curve with six parameters (there are indeed ~ 20 parameters; but the most important ones are six in number; the rest of them produce small dependence), with some problems to reproduce the very large scale fluctuations. Nonetheless, there are also other papers which reproduce the same WMAP data with totally different cosmologies with a similar number of free parameters: e.g., Narlikar et al. (2003), McGaugh (2004). The fact that different cosmologies with different elements can fit the same data (with a similar number of free parameters to fit) indicates that the number of independent numbers in the information provided by WMAP data is comparable to the number of free parameters in any of the theories.

WUM: The World – Universe model is based on two fundamental parameters in various rational exponents: Fine-structure constant α and dimensionless quantity Q. While α is a constant, Q increases with time, and is in fact a measure of the size and the age of the World.

The main parameters of the flat World – the fractions of the total mass-energy density are constant in time, related to and expressed through α (Sections 2.7, 2.9):

$$\Omega_B = \pi^2\alpha = 0.07202 \quad \text{Baryon density}$$

$$\Omega_{DM} = \frac{10}{3}\pi^2\alpha = 0.24007 \quad \text{Dark matter density}$$

$$\Omega_\nu = 30\pi\alpha = 0.68776 \quad \text{Neutrinos density}$$

The sum of electron, MBR photons, and black body radiation from cosmic dust, X-rays, and Gamma rays' energy densities can be expressed through α too (Section 2.9) and equals to:

Electron plus Radiations density

$$\Omega_e + \Omega_{rad} = 0.00015$$

The sum of all components densities of the World is

$$\Omega_B + \Omega_{DM} + \Omega_\nu + \Omega_e + \Omega_{rad} = 1$$

The implication is that the World is flat.

In the World – Universe model, neutrinos density is much higher than that of ΛCDM model. Dark energy density is absent (elaborated below).

All physical parameters of the World represented in natural units $c = a = h = 1$ (h is the Planck constant) can be expressed in terms of Q in various rational exponents, as well as small integer numbers and π (Section 4).

Dark Energy

BBM*: In physical cosmology and astronomy, dark energy is a hypothetical form of energy that permeates all of space and tends to accelerate the expansion of the universe. Dark energy is the most accepted hypothesis to explain observations since the 1990s that indicate that the universe is expanding at an accelerating rate. According to the Planck mission team, and based on the standard model of cosmology, the total mass-energy of the universe contains 4.9% ordinary matter, 26.8% dark matter and 68.3% dark energy.*

Two proposed forms for dark energy are the cosmological constant, a constant energy density filling space homogeneously, and scalar fields such as quintessence or moduli, dynamic quantities whose energy density can vary in time and space. The cosmological constant is physically equivalent to vacuum energy.

Many things about the nature of dark energy remain matters of speculation. The evidence for dark energy is indirect. However, it comes from three independent sources. These are:

- *Distance measurements and their relation to redshift, which suggest the universe has expanded more in the last half of its life.*
- *The theoretical need for a type of additional energy that is not matter or dark matter to form our observationally flat universe (absence of any detectable global curvature).*
- *It can be inferred from measures of large scale wave-patterns of mass density in the universe.*

Dark energy is thought to be very homogeneous, not very dense and is not known to interact through any fundamental forces other than gravity.

Some people argue that the only indication for the existence of dark energy is observations of distance measurements and associated redshifts. Cosmic microwave background anisotropies and baryon acoustic oscillations are only observations that redshifts are larger than expected from a "dusty" Friedmann-Lemaitre universe and the local measured Hubble constant.

Supernovae are useful for cosmology because they are excellent standard candles across cosmological distances. They allow the expansion history of the Universe to be measured by looking at the relationship between the distance to an object and its redshift, which gives how fast it is receding from us. The relationship is roughly linear, according to Hubble's law. It is relatively easy to measure redshift but finding the distance to an object is more difficult. Usually, astronomers use standard candles: objects for which the intrinsic brightness, the absolute magnitude, is known. This allows the object's distance to be measured from its actual observed brightness, or apparent magnitude. Type 1a supernovae are the best-known standard candles across cosmological distances because of their extreme and extremely consistent luminosity [Wikipedia, Dark energy].

T. Davis and B. Griffen have this to say about Cosmological constant [6]:

The critical observational result that brought the cosmological constant into its modern prominence was the discovery that distant type 1a supernovae ($0<z<1$), used as standard candles, were fainter than expected in a decelerating universe (Riess et al. 1998, Perlmutter et al. 1999). Since then many groups have confirmed this result with more supernovae and over a larger range of redshifts. Of particular importance are the observations that extremely high red shift ($z>1$) supernovae are brighter than expected, which is the observational signature that is expected from a period of deceleration preceding our current period of acceleration. These higher-redshift observations of *brighter-than-expected supernovae protect us against any systematic effects that would dim supernovae for reasons other than acceleration.*

Apart from its density and its clustering properties (no clustering)*, nothing is known about dark energy. Quantum field theory predicts a cosmological constant much like dark energy, but 120 orders of magnitude larger than that observed. The nature of dark energy is one of the most challenging problems in cosmology* [Wikipedia, Physical cosmology].

WUM: The World – Universe model gives the following explanations for supernovae 1a distance measurements and their relation to redshift:

- All macroobjects of the World were fainter in the past. As their cores absorb new energy, the sizes of macroobjects and thus their luminosity are increasing in time $\propto t$ (section 2.14). For example, taking the age of the World $\cong$ 14.2 Byr and the age of solar system $\cong$ 4.6 Byr, it is easy to find that the young Sun's output was only 67.6% of what it is today. Literature commonly refers to the value of 70%. So-called "Faint young Sun" paradox is thus resolved. The same holds true for all other macroobjects as well, including supernovae.
- In accordance with Hubble's law, the distance d to galaxies for $z \ll 1$ is found to be proportional to z:

$$d = \frac{c}{H_0} z = Rz \qquad 1.2.1$$

where H_0 is the Hubble's parameter.

The relationship of distance d to the redshift z for large values of z is not presently conclusive, active research is conducted in the area.

In the World – Universe model, the distance to galaxies equals to (Section 2.19):

$$d = \frac{c}{H_0} \frac{z}{1+z} = R \frac{z}{1+z} \qquad 1.2.2$$

which reduces to 1.2.1 for $z \ll 1$ and $d = R$ for $z \to \infty$. Thus for $z>1$, the distance to supernovae is smaller than expected and hence supernovae are brighter.

There is then no reason to introduce dark energy in order to explain the nonlinear relationship of distance to the redshift.

The theoretical need for additional energy distinct from the baryon matter and dark matter to form our observationally flat World is satisfied with the considerably larger fraction of the neutrino energy density in the total energy density of the World:

$$\Omega_\nu = 30\pi\alpha = 0.68775928 \qquad 1.2.3$$

Consequently, we are dealing with well-known particles instead of dark energy.

Dark Matter

BBM: *Dark matter (DM) neither emits nor absorbs light or other electromagnetic radiation, and so cannot be seen directly with telescopes. DM is estimated to constitute 23% of the mass-energy. Dark matter came to the attention of astrophysicists due to discrepancies between the mass of large astronomical objects determined from their gravitational effects, and mass calculated from the "luminous matter" they contain; such as stars, gas and dust. It was first postulated by Jan Oort in 1932.*

There are three prominent hypotheses on nonbaryonic DM, namely Hot Dark Matter (HDM), Warm Dark Matter (WDM), and Cold Dark Matter (CDM). The most widely discussed models for *nonbaryonic DM are based on the CDM hypothesis, and corresponding particles are most commonly assumed to be Weakly Interacting Massive Particles (WIMPs)* [Wikipedia, Dark matter].

The gravitational effects of DM are well understood, as it behaves like a cold, non-radiative fluid that forms haloes around galaxies. DM has never been detected in the laboratory, and the particle physics nature of DM remains completely unknown [Wikipedia, Physical cosmology]. *The Universe today is far more lumpy and contains far less deuterium than can be accounted for without DM* [Wikipedia, Big Bang].

A neutralino with mass m_N *in* $100 \Leftrightarrow 10{,}000\ GeV/c^2$ *range is the leading DM candidate* [Wikipedia, Neutralino]. *Light Dark Matter Particles that are heavier than WDM and HDM but lighter than the traditional forms of CDM (neutralino) are DM candidates too. Their masses* m_{WIMP} *fall into* $1 \Leftrightarrow 10\ GeV/c^2$ *range* [Wikipedia, Light dark matter]. Subsequently, we will refer to the light dark matter particles as WIMPs.

It is known that a sterile neutrino with mass m_{ν_s} *in* $1 \Leftrightarrow 10\ keV/c^2$ *range is a good WDM candidate* [Wikipedia, Warm dark matter]. *The best candidate for the identity of HDM is neutrino* [Wikipedia, Hot dark matter]. In our opinion, a tauonic neutrino is a good HDM candidate.

WUM: In addition to fermions discussed above, the World – Universe model (Section 2.9) offers another type of DM particles – bosons, consisting of two fermions each. There are two types of DM bosons: DIRACs possessing mass of $m_0 \cong 70\ MeV/c^2$ that are in fact magnetic dipoles, and ELOPs having mass of $\frac{2}{3}m_e$ – preon dipoles (m_e is the electron mass).

Dissociated DIRACs can only exist at nuclear densities or at high temperatures. A DIRAC breaks into two Dirac monopoles with mass $\frac{m_0}{2}$ and charge $\mu = \frac{e}{2\alpha}$ (Section 3.2). In our opinion, these monopoles are the smallest building blocks of fractal structure of constituent quarks and hadrons (Section 3.6).

ELOPs break into two preons whose mass m_{pr} equals to one third of an electron's mass:

$$m_{pr} = \frac{1}{3}m_e \qquad 1.2.4$$

and charge e_{pr} – to one third of an electron's charge:

$$e_{pr} = \frac{1}{3}e \qquad 1.2.5$$

Preons are the smallest building blocks of a fractal structure of quarks and leptons (section 3.6).

We did not take into account the binding energies of DIRACs and ELOPs, and thus the values of their masses are approximate. They have negligible electrostatic and electromagnetic charges because the separation between charges is very small. They do however possess non-negligible electrostatic and electromagnetic dipole momentum (Section 3.2).

In the World-Universe model, DM particle masses are related to and proportional to m_0 multiplied by different exponents of α. Consequently, masses of various types of DM particles can be predicted:

CDM particles (Neutralinos and WIMPs):

$$m_N = \alpha^{-2}m_0 = 1.3149950\ \ TeV/c^2 \qquad 1.2.6$$

$$m_{WIMP} = \alpha^{-1}m_0 = 9.5959823\ \ GeV/c^2 \qquad 1.2.7$$

DIRACs:

$$m_{DIRAC} = 2\alpha^0 \frac{m_0}{2} = 70.025267\ MeV/c^2 \qquad 1.2.8$$

ELOPs:

$$m_{ELOP} = 2\alpha^1 \frac{m_0}{3} = 340.66606\ keV/c^2 \qquad 1.2.9$$

WDM particles (sterile neutrinos):

$$m_{\nu_s} = \alpha^2 m_0 = 3.7289402\ keV/c^2 \qquad 1.2.10$$

These values fall into the ranges estimated in literature.

The Model holds that the energy densities of all types of DM particles are proportional to the proton energy density in the World's Medium:

$$\Omega_p = \frac{2\pi^2\alpha}{3} = 0.048014655 \qquad 1.2.11$$

In all, there are 5 different types of DM particles. Then the total energy density of DM is

$$\Omega_{DM} = 5\Omega_p = 0.24007327 \qquad 1.2.12$$

which is close to the DM energy density discussed in literature: $\Omega_{DM} \cong 0.23$ [Wikipedia, Dark Matter].

The main suggestion for experimentalists dealing with observations of Dark Matter is to concentrate their efforts on particles possessing masses shown above.

1.3. Basis of the World – Universe Model

In the proposed Model, the World was started by a fluctuation in the Universe, and the Nucleus of the World was born. Its extrapolated initial energy density was much smaller than the nuclear density, and we extrapolate its temperature to have been only about 2 MeV. The World has since been expanding through the Universe, consuming energy from the Universe as the World – Universe boundary advances.

The World consists of the Medium (protons, electrons, photons, neutrinos, and dark matter particles) and Macroobjects (Galaxy clusters, Galaxies, Star clusters, Extrasolar systems, etc.) made of these particles. There is no empty space in frames of the Model.

According to the Model, the World is a Black Hole. Residing inside of a black hole, we can conduct no observations of the outside Universe, and learn nothing about its characteristics. The World is expanding in the Universe without limit with the speed equal to the electrodynamic constant c. The Universe serves as an unlimited source of energy that the World is consuming as it grows.

The proposed Model provides a mathematical framework based on a few basic assumptions, that allows to calculate the primary parameters of the World (its size, age, temperature of the cosmic microwave background radiation, masses of neutrinos and dark matter particles, etc.), in good agreement with the most recent measurements and observations. To the best of my knowledge, there is no other Model that would allow one to calculate these values:

$$R = 1.3459 \times 10^{26}\ m \qquad \text{Size}$$

$$A_t = 4.4894 \times 10^{17}\ s = 14.226 \text{ billion years} \qquad \text{Age}$$

$H_0 = 2.2275 \times 10^{-18}\ s^{-1} = 68.733\ \frac{km/s}{Mpc}$	Hubble's parameter
$\rho_{cr} = 7.9773 \times 10^{-10}\ \frac{J}{m^3}$	Critical density
$\rho_{cr0} = 6.0638901 \times 10^{30}\ \frac{J}{m^3}$	Critical density at the Beginning
$\sigma_0 = 3.5788363 \times 10^{16}\ \frac{J}{m^2}$	Surface enthalpy of the Front
$E_W = 8.1464 \times 10^{69}\ J$	Total energy of the World
$\Omega_p = 0.048014655$	Proton density in the Medium
$n_p = 0.25480\ m^{-3}$	Proton concentration in the Medium
$T_{MBR} = 2.7250\ K$	Microwave Background Radiation Temperature
$\Omega_{\nu tot} = 0.68775927$	Total neutrinos density
$\Omega_{DMtot} = 0.24007327$	Total dark matter density
$\Omega_B = 0.07202198$	Total baryonic density
$\Omega_e + \Omega_{rad} = 0.00014548$	Electron plus radiations density
$T_{st} = 28.95\ K$	Cosmic dust temperature
$m_N = 1.3149950\ TeV/c^2$	Neutralino mass
$m_{WIMP} = 9.5959823\ GeV/c^2$	WIMP mass
$m_{DIRAC} = 70.025267\ MeV/c^2$	DIRAC mass
$m_{ELOP} = 340.66606\ keV/c^2$	ELOP mass
$m_{\nu_s} = 3.7289402\ keV/c^2$	Sterile neutrino mass
$M_{Smax} = 3.4654 \times 10^{32} kg\ (\cong\ 174\ M_{Sun})$	Maximum stellar mass

The Model makes predictions pertaining to masses of photons, axions, and neutrinos; proposes new types of particle interactions and fundamental physical parameters of the World; resolves paradoxes like "Matter – Antimatter Asymmetry" and "Faint Young Sun".

World – Universe Model, at its present state, requires significant further elaboration and validation. I welcome criticism of the overall Model and individual ideas underpinning it.

The Model is developed around two fundamental parameters: Fine-structure constant α and dimensionless quantity Q. While α is a constant, Q increases with time, and in fact defines the size and the age of the World.

Intermediate results in subsequent analysis will often be obtained using classical notions and parameters. All final formulas, however, will be expressed in terms of α and Q in various rational exponents, as well as small integer numbers and π.

The manuscript contains references to original papers, as well as Wikipedia articles that summarize and in turn refer to original papers. Numerical values are provided in SI for convenience. α-Dependent quantities are calculated to 8 significant digits, and Q-dependent quantities – to 5 significant digits. We will use ⟺ symbol to describe ranges of values.

2. COSMOLOGY

Cosmology is still a very young science and should leave the door wide open to other positions.

M. Lopez-Corredoira

2.1. The Beginning

The Big Bang is a mythical "creation event", before that there was nothing. Can we really believe in nothing turning to something out of the blue? Where did all that energy for the rapid expansion of the Universe and the forming of Galaxies and such come from?

O.A. van den Berg

World – Universe Model is based on the following primary assumptions:

- In the beginning, there was nothing but the Universe – unlimited source of energy. Our World was started by a fluctuation in the Universe, and the Nucleus of the World was born. The World has since been expanding through the Universe, consuming energy as the World – Universe boundary advances.
- The World is expanding with speed equal to the electrodynamic constant c for time t, and has the radius of $R = ct$. Subsequently, we will refer to the moving World – Universe boundary as the Front.
- The Front has a temperature invariant surface enthalpy σ_0. Generation of particle – antiparticle pairs is occurring at the Front due to high surface energy density of the Universe. Antiparticles remain at the Front, and particles continue on into the World. In other words, all antimatter is concentrated at the Front, and equal amount of matter exists in the World, resolving the long-standing "Matter – Antimatter Asymmetry" paradox.

Amount of energy added to the World is proportional to the increase of the area of the Front. The total amount of the World energy is thus

$$E_W = 4\pi R^2 \sigma_0 \qquad 2.1.1$$

The energy density of the World ρ_W is inversely proportional to the radius of the World R:

$$\rho_W = \frac{3\sigma_0}{R} \qquad 2.1.2$$

The proposed mechanism of creation of matter at the Front differs from the continuous creation of matter discussed by Paul Dirac in 1974 [7]:

- *One might assume that nucleons are created uniformly throughout space, and thus mainly in intergalactic space. We may call this **additive creation**.*
- *One might assume that new matter is created where it already exists, in proportion to the amount existing there. Presumably the new matter consists of the same kind of atoms as those already existing. We may call this **multiplicative creation**.*

2.2. Time Varying Parameters

From General Relativity, recall the well-known equation for the critical energy density of the World ρ_{cr}:

$$\rho_{cr} = \frac{3H_0^2c^2}{8\pi G} \qquad 2.2.1$$

where H_0 is the Hubble parameter:

$$H_0 = \frac{1}{t} = \frac{c}{R} \qquad 2.2.2$$

Equation 2.2.1 can be rewritten as

$$\frac{4\pi G}{c^2} \times \frac{2}{3}\rho_{cr} = \mu_g \times \frac{2}{3}\rho_{cr} = H_0^2 = \frac{c^2}{R^2} \qquad 2.2.3$$

where μ_g is the gravitomagnetic parameter of the Medium.

The principal idea of our Model is that the energy density of the World ρ_W equals to the critical energy density ρ_{cr}:

$$\rho_{cr} = \rho_W = \frac{3\sigma_0}{R} \propto \frac{1}{R} \qquad 2.2.4$$

We see that the gravitational parameter G is also proportional to $\frac{1}{R}$ and is decreasing in time as $G \propto \frac{1}{t}$. This property of gravitational parameter G was originally hypothesized by Paul Dirac in 1937 [8]. Since $M_p^2 = \frac{hc}{2\pi G}$, the Planck mass M_P is proportional to $t^{\frac{1}{2}}$, and the Planck length $L_P = \frac{h}{M_P c}$ is proportional to $t^{-\frac{1}{2}}$, where h is the Planck constant.

The Dirac large number hypothesis (LHN) is an observation made by Paul Dirac in 1937 relating ratios of size scales in the Universe to that of force scales. The ratios constitute very large, dimensionless numbers: some 40 orders of magnitude in the present cosmological epoch. According to Dirac's hypothesis, the apparent equivalence of these ratios might not to be a mere coincidence but instead could imply a cosmology with these unusual features:

- *The strength of gravity, as represented by the gravitational constant, is inversely proportional to the age of the universe:* $G \propto 1/t$
- *The mass of the universe is proportional to the square of the universe's age:* $M \propto t^2$.

Dirac's theory has inspired and continues to inspire a significant body of scientific literature in a variety of disciplines. Arguments both for and against LNH are also made from astrophysical considerations. For example, D. Falik [53] argued that LNH is inconsistent with the experimental results for microwave background radiation whereas Canuto and Hsieh [54, 55] argued that it is consistent. One argument that has created significant controversy was put forward by Robert Dicke in 1961. Known as the anthropic coincidence or fine-tuned universe, it simply states that the large numbers in LNH are a necessary coincidence for intelligent beings since they parameterize fusion of hydrogen in stars and hence carbon-based life would not arise otherwise [Wikipedia, Dirac large number hypothesis].

Different theoretical frameworks, including a modification of the General Relativity and several scalar models, were considered in the literature (see, for example, papers [56, 57, 58, 59, 60, 61, 62, 63]). Numerous works trying to find time variation of G have been performed (see, for example, reviews [62, 63]).

Wikipedia has this to say about G [Gravitational constant]:

The accuracy of the measured value of G has increased only modestly since the original Cavendish experiment. G is quite difficult to measure, as gravity is much weaker than other fundamental forces, and an experimental apparatus cannot be separated from the gravitational influence of other bodies. Furthermore, gravity has no established relation to other fundamental forces, so it does not appear possible to calculate it indirectly from other constants that can be measured more accurately, as is done in some other areas of physics. Published values of G have varied rather broadly, and some recent measurements of high precision are, in fact, mutually exclusive.

The following **Table** summarizes the CODATA internationally recommended values of the Newtonian constant of gravitation at different years:

Observe that the values of G seem to fluctuate around the average value G_{av} :

$$G = G_{av} \pm \Delta G = (6.673 \pm 0.001) \times 10^{-11}\ m^3 kg^{-1} s^{-2} \qquad 2.2.5$$

and the value of G has 4 significant digits.

The gravitational parameter G in our Model is changing in time with the following rate:

$$\dot{G}/G = 7.029 \times 10^{-11}\ yr^{-1} \qquad 2.2.6$$

During the 212 years elapsed from the first measurement of the value of G by Henry Cavendish, value of G has decreased by ΔG :

$$\Delta G = 1.49 \times 10^{-8}\ m^3 kg^{-1} s^{-2} \ 2.2.7$$

The above ΔG is far smaller than the precision that we have attained when measuring G, and thus measuring ΔG directly seems to be impossible using contemporary techniques.

Year	$\boldsymbol{G \times 10^{11}\ m^3 kg^{-1} s^{-2}}$	**Relative std. uncert. ppm**
1969	6.6732(31)	460
1973	6.6720(41)	615
1986	6.67259(85)	128
1998	6.673(10)	1500
2002	6.6742(10)	150
2006	6.67428(67)	100
2010	6.67384(80)	120

In his papers [62, 63], Jean-Philippe Uzan reviewed the main experimental and observational constraints that have been obtained for variations of the gravitational constant in different areas:

- Solar systems constraints
- Pulsar timing
- Stellar constraints
- Cosmological constraints

and found that

$$\dot{G}/G \lesssim 10^{-11} \Leftrightarrow 10^{-12} yr^{-1} \qquad 2.2.8$$

The experimentally obtained constraints on G variation rates are significantly larger than theoretically calculated 2.2.6.

Note that all obtained constraints are the results of the calculations based on different theoretical models. One example from review [63]:

The Lunar Laser Ranging (LLR) experiment has measured the relative position of the Moon with respect to the Earth with accuracy of the order of 1 cm over 3 decades. An early analysis of this data ***assuming a Brans-Dicke theory of gravitation*** *gave that* $\dot{G}/G \leq 3 \times 10^{-11}\, yr^{-1}$*. It was improved by using 20 years of observation to get* $\dot{G}/G \leq 1.04 \times 10^{-11}\, yr^{-1}$*,* ***the main uncertainty arising from Lunar tidal acceleration****. With 24 years of data, one reached* $\dot{G}/G \leq 6 \times 10^{-12}\, yr^{-1}$ *and finally, the latest analysis of the Lunar laser ranging experiment increased the constraint to*

$$\dot{G}/G \leq (4 \pm 9) \times 10^{-13}\, yr^{-1}$$

Another example from review [62]:

Teller (1948) first emphasized that Dirac hypothesis may be in conflict with paleontological evidence. His argument is based on the estimation of the temperature at the center of the Sun $T_{\odot} \propto G\, M_{\odot}/R_{\odot}$ *using the virial theorem. The luminosity of the Sun is then proportional to the radiation energy gradient times the mean free path of a photon times the surface of the Sun, that is* $L_{\odot} \propto T_{\odot}^{7} R_{\odot}^{7} M_{\odot}^{-2}$ *, hence concluding that* $L_{\odot} \propto T_{\odot}^{7} M_{\odot}^{5}$ *. Computing the radius of the Earth orbit in Newtonian mechanics, assuming the conservation of angular momentum (so that* $G M_{\odot} R_{Earth}$ *is constant) and stating that the Earth mean temperature is proportional to the fourth root of the energy received, he concluded that*

$$T_{Earth} \propto G^{2.25} M_{\odot}^{1.75}$$

If $M_{\odot}$ *is constant and G was 10% larger 300 million years ago, the Earth surface temperature should have been 20% higher, that is close to the boiling temperature. This was in contradiction with the existence of trilobites in the Cambrian.*

Teller (1948) used a too low value for the age of the universe. Gamow (1967) actualized the numbers and showed that even if it was safe at the Cambrian era, there was still a contradiction with bacteria and alga estimated to have lived 4×10^{9} *years ago.*

When using such an argument, the heat balance of the atmosphere is affected by many factors (water vapor content, carbon dioxide content, circulatory pattern, …) is completely neglected. This renders the extrapolation during several billion years very unreliable. For instance, the rise of the temperature implies that the atmosphere is at some stage mostly composed of water vapor so that its convective mechanism is expected to change in such a way to increase the Earth albedo and thus to decrease the temperature!

Moreover, in this debate the scientists didn't take the "Faint Young Sun" paradox into account: the young Sun's output was only 67.6% of what it is today (Section 2.14).

With respect to our Model, the mass of the Sun and its luminosity were smaller in the past (Section 2.14). Masses of macroobjects M_{MO} , consisting of the smallest building blocks with masses around

M_P (which is proportional to the square root of time: $M_P \propto \sqrt{t}$) are increasing in time: $M_{MO} \propto \sqrt{t}$. Then the gravitational force F_{gr} between two macroobjects stays constant in time:

$$F_{gr} \propto G \times M_1 \times M_2 \propto \frac{1}{t} \times \sqrt{t} \times \sqrt{t} = const \qquad 2.2.9$$

Masses of stars in extra solar systems M_{ESS} are increasing in time: $M_{ESS} \propto t^{\frac{3}{2}}$. The gravitational force between stars and planets can even increase depending on the model.

The constancy of the universe fundamental constants, including G, M_P, L_P, is now commonly accepted. Although it is believed that G is a constant, it has not yet been firmly established. Alternative cosmological models for the Universe with time varying G are widely discussed in literature.

There is an opinion that *gravity has no established relation to other fundamental forces, so it does not appear possible to calculate it indirectly from other constants that can be measured more accurately, as is done in some other areas of physics* [Wikipedia, Gravitational constant].

In frames of our Model there are established relations between all Q-dependent, time varying parameters: G, H_0, R, ρ_{cr}, T_{MBR} (Temperature of the microwave background radiation, Section 2.5), m_a (Axion mass, Section 2.6), m_ν (Neutrino mass, Section 2.7), G_F (Fermi's coupling parameter, Section 3.7), etc.

For example, we can calculate G from the results of the T_{MBR} measurements (Section 2.5):

$$G = \frac{2\pi^3}{15\alpha}\frac{m_p}{m_e}\frac{a^2c^4}{8\pi hc}\left(\frac{k_B T_{MBR}}{hc/a}\right)^4 = 1.2100257 \times 10^{-12} T_{MBR}^4 \qquad 2.2.10$$

where $\alpha -$ fine-structure constant, $\frac{m_p}{m_e} -$ proton-electron mass ratio, $k_B -$ Boltzmann constant.

Let's proceed to calculate the value of G for different T_{MBR} :

T_{MBR}, K	$G \times 10^{11} m^3\ kg^{-1} s^{-2}$
2.7250	6.67207
2.7251	6.67305
2.7252	6.67403

Observe that the increase of accuracy of T_{MBR} measurements will increase precision of G value.

In Section 2.3 we calculated the value of the Hubble's parameter H_0 based on the value of the gravitational parameter G. Conversely, we can calculate the value of G based on the value of H_0 :

$$G = \frac{a^3c^3}{8\pi hc} H_0 = \frac{c^3}{8\pi\sigma_0} H_0 \qquad 2.2.11$$

the value of the gravitomagnetic parameter of the Medium μ_g :

$$\mu_g = \frac{4\pi G}{c^2} = \frac{c^2}{2\sigma_0}\frac{H_0}{c} = \frac{c^2}{2\sigma_0}\mu_W \qquad 2.2.12$$

and the value of the Einstein's parameter æ :

$$æ = \frac{8\pi G}{c^4} = \frac{1}{\sigma_0}\frac{H_0}{c} = \frac{1}{\sigma_0}\mu_W \qquad 2.2.13$$

where $\mu_W = \frac{H_0}{c} = \frac{1}{R}$ is the gravitomagnetic parameter of the World's Medium that has all parameters of the gravitoelectromagnetic field with dimensions of length and time only. The impedance of that Medium Z_W equals to the Hubble's parameter $H_0 = \frac{1}{t}$ for the whole World (Section 4).

H_0 and G are interchangeable! Knowing value of one, it is possible to calculate the other. While in our Model the Hubble's parameter H_0 has a clear physical meaning (Impedance of the Medium), the gravitational parameter G is the phenomenological coefficient in the Newton's law of universal gravitation and in Einstein's theory of general relativity.

In our opinion, a new fundamental parameter Q, calculated to the best matching of all measured time dependent parameters, should be introduced in the CODATA internationally recommended values. The rest of the parameters can then be calculated from Q according to the relations the current Model proposes.

2.3. The Size and the Age of the World

Let's introduce a dimensionless time-varying quantity Q:

$$Q = \frac{R}{2\pi a_0} = \frac{R}{a} \qquad 2.3.1$$

where a_0 is the classical electron radius and a is the radius of the World's Nucleus at the Beginning (Q=1):

$$a = 2\pi a_0 = 1.7705645 \times 10^{-14}\ m \qquad 2.3.2$$

Let us additionally introduce a basic unit of time t_0:

$$t_0 = \frac{a}{c} = 5.9059674 \times 10^{-23}\ s \qquad 2.3.3$$

We will subsequently use a as the basic unit of measure of length and t_0 – as the unit of time. Quantity Q is then the radius of the World measured in terms of a.

Let's introduce a length parameter L_g that is the geometric mean of the World's current radius R and its Nucleus radius a:

$$L_g = \sqrt{aR} \qquad 2.3.4$$

In our Model, L_g is a basic unit of measure of macroobjects size (Section 2.10). Let's assume that L_g satisfies the following equation:

$$2L_g L_P = a^2 \qquad 2.3.5$$

The radius of the World R is then

$$R = \frac{a^3}{4L_P^2} = a \times Q \qquad 2.3.6$$

Substituting values of a and L_P into 2.3.6 we obtain:

$$R = 1.3459 \times 10^{26}\ m \qquad 2.3.7$$

We can now calculate the age of the World A_t at current time t:

$$A_t = \frac{R}{c} = 4.4894 \times 10^{17}\ s =$$

$$= 14.226 \text{ billion years (Byr)} \quad 2.3.8$$

The age of the World calculated based on the gravitational parameter G (14.226 Byr) is somewhat greater than the commonly adopted value of 13.772 Byr.

Calculating the value of Hubble parameter H_0 based on A_t, we obtain

$$H_0 = \frac{1}{A_t} = 2.2275 \times 10^{-18}\ s^{-1} = 68.733\ \frac{km/s}{Mpc} \quad 2.3.9$$

which is in good agreement with $H_0 = 69.32 \pm 0.8\ \frac{km/s}{Mpc}$ obtained using WMAP data [Wikipedia, Hubble's Law].

From 2.3.6 we calculate the value of the dimensionless parameter Q:

$$Q = 0.76014 \times 10^{40} \quad 2.3.10$$

Parameter Q defines both the size and the age of the World: radius of the World $R = a \times Q$, and age of the World $A_t = \frac{R}{c} = t_0 \times Q$.

2.4. Critical Energy Density, Gravitational Parameter, Front Surface Enthalpy

The gravitational parameter G equals to

$$G = \frac{L_P^2 c^4}{2\pi hc} = \frac{a^2 c^4}{8\pi hc} \times Q^{-1} =$$
$$= 6.6726 \times 10^{-11}\ m^3 kg^{-1} s^{-2} \quad 2.4.1$$

Using equation 2.2.3 we calculate the value of critical energy density ρ_{cr}:

$$\rho_{cr} = \frac{3hc}{a^4} \times Q^{-1} = \rho_{cr0} \times Q^{-1} =$$
$$= 7.9773 \times 10^{-10}\ \frac{J}{m^3} \quad 2.4.2$$

ρ_{cr0} is the extrapolated energy density of the World at the Beginning:

$$\rho_{cr0} = 3\rho_0 = 6.0638901 \times 10^{30}\ \frac{J}{m^3} \quad 2.4.3$$

ρ_0 is the basic unit of energy density:

$$\rho_0 = \frac{hc}{a^4} = 2.0212967 \times 10^{30}\ \frac{J}{m^3} \quad 2.4.4$$

The gravitomagnetic parameter of the World's Medium μ_g is

$$\mu_g = \frac{4\pi G}{c^2} = \frac{a^2 c^2}{2hc} \times Q^{-1} = (2\rho_0 t_0^2)^{-1} \times Q^{-1} \quad 2.4.5$$

and the gravitoelectric parameter of the Medium ε_g is

$$\varepsilon_g = \frac{1}{\mu_g c^2} \quad 2.4.6$$

The surface enthalpy of the World – Universe Front is

$$\sigma_0 = \frac{hc}{a^3} = (\rho_0^2 E_0)^{\frac{1}{3}} = 3.5788363 \times 10^{16}\ \frac{J}{m^2} \quad 2.4.7$$

The total energy of the World E_W at current time t then equals to

$$E_W = \frac{4\pi R^2 hc}{a^3} = 4\pi E_0 \times Q^2 = 4\pi E_0 \left(\frac{A_t}{t_0}\right)^2 =$$

$$= 8.1464 \times 10^{69}\, J \qquad 2.4.8$$

where basic energy unit E_0 equals to

$$E_0 = \frac{hc}{a} = 1.1219288 \times 10^{-11}\, J = 70.025267\, MeV \qquad 2.4.9$$

The proportionality of total energy in the World to its age squared ($E_W \propto A_t^2$) was also hypothesized by Paul Dirac [8].

In our Model, Length, Time, Energy, and Energy Density are measured in units of basic length a, time t_0, energy E_0, and energy density ρ_0 respectively. All other physical characteristics are calculated in terms of these basic units.

Plugging the values of G and E_W into the formula of Schwarzschild radius,

$$R_{SH} = \frac{2GE_W}{c^4} = \frac{2}{c^4}\frac{a^2c^4}{8\pi hc} \times Q^{-1} \times 4\pi\frac{hc}{a} \times Q^2 = R \qquad 2.4.10$$

we conclude that the World is a black hole.

The hypothesis *that the universe may not only be a closed structure (as perceived by its inhabitants at the present epoch) but may also be a black hole, confined to a localized region of space which cannot expand without limit* was proposed by Raj Pathria in 1972 [9]. In our Model, the World expands in the Universe without limit, because the Universe is an unlimited source of energy.

Residing inside of a black hole, we can conduct no observations of the outside Universe, and learn nothing about its characteristics. We can only observe and measure the Universe's interaction with the World that occurs at the World – Universe Front: the temperature invariant surface enthalpy σ_0.

2.5. Microwave Background Radiation

In our Model, the World consists of stable elementary particles with lifetimes longer than the age of the World. Protons with mass m_p and energy $E_p = m_p c^2$ and electrons with mass m_e and energy $E_e = \alpha E_0$ have identical concentrations in the World: $n_p = n_e$, where E_0 is the basic energy and α is the fine-structure constant.

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

$$\omega_{pl}^2 = \frac{4\pi n_e e^2}{4\pi\varepsilon_0 m_e} = 4\pi n_e \alpha \frac{h}{2\pi m_e c} c^2 = 2n_e a c^2 \qquad 2.5.1$$

where e is the elementary charge and ε_0 is the permittivity of the Medium.

Let's choose ω_{pl} that satisfies the following equation:

$$\omega_{pl} = \frac{m_e}{m_p}\frac{2\pi c}{L_g} = \frac{m_e}{m_p} t_0^{-1} \times Q^{-\frac{1}{2}} \qquad 2.5.2$$

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

Since the formula calculating the potential energy of interaction of protons and electrons contain the same parameter k_{pe}:

$$k_{pe} = m_p \omega_{pl}^2 = m_e \left(\frac{2\pi c}{L_g}\right)^2 \tag{2.5.3}$$

we substitute $\omega_{pl}^2 = \frac{m_e}{m_p}\left(\frac{2\pi c}{L_g}\right)^2$ into 2.5.1 and calculate concentrations of protons and electrons:

$$n_p = n_e = \frac{2\pi^2}{a^3}\frac{m_e}{m_p} \times Q^{-1} \tag{2.5.4}$$

$\rho_p = n_p E_p$ is the energy density of protons in the Medium. The relative energy density of protons Ω_p is then the ratio of $\frac{\rho_p}{\rho_{cr}}$:

$$\Omega_p = \frac{\rho_p}{\rho_{cr}} = \frac{2\pi^2 \alpha}{3} = 0.048014655 \tag{2.5.5}$$

The above value is in good agreement with estimations of baryonic matter in the World $\Omega_p \cong 0.046$ [Wikipedia, Dark Matter].

From equations 2.5.1 and 2.5.4 we obtain the value of the lowest radio-wave frequency ν_{pl}:

$$\nu_{pl} = \frac{\omega_{pl}}{2\pi} = (\frac{m_e}{m_p})^{\frac{1}{2}} t_0^{-1} \times Q^{-\frac{1}{2}} = 4.5322\ Hz \tag{2.5.6}$$

Note that this value is close to the low limit of the standard Extremely low frequency band $3 \Leftrightarrow 30$ Hz [Wikipedia, Radio Spectrum].

Substituting radius of the World R obtained in 2.3.6, we use equation 2.5.4 to calculate the proton and electron concentrations in the Medium:

$$n_p = n_e = 8\pi^2 \frac{m_e}{m_p}\frac{L_P^2}{a^5} = 0.25480\ m^{-3} \tag{2.5.7}$$

which is in good agreement with their estimated concentration in the intergalactic medium $n_p \cong 0.25\ m^{-3}$ [Wikipedia, Outer space].

$\rho_e = n_e E_e$ is the energy density of electrons in the Medium. The relative energy density of electrons Ω_e is then the ratio of $\frac{\rho_e}{\rho_{cr}}$:

$$\Omega_e = \frac{\rho_e}{\rho_{cr}} = \frac{2\pi^2 \alpha}{3}\frac{m_e}{m_p} \tag{2.5.8}$$

Let's assume that the energy density of Microwave Background Radiation ρ_{MBR} is twice larger than ρ_e (due to two polarizations of photons):

$$\rho_{MBR} = 4\pi^2 \alpha \frac{m_e}{m_p}\rho_0 \times Q^{-1} = \frac{8\pi^5}{15}\frac{k_B^4}{(hc)^3} T_{MBR}^4 \tag{2.5.9}$$

where k_B is the Boltzmann constant and T_{MBR} is MBR temperature. The black body spectrum of MBR is due to thermodynamic equilibrium of photons with low density intergalactic plasma consisting of protons and electrons.

We can now calculate the value of T_{MBR}:

$$T_{MBR} = \frac{E_0}{k_B}(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p})^{\frac{1}{4}} \times Q^{-\frac{1}{4}} = 2.7250\ K \tag{2.5.10}$$

Thus, calculated value of T_{MBR} is in excellent agreement with experimentally measured value of $2.72548 \pm 0.00057\ K$ [Wikipedia, Cosmic microwave background radiation].

At the Beginning of the World, the extrapolated value of T_{MBR0} at $Q = 1$ is

$$T_{MBR0} = 2.1927 \text{ MeV} = 2.5445\times10^{10} \text{ K} \qquad 2.5.11$$

Note that T_{MBR0} is considerably smaller than values commonly discussed in literature.

Let's proceed to calculate the value of T_{MBR} at different Ages of the World A_t .

Observe that practically all macroobjects – galaxies, stars, planets, etc. – have arisen in a cold World. Our Solar system, for instance, was created when the temperature of MBR was about $3\ K$. Therefore, any Model describing creation of macroobjects must hold true in cold World conditions.

Age	T_{MBR}
1 s	6.0785 eV = 70,537 K
10^8 s ≅ 3.2 yr	705.37 K
10^{16} s ≅ 0.32 Byr	7.0537 K
3×10^{17} s ≅ 9.6 Byr (birth of Solar system)	3.0140 K
4.49×10^{17} s ≅ 14.23 Byr (present)	2.7250 K

Observe that practically all macroobjects – galaxies, stars, planets, etc. – have arisen in a cold World. Our Solar system, for instance, was created when the temperature of MBR was about $3\ K$. Therefore, any Model describing creation of macroobjects must hold true in cold World conditions.

2.6. Mass Varying Photons, Speed of Light

Photons with energy smaller than $E_{ph} = h\nu_{pl}$ cannot propagate in plasma, thus $h\nu_{pl}$ is the smallest amount of energy a photon may possess. This amount of energy can be viewed as a particle (we'll name it axion), whose frequency-independent effective "rest mass" equals to

$$m_a = \frac{E_a}{c^2} = \left(\frac{m_e}{m_p}\right)^{\frac{1}{2}} m_0 \times Q^{-\frac{1}{2}} = 3.6680 \times 10^{-20} m_e =$$

$$= 1.8743 \times 10^{-14}\ eV/c^2 \qquad 2.6.1$$

where E_a is a rest energy of the axion and m_0 is a basic unit of mass that equals to

$$m_0 = \frac{E_0}{c^2} = 70.025267\ MeV/c^2 = 1.2483143 \times 10^{-28}\ kg \qquad 2.6.2$$

The calculated mass of an axion is in agreement with $m_a \sim 10^{-15} eV/c^2$ discussed by C. Csaki *et al.* [10] and with experimental checks of Coulomb's law on photon mass m_{ph}. *A null result of such an experiment has set a limit of* $m_{ph} \lesssim 10^{-14}\ eV/c^2$. *If the photon mass is generated via the Higgs mechanism then the upper limit of* $m_{ph} \lesssim 10^{-14}\ eV/c^2$ *from the test of Coulomb's law is valid* [Wikipedia, Photon].

According to Special Relativity, energy of an axion moving with a group velocity v_{gr} is given by

$$E_a(v_{gr}) = \frac{h\nu_{pl}}{\sqrt{1-\frac{v_{gr}^2}{c^2}}} \quad 2.6.3$$

Taking into account the dispersion relation for plasma:

$$v_{gr}v_{ph} = c^2 \quad 2.6.4$$

and the value of phase velocity $v_{ph} = \frac{c}{n_{pl}}$, where n_{pl} is the index of plasma refraction,

$$n_{pl} = \sqrt{1 - \frac{\nu_{pl}^2}{\nu^2}} \quad 2.6.5$$

from equation 2.6.4 it follows that

$$\frac{v_{gr}^2}{c^2} = 1 - \frac{\nu_{pl}^2}{\nu^2} \quad 2.6.6$$

and we calculate moving axion energy $E_a(v_{gr})$ to be

$$E_a(v_{gr}) = h\nu = E_{ph} \quad 2.6.7$$

where ν is photon frequency.

In our Model, the total energy of a moving particle consists of two components: rest energy and "coat" energy. A particle's coat is the response of the Medium to the particle's movement. A photon is then a constituent axion with rest energy $E_a = h\nu_{pl}$ and total energy $E_{ph} = h\nu$. In most cases $\nu \gg \nu_{pl}$, and practically all of the photon's energy is concentrated in the axion's coat that is the part of the Medium surrounding the axion. Axions are fully characterized by their four-momentum.

Rest energy of the axion is decreasing with time: $E_a \propto t^{-\frac{1}{2}}$ (see 2.6.1), and total energy remains constant in the ideal frictionless Medium (Section 2.19).

The higher the photon's energy, the closer its speed approaches c. But the fact that axions possess non-zero rest masses means that photons can never reach that speed.

2.7. Mass Varying Neutrinos, Distribution of the World's Energy Density

It is now established that there are at least three different types of neutrinos: electronic ν_e, muonic ν_μ, and tauonic ν_τ, and their antiparticles. Pontecorvo and Smorodinskii discussed the possibility of energy density of neutrinos exceeding that of baryonic matter [11]. Neutrino oscillations imply that neutrinos have non-zero masses.

Let's take neutrinos masses m_{ν_e}, m_{ν_μ}, m_{ν_τ} that are near

$$m_\nu = m_0 \times Q^{-\frac{1}{4}} \cong 7.5 \times 10^{-3}\ eV/c^2 \quad 2.7.1$$

Their concentrations n_ν are then proportional to

$$n_\nu \propto \frac{1}{a^3} \times Q^{-\frac{3}{4}} = \frac{1}{L_F^3} \quad 2.7.2$$

where Fermi length parameter L_F

$$L_F = a \times Q^{\frac{1}{4}} \quad 2.7.3$$

is a characteristic of neutrino density (2.7.2), and also of critical energy density:

$$\rho_{cr} = \frac{3hc}{L_F^4} \tag{2.7.4}$$

Energy densities of neutrinos are proportional to Q^{-1}, and consequently to $\frac{1}{R}$, since critical energy density ρ_{cr} is proportional to $\frac{1}{R}$.

Experimental results obtained by M. Sanchez [12] show $\nu_e \to \nu_{\mu,\tau}$ neutrino oscillations with parameters given by

$$2.3 \times 10^{-5}\ eV^2/c^4 \leq \Delta m_{sol}^2 \leq 9.3 \times 10^{-5}\ eV^2/c^4 \tag{2.7.5}$$

and $\nu_\mu \to \nu_\tau$ neutrino oscillations with parameters

$$1.6 \times 10^{-3}\ eV^2/c^4 \leq \Delta m_{atm}^2 \leq 3.9 \times 10^{-3}\ eV^2/c^4 \tag{2.7.6}$$

where Δm_{sol}^2 and Δm_{atm}^2 are mass splitting for solar and atmospheric neutrinos respectively.

Significantly more accurate results were obtained by P. Kaus *et al.* [13] for the following ratio:

$$\sqrt{\frac{\Delta m_{sol}^2}{\Delta m_{atm}^2}} \cong 0.16 \tag{2.7.7}$$

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

$$m_{\nu_\mu} = m_\nu = m_0 \times Q^{-\frac{1}{4}} \cong 7.5 \times 10^{-3}\ eV/c^2 \tag{2.7.8}$$

From equation 2.7.7 it then follows that

$$m_{\nu_\tau} = 6m_\nu \cong 4.5 \times 10^{-2}\ eV/c^2 \tag{2.7.9}$$

Based on equation for Fermi Coupling Parameter G_F (Section 3.7),

$$m_{\nu_e} = \frac{1}{24} m_\nu \cong 3.1 \times 10^{-4}\ eV/c^2 \tag{2.7.10}$$

Then the squared values of the muonic and tauonic masses fall into ranges 2.7.5 and 2.7.6:

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

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

2.7.11

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

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

$$i = e, \mu, \tau \tag{2.7.12}$$

we obtain the following neutrino energy densities in accordance with theoretical calculations made by L. D. Landau and E. M. Lifshitz [14]:

$$\rho_{\nu i} = \frac{8\pi c}{h^3} \int_0^{p_F} p^2 \sqrt{p^2 + m_{\nu i}^2 c^2}\, dp =$$

$$= \frac{2\pi(p_F c)^4}{(hc)^3} \times F(x_{\nu i}) \qquad 2.7.13$$

where p_F is Fermi momentum,

$$F(x_{\nu i}) = \frac{x_{\nu i}^{\frac{1}{2}}(2x_{\nu i}+1)(x_{\nu i}+\frac{1}{2})^{\frac{1}{2}} - ln\left[x_{\nu i}^{\frac{1}{2}} + (x_{\nu i}+1)^{\frac{1}{2}}\right]}{2x_{\nu i}^2} \qquad 2.7.14$$

$$x_{\nu i} = (\frac{p_F}{m_{\nu i}c})^2 \qquad 2.7.15$$

$$m_{\nu i} = A_i m_0 \times Q^{-\frac{1}{4}} \qquad 2.7.16$$

$$A_i = \frac{1}{24};\ 1;\ 6 \qquad 2.7.17$$

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

$$p_F^2 = \frac{h^2}{2\pi^2 L_F^2} = \frac{h^2}{2\pi^2 a^2} \times Q^{-\frac{1}{2}} = p_0^2 \times Q^{-\frac{1}{2}} \qquad 2.7.18$$

where $p_0^2 = \frac{h^2}{2\pi^2 a^2}$ is the extrapolated value of p_F at the Beginning when $Q = 1$. As a side note, the equation for surface enthalpy of the World – Universe Front σ_0 can be rewritten as $\sigma_0 a_0^2 = \frac{p_0^2}{2m_0}$.

Using 2.7.13, we obtain neutrino relative energy densities $\Omega_{\nu i}$ in the Medium in terms of the critical energy density ρ_{cr}:

$$\Omega_{\nu i} = \frac{\rho_{\nu i}}{\rho_{cr}} = \frac{1}{6\pi^3} F(y_{\nu i}) \qquad 2.7.19$$

where

$$y_{\nu i} = (2\pi^2 A_i^2)^{-1} \qquad 2.7.20$$

It's commonly accepted that concentrations of all types of neutrinos are equal. This assumption allows us to calculate the total neutrino relative energy density in the Medium:

$$\Omega_\nu = \frac{\rho_\nu}{\rho_{cr}} = \frac{\rho_{\nu e} + \rho_{\nu \mu} + \rho_{\nu \tau}}{\rho_{cr}} = 0.45801647 \qquad 2.7.21$$

One of the principal ideas of World – Universe Model holds that energy densities of Medium particles are proportional to proton energy density in the World's Medium (2.5.5):

$$\Omega_p = \frac{2\pi^2 \alpha}{3} = 0.048014655 \qquad 2.7.22$$

Let's take $\Omega_\nu = \frac{30}{\pi}\Omega_p$. We obtain

$$\Omega_\nu = 20\pi\alpha = 0.45850618 \qquad 2.7.23$$

which is close to the value calculated in 2.7.21 (the difference is $\cong 0.1\%$). The slight increase of neutrinos energy density can be attributed to the additional temperature-dependent part of neutrinos energy density at the Medium temperature $T_M > 0$: $T_M = T_{MBR} = 2.7250\ K$.

The electron relative energy density in the Medium Ω_e is

$$\Omega_e = \frac{m_e}{m_p}\Omega_p \qquad 2.7.24$$

The sum of MBR photons, black body radiation from cosmic dust, X-rays, and Gamma rays relative energy densities (Section 2.9) is

$$\Omega_{rad} = \left(\frac{8}{3} + \frac{2}{15\pi}\right)\Omega_e \qquad 2.7.25$$

Dark Matter (DM) energy density in the Medium (Section 2.9) is

$$\Omega_{DM} = \frac{10}{3}\Omega_p \qquad 2.7.26$$

The total Medium relative energy density Ω_M then equals to

$$\Omega_M = \Omega_p + \Omega_e + \Omega_{rad} + \Omega_\nu + \Omega_{DM} =$$

$$= \left[\frac{13}{3} + \left(\frac{11}{3} + \frac{2}{15\pi}\right)\frac{m_e}{m_p} + \frac{30}{\pi}\right]\Omega_p = \frac{2}{3} \qquad 2.7.27$$

Let's recall that equation 2.2.3 contains the gravitomagnetic parameter of the World's Medium $\mu_g = \frac{4\pi G}{c^2}$ multiplied by $\frac{2}{3}\rho_{cr}$. It follows that the World's Medium has energy density $\rho_M = \frac{2}{3}\rho_{cr}$, and the remaining energy $E_{MO} = \frac{1}{3}\rho_{cr}V_W$ resides in the World's macroobjects (galaxies, stars, planets, cosmic dust, etc.). The World relative energy density Ω_W is then

$$\Omega_W = 1.5\Omega_M = 1 \qquad 2.7.28$$

The obtained result means that the calculated energy density of the World ρ_W equals to the critical energy density ρ_{cr} that is in accordance with the principal idea of our Model (Section 2.2).

The total neutrinos energy density (in the Medium and in macroobjects) equals to

$$\Omega_{\nu tot} = \frac{45}{\pi}\Omega_p = 0.68775927 \qquad 2.7.29$$

The total Dark Matter energy density is

$$\Omega_{DMtot} = 5\Omega_p = 0.24007327 \qquad 2.7.30$$

The total baryonic energy density Ω_B is

$$\Omega_B = 1.5\Omega_p = 0.072021982 \qquad 2.7.31$$

To summarize:

- The World's energy density is proportional to Q^{-1};
- The particles relative energy densities are proportional to α;
- The total neutrinos energy density is almost 10 times greater than baryonic energy density, and about 3 times greater than Dark Matter energy density.

2.8. Fine-Structure Constant

The mystery about α is actually a double mystery. The first mystery - the origin of its numerical value ≈ 1/137 has been recognized and discussed for decades. The second mystery – the range of its domain – is generally unrecognized.

Malcolm H. Mac Gregor

The Fine-structure constant (FSC) α is a fundamental physical constant. Wikipedia has this to say about the FSC [Fine-structure constant]:

Arnold Sommerfeld introduced the Fine-Structure Constant in 1916, as part of his theory of the relativistic deviations of atomic spectral lines from the predictions of the Bohr model. The first physical interpretation of the fine-structure constant α *was as the ratio of the velocity of the electron in the first circular orbit of the relativistic Bohr atom to the speed of light in vacuum. Equivalently, it was the quotient between the maximum angular momentum allowed by relativity for a closed orbit, and the minimum angular momentum allowed for it by the quantum mechanics. It appears naturally in Sommerfeld's analysis and determines the size of the splitting or fine-structure of the hydrogenic spectral lines.*

The fine-structure constant α *has several physical interpretations.* α *is:*

- *The square of* α *is the ratio between the Hartree energy (27.2 eV = twice the Rydberg energy) and the electron rest mass (511 keV);*
- *The ratio of three characteristic lengths: the classical electron radius* a_0*, the Bohr radius* a_B *and the Compton wavelength of electron* L_{ce} *over 2π:* $a_0 = \frac{\alpha L_{ce}}{2\pi} = \alpha^2 a_B$;
- *The ratio of the electromagnetic impedance of the free space* $\frac{1}{\varepsilon_0 c} \cong 377\ \Omega$*, to the quantum of Resistance,* $\frac{h}{e^2} \approx 25.8\ k\Omega$ *is* 2α*, etc.*

The Fine-structure constant α plays a central role in the World – Universe Model.

Recall that by definition, the classical radius of an electron a_0 is

$$a_0 = \frac{e^2}{4\pi\varepsilon_0 m_e c^2} \tag{2.8.1}$$

Using the following equation:

$$\frac{e^2}{4\pi\varepsilon_0} = \frac{2\pi a_0}{L_{ce}}\frac{hc}{2\pi} = \alpha\frac{hc}{2\pi} \tag{2.8.2}$$

we can conclude that α is really the ratio of the classical electron radius to the electron Compton length over *2π*.

Equivalently, α is the rest mass of an electron m_e measured in terms of basic units m_0

$$m_0 = \frac{h}{ac} = 70.025267\ MeV/c^2 \tag{2.8.3}$$

which is related to the basic energy unit E_0:

$$E_0 = m_0 c^2 \tag{2.8.4}$$

Masses of all stable elementary particles of the World can be expressed in terms of m_0 as follows:

$$m_e = \alpha m_0$$

$$m_p = \beta m_0$$

$$m_a = (\frac{\alpha}{\beta})^{\frac{1}{2}} m_0 \times Q^{-\frac{1}{2}}$$

$$m_\nu = m_0 \times Q^{-\frac{1}{4}} \tag{2.8.5}$$

$\beta = 13.399053$ is the ratio of proton mass m_p to the basic mass m_0. The ratio of the electron mass to the proton mass can then be expressed as follows:

$$\frac{m_e}{m_p} = \frac{\alpha}{\beta} \qquad 2.8.6$$

Additionally, m_0 plays a key role when masses of Dark Matter particles are discussed in the next Section.

2.9. Dark Matter Particles

Dark Matter (DM) is among the most important open problems in both cosmology and particle physics.

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

The most widely discussed models for nonbaryonic DM are based on the CDM hypothesis, and corresponding particles are most commonly assumed to be Weakly Interacting Massive Particles (WIMPs) [Wikipedia, Dark matter].

A neutralino with mass m_N *in* $100 \Leftrightarrow 10{,}000\ GeV/c^2$ *range is the leading DM candidate* [Wikipedia, Neutralino]. *Light Dark Matter Particles that are heavier than WDM and HDM but lighter than the traditional forms of CDM (neutralino) are DM candidates too. Their masses* m_{WIMP} *fall into* $1 \Leftrightarrow 10\ GeV/c^2$ *range* [Wikipedia, Light dark matter]. Subsequently, we will refer to the light dark matter particles as WIMPs.

It is known that a sterile neutrino with mass m_{ν_s} *in* $1 \Leftrightarrow 10\ keV/c^2$ *range is a good WDM candidate* [Wikipedia, Warm dark matter]. *The best candidate for the identity of HDM is neutrino* [Wikipedia, Hot dark matter]. In our opinion, a tauonic neutrino is a good HDM candidate.

In addition to fermions discussed above, we offer another type of Dark Matter particles – bosons, consisting of two fermions each. There are two types of Dark Matter bosons: DIRACs possessing mass of m_0 that are in fact magnetic dipoles, and ELOPs having mass of $\frac{2}{3}m_e$ – preon dipoles.

Dissociated DIRACs can only exist at nuclear densities or at high temperatures. A DIRAC breaks into two Dirac monopoles with mass $\frac{m_0}{2}$ and charge $\mu = \frac{e}{2\alpha}$ (Section 3.2). In our opinion, these monopoles are the smallest building blocks of fractal structure of constituent quarks and hadrons (mesons and baryons).

Over 60 years ago, Y. Nambu proposed an empirical mass spectrum of elementary particles with a mass unit close to one quarter of the mass of a pion $\cong \frac{m_0}{2}$ (Section 3.5).

ELOPs break into two preons whose mass m_{pr} equals to one third of an electron's mass:

$$m_{pr} = \frac{1}{3}m_e = 170.33303\ keV/c^2 \qquad 2.9.1$$

and charge e_{pr} – to one third of an electron's charge:

$$e_{pr} = \frac{1}{3}e \qquad 2.9.2$$

Preons are the smallest building blocks of a fractal structure of quarks and leptons.

According to Wikipedia [Preon]: *In particle physics, preons are postulated "point-like" particles, conceived to be subcomponents of quarks and leptons* [15].

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 levels of different nuclei including low-spin levels observed in (γ, γ) and (n, γ) reactions. In this work we show such tuning effect in numerous levels from new compilation for light nuclei. Together with long-range correlations in nuclear binding energies they provide a support for the observed correlation between masses of hadrons and leptons (including masses of nucleons and m_e *).*

We did not take into account the binding energies of DIRACs and ELOPs, and thus the values of their masses are approximate. They have negligible electrostatic and electromagnetic charges because the separation between charges is very small. They do however possess electrostatic and electromagnetic dipole momentum (Section 3.2).

In our Model, DM particle masses are proportional to m_0 multiplied by different exponents of α. Consequently, we can predict the masses of various types of DM particles:

CDM particles (Neutralinos and WIMPs):

$$m_N = \alpha^{-2} m_0 = 1.3149950\ \ TeV/c^2 \qquad 2.9.3$$

$$m_{WIMP} = \alpha^{-1} m_0 = 9.5959823\ \ GeV/c^2 \qquad 2.9.4$$

DIRACs:

$$m_{DIRAC} = 2\alpha^0 \frac{m_0}{2} = 70.025267\ \ MeV/c^2 \qquad 2.9.5$$

ELOPs:

$$m_{ELOP} = 2\alpha^1 \frac{m_0}{3} = 340.66606\ \ keV/c^2 \qquad 2.9.6$$

WDM particles (sterile neutrinos):

$$m_{\nu_s} = \alpha^2 m_0 = 3.7289402\ \ keV/c^2 \qquad 2.9.7$$

These values fall into the ranges estimated in literature.

Our Model holds that the energy densities of all types of DM particles are proportional to the proton energy density in the World's Medium:

$$\rho_p = \frac{2\pi^2\alpha}{3}\rho_{cr} \qquad 2.9.8$$

In all, there are 5 different types of DM particles. Then the total energy density of DM is

$$\rho_{DM} = 5\rho_p = 0.24007327\rho_{cr} \qquad 2.9.9$$

which is close to the DM energy density discussed in literature: $\rho_{DM} \cong 0.23\ \rho_{cr}$ [Wikipedia, Dark Matter].

The total neutrino energy density (in the Medium and in macroobjects, Section 2.7) equals to

$$\rho_{\nu tot} = \frac{45}{\pi}\rho_p \qquad 2.9.10$$

The total baryonic energy density ρ_B is:

$$\rho_B = 1.5\rho_p \qquad 2.9.11$$

The sum of MBR photons, black body radiation from cosmic dust, X-rays, and Gamma rays energy densities equals to

$$\rho_{rad} = (4 + \frac{1}{5\pi})\frac{\alpha}{\beta}\rho_p \qquad 2.9.12$$

We chose the above value of ρ_{rad} so that the energy density of the World ρ_W equals to the theoretical critical energy density ρ_{cr} in accordance with the principal idea of our Model:

$$\rho_W = \left[\frac{13}{2} + \left(\frac{11}{2} + \frac{1}{5\pi}\right)\frac{\alpha}{\beta} + \frac{45}{\pi}\right]\rho_p = \rho_{cr} \qquad 2.9.13$$

From equation 2.9.13 we can calculate the value of the FSC, using electron-to-proton mass ratio

$$\frac{1}{\alpha} = \frac{\pi}{15}\left[450 + 65\pi + (55\pi + 2)\frac{m_e}{m_p}\right] = 137.03600 \qquad 2.9.14$$

which is in an excellent agreement with the commonly adopted value of 137.035999074(44).

It follows that there are direct correlations between constants α, β, and $\frac{m_e}{m_p}$ expressed by equation of the total energy density of the World (2.9.13).

As shown above, β and $\frac{m_e}{m_p}$ are not independent constants, but are instead derived from α. We will, however, continue to use β for convenience.

The main suggestion for experimentalists dealing with observations of Dark Matter is to concentrate their efforts on particles possessing masses shown above.

2.10. Macroobject Cores Built Up From Fermionic Dark Matter

According to Wikipedia [Compact star]: *In astronomy, the term Compact Star (sometimes compact object) is used to refer collectively to white dwarfs, neutron stars, other exotic dense stars, and black holes. The term compact star is often used when the exact nature of the star is not known, but evidence suggests that it is very massive and has a small radius.*

In this section, we discuss the possibility of all macroobject cores consisting of Dark Matter particles introduced in Section 2.9. In our view, all macroobjects of the World (including galaxy clusters, galaxies, star clusters, extrasolar systems, and planets) possess the following properties:

- Macroobject cores are made up of DM particles;
- Macroobjects consist of all particles under consideration, in the same proportion as they exist in the World's Medium;
- Macroobjects contain other particles, including DM and baryonic matter, in shells surrounding the cores.

The first phase of stellar evolution in the history of the World may be dark stars, powered by Dark Matter heating rather than fusion. Neutralinos and WIMPs, which are their own antiparticles, can annihilate and provide an important heat source for the stars and planets in the World.

Taking into account the main principle of the World – Universe Model (all equations should contain α, β, Q, small integer numbers and π) we modify the published theory of fermionic compact stars developed by G. Narain *et al.* [17] as follows. We'll take a scaling solution for a free Fermi gas consisting of fermions with mass m_f in accordance with following equations:

Maximum mass: $M_{max} = A_1 M_F$; 2.10.1

Minimum radius: $R_{min} = A_2 R_F$; 2.10.2

Maximum density: $\rho_{max} = A_3 \rho_0$ 2.10.3

where

$$M_F = \frac{M_P^3}{m_f^2}; \;\; R_F = \frac{M_P}{m_f}\frac{L_{cf}}{2\pi}; \;\; \rho_0 = \frac{hc}{a^4} \qquad 2.10.4$$

and L_{Cf} is a Compton length of the fermion. A_1, A_2, and A_3 are parameters.

Let us choose π as the value of A_2 (instead of $A_2 = 3.367$ taken by G. Narain *et al.* [17]). Then diameter of CS is proportional to the fermion Compton length L_{Cf}. We use $\frac{\pi}{6}$ as the value of A_1 (instead of $A_1 = 0.384$ taken by G. Narain *et al.* [17]). Then A_3 will equal to

$$A_3 = (\frac{m_f}{m_0})^4 \qquad 2.10.5$$

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

Table 1

Fermion	Fermion relative mass m_f/m_0	Macroobject relative mass M_{max}/M_0	Macroobject relative radius R_{min}/L_g	Macroobject relative density ρ_{max}/ρ_0
Muonic neutrino	$Q^{-\frac{1}{4}}$	$Q^{\frac{1}{2}}$	$Q^{\frac{1}{2}}$	Q^{-1}
Tauonic neutrino	$6 \times Q^{-\frac{1}{4}}$	$6^{-2} \times Q^{\frac{1}{2}}$	$6^{-2} \times Q^{\frac{1}{2}}$	$6^4 \times Q^{-1}$
Sterile neutrino	α^2	α^{-4}	α^{-4}	α^8
Preon	$3^{-1}\alpha^1$	$3^2\alpha^{-2}$	$3^2\alpha^{-2}$	$3^{-4}\alpha^4$
Electron-proton (white dwarf)	α^1, β	β^{-2}	$(\alpha\beta)^{-1}$	$\alpha^3\beta$
Monopole	2^{-1}	2^2	2^2	2^{-4}
WIMP	α^{-1}	α^2	α^2	α^{-4}
Neutralino	α^{-2}	α^4	α^4	α^{-8}
Interacting WIMPs	α^{-1}	β^{-2}	β^{-2}	β^4
Interacting neutralinos	α^{-2}	β^{-2}	β^{-2}	β^4
Neutron (star)	$\approx \beta$	β^{-2}	β^{-2}	β^4

where

$$M_0 = \frac{4\pi m_0}{3} \times Q^{\frac{3}{2}} \qquad 2.10.6$$

$$L_g = a \times Q^{\frac{1}{2}} \qquad 2.10.7$$

The maximum density of neutron stars equals to the nuclear density

$$\rho_{max} = (\frac{m_p}{m_0})^4 \rho_0 = \beta^4 \rho_0 \qquad 2.10.8$$

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

A Compact Star made up of heavier particles – WIMPs and neutralinos – could in principle have a much higher density. In order for such a star to remain stable and not exceed the nuclear density, WIMPs and neutralinos must partake in an annihilation interaction whose strength equals to $\frac{1}{\alpha}$ and $\frac{1}{\alpha^2}$ respectively.

Scaling solution for interacting WIMPs can also be described with equations 2.10.1 – 2.10.3 and the following values of A_1, A_2 and A_3:

$$A_{1max} = \frac{\pi}{6}(\alpha\beta)^{-2} \tag{2.10.9}$$

$$A_{2min} = \pi(\alpha\beta)^{-2} \tag{2.10.10}$$

$$A_{3max} = \beta^4 \tag{2.10.11}$$

The maximum mass and minimum radius increase about two orders of magnitude each and the maximum density equals to nuclear density. Note that parameters of a CS made up of strongly interacting WIMPs are identical to those of neutron stars.

In accordance with the paper by G. Narain *et al.* [17], the most attractive feature of the strongly interacting Fermi gas of WIMPs is practically constant value of CS minimum radius in the large range of masses M_{WIMP} from

$$M_{WIMPmax} = \frac{\pi}{6}(\alpha\beta)^{-2}M_F = \frac{1}{\beta^2}M_0 \tag{2.10.12}$$

down to

$$M_{WIMPmin} = \alpha^4 M_{WIMPmax} \tag{2.10.13}$$

$M_{WIMPmin}$ is more than eight orders of magnitude smaller than $M_{WIMPmax}$. It makes strongly interacting WIMPs good candidates for stellar and planetary cores (Sections 2.14, 2.16).

When the mass of a CS made up of WIMPs is much smaller than the maximum mass, the scaling solution yields the following equation for parameters A_1 and A_2:

$$A_1 A_2^3 = \pi^4 \tag{2.10.14}$$

Compare $\pi^4 \cong 97.4$ with the value of 91 used by G. Narain *et al.* [17].

Minimum mass and maximum radius take on the following values:

$$A_{1min} = \frac{\pi}{6}\sqrt{6}(\alpha\beta)^2 \tag{2.10.15}$$

$$A_{2max} = \pi\sqrt[6]{6}(\alpha\beta)^{-\frac{2}{3}} \tag{2.10.16}$$

It follows that the range of stellar masses ($A_{1min} \Leftrightarrow A_{1max}$) spans about three orders of magnitude, and the range of star core radii ($A_{2min} \Leftrightarrow A_{2max}$) – one order of magnitude. It makes WIMPs good candidates for brown dwarf cores too (Section 2.15).

Scaling solution for interacting neutralinos can be described with the same equations (2.10.1 – 2.10.3) and the following values of A_1^*, A_2^* and A_3^*:

$$A_{1max}^* = \frac{\pi}{6}(\alpha^2\beta)^{-2} \tag{2.10.17}$$

$$A_{2min}^* = \pi(\alpha^2\beta)^{-2} \tag{2.10.18}$$

$$A^*_{3max} = \beta^4 \quad 2.10.19$$

In this case, the maximum mass and minimum radius increase about four orders of magnitude each and the maximum density equals to the nuclear density. Note that parameters of a CS made up of strongly interacting neutralinos are identical to those of neutron stars.

Practically constant value of CS minimum radius takes place in the huge range of masses M_N from

$$M_{Nmax} = \frac{\pi}{6}(\alpha\beta)^{-2}\alpha^2 M_F = \frac{1}{\beta^2} M_0 \quad 2.10.20$$

down to

$$M_{Nmin} = \alpha^8 M_{Nmax} \quad 2.10.21$$

M_{Nmin} is more than seventeen orders of magnitude smaller than M_{Nmax}. It makes strongly interacting neutralinos good candidates for stellar and planetary cores (Sections 2.14, 2.16).

When the mass of a CS made up of neutralinos is much smaller than the maximum mass, the scaling solution yields the following equation for parameters A^*_1 and A^*_2:

$$A^*_1 {A^*_2}^3 = \pi^4 \quad 2.10.22$$

Minimum mass and maximum radius take on the following values:

$$A^*_{1min} = \frac{\pi}{6}\sqrt{6}(\alpha^2\beta)^2 \quad 2.10.23$$

$$A^*_{2max} = \pi\sqrt[6]{6}(\alpha^2\beta)^{-\frac{2}{3}} \quad 2.10.24$$

It means that the range of stellar masses ($A^*_{1min} \Leftrightarrow A^*_{1max}$) is about twelve orders of magnitude, and the range of star core radiuses ($A^*_{2min} \Leftrightarrow A^*_{2max}$) is about four orders of magnitude.

The numerical values for CS masses and radii will be given in Section 2.11.

Fermionic Compact Stars (FCS) have the following properties:

- The maximum potential of interaction U_{max} between any particle or macroobject and FCS made up of any fermions

  $$U_{max} = \frac{GM_{max}}{R_{min}} = \frac{c^2}{6} \quad 2.10.25$$

  does not depend on the nature of the fermions;

- The minimum radius of FCS made of any fermion

  $$R_{min} = 3R_{SH} \quad 2.10.26$$

  equals to three Schwarzschild radii and does not depend on the nature of the fermion;

- FCS density does not depend on M_{max} and R_{min} and does not change in time while $M_{max} \propto t^{\frac{3}{2}}$ and $R_{min} \propto t^{\frac{1}{2}}$.

Boson stars made up of bosonic DM are discussed in literature (see, for example, the paper by J. Ho *et al.* [18]) as an alternative to black holes. Axions with mass m_a introduced in Section 2.6. are good candidates for such compact macroobjects:

$$m_a = (\frac{\alpha}{\beta})^{\frac{1}{2}} m_0 \times Q^{-\frac{1}{2}} \quad 2.10.27$$

We calculate maximum mass M_{Bmax}, minimum radius R_{Bmin}, and maximum density ρ_{Bmax}:

$$M_{Bmax} \sim \frac{M_P^2}{m_a} = 4\left(\frac{\beta}{\alpha}\right)^{\frac{1}{2}} m_0 \times Q^{\frac{3}{2}} = \frac{3}{\pi}\left(\frac{\beta}{\alpha}\right)^{\frac{1}{2}} M_0 \qquad 2.10.28$$

$$R_{Bmin} \sim \frac{h}{m_a c} = \left(\frac{\beta}{\alpha}\right)^{\frac{1}{2}} L_g \qquad 2.10.29$$

$$\rho_{Bmax} \sim \frac{\alpha}{\beta}\rho_0 \qquad 2.10.30$$

Boson stars made up of axions are good candidates for the cores of star clusters. These stars have a constant density in time, similar to fermionic compact stars.

2.11. Fractal Cosmology

All attempts to explain the workings of the universe without recognizing the existence of the ether and the indispensable function it plays in the phenomena are futile and destined to oblivion.

There is no energy in matter other than that received from the environment.

Nikola Tesla

Yu. Baryshev and P. Teerikorpi have this to say about fractal cosmology [19]:

A fundamental task of practical cosmology is to study how matter is distributed in space and how it has evolved in cosmic time. The discovery of the strongly inhomogeneous spatial distribution of galaxies, at scales from galaxies to Superclusters, i.e. over four orders of magnitude in scale, was of profound cosmological significance.

The debate on the fractality of the large scale galaxy distribution has been going on around two new fundamental empirical cosmic numbers, - the fractal dimension D, which determines the global mass-radius behavior of the Universe:

$$M(r) \propto r^D \qquad 2.11.1$$

and the bordering scale where fractality transforms into homogeneity R_{hom}*. Their values have been debated, and D = 1.2 indirectly deduced from angular catalogues has been replaced by* $D = 2.2 \pm 0.2$ *obtained from 3-d maps. The discussion of galaxy clustering started from scales 1 Mpc – 10 Mpc, then observations of the large scale structure have shifted to the scales of 10 Mpc – 100 Mpc, and now we are entering gigantic scales of 100 Mpc – 1000 Mpc.*

In the realm of physics real structures usually have a lower scale R_{min} *and an upper scale* R_{max} *between which the physical system follows fractal self-similar behavior. These scales are called lower and upper cutoffs.*

For different cosmological problems there could be different choices of the lower cutoff: dark matter clumps of $(10^6 - 10^8)M_{Sun}$*, stars, comet-size objects, atoms, elementary particles.*

The upper cutoff presents a much more complicated problem in studies of the galaxy distribution. Is there an upper cutoff for the large-scale galaxy distribution and what is its value? These are the primary questions around which the most acute discussion is going on.

The fractal mass-radius law of galaxy clustering has become a key phenomenon in observational cosmology. It creates novel challenges for theoretical understanding of the origin and evolution of the galaxy distribution, including the role of dark matter.

Walls and filaments are the largest known structures in the World. The Great Wall is a sheet of galaxies more than 500 million light-years long and 200 million wide (but only 15 million light-years thick). The Sloan Great Wall is up to 1.5 billion light-years across. On January 11, 2013, a large quasar group, the Huge-LOG, was discovered. It was measured to be four billion light-years across, and is presently the largest known structure in the World [Wikipedia, Observable universe].

In astronomy, voids are the vast empty spaces between filaments (the largest-scale structures in the Universe), which contain very few, or no, galaxies [Wikipedia, Void (astronomy)]. A Supervoid in the constellation Eridanus is possibly a billion light-years across. In our opinion, voids are the Medium of the World in its purest.

Superclusters are largest known grouping of galaxies. The Local Supercluster (Virgo Supercluster), for example, contains over 47,000 galaxies, is about 10^{24} m across and weighs $\sim 10^{17}$ solar masses (10^{47} kg) [Wikipedia, Supercluster];

Galaxy clusters contain 50 to 1,000 galaxies. Galaxy clusters have diameters of $\sim 10^{23}$ m and total masses of 10^{14} to 10^{15} solar masses ($10^{44} \Leftrightarrow 10^{45}$) kg [Wikipedia, Galaxy cluster];

Groups of galaxies typically contain no more than 50 galaxies, and have a diameter of $\sim 10^{22}$ m and weigh in at $\sim 10^{13}$ solar masses ($\sim 10^{43}$ kg) [Wikipedia, Galaxy groups and clusters];

Galaxies range from dwarfs with as few as 10^{7} stars to giants containing 10^{14} stars, each orbiting their galaxy's own center of mass. There are more than 1.7×10^{11} galaxies in the World. Most galaxies are 3,000 to 300,000 light-years in diameter. Galaxies are usually separated by distances on the order of 3 million light-years. Ultra-compact dwarf galaxies have recently been discovered that are only 300 light-years across [Wikipedia, Galaxy].

Two types of Star Clusters can be distinguished: globular clusters are tight groups of hundreds of thousands of very old stars which are gravitationally bound, while open clusters, more loosely clustered groups of stars, generally contain fewer than a few hundred members, and are often very young [Wikipedia, Star cluster].

Extrasolar systems range from brown dwarfs with minimum mass of about 0.013 solar masses ($2.6 \times 10^{28}\ kg$) [Wikipedia, List of least massive stars], red dwarfs with the minimum mass about of 0.075 solar masses ($1.5 \times 10^{29}\ kg$) [Wikipedia, Red dwarf], to giant stars that are 150 times as massive as the Sun ($3 \times 10^{32}\ kg$) [Wikipedia, Star].

The following **Table** summarizes the various macroobjects:

Macroobject	Size (m)	Mass (kg)
World	10^{26}	3×10^{52}
Walls, Filaments	$10^{24} \Leftrightarrow 10^{25}$	$10^{48} \Leftrightarrow 10^{51}$
Supercluster	10^{24}	$10^{47} \Leftrightarrow 10^{48}$
Galaxy cluster	10^{23}	$10^{45} \Leftrightarrow 10^{47}$
Group of galaxies	10^{22}	$10^{43} \Leftrightarrow 10^{45}$
Galaxy	$10^{19} \Leftrightarrow 10^{21}$	$10^{38} \Leftrightarrow 10^{43}$
Star cluster	$10^{17} \Leftrightarrow 10^{18}$	$10^{33} \Leftrightarrow 10^{38}$
Extrasolar system	$10^{14} \Leftrightarrow 10^{16}$	$10^{28} \Leftrightarrow 10^{33}$

According to World – Universe Model, the total macroobject energy E_{MO} enclosed in surface S_{MO} is proportional to the area of that surface:

$$E_{MO} = \sigma_0 S_{MO} \qquad 2.11.2$$

where σ_0 is the surface enthalpy defined in Section 2.4. All the energy contained in macroobjects was received from the environment.

In case when the stars and galaxies are distributed in a hierarchy of spherical clusters of radius R_{MO}, the energy E_{MO} equals to

$$E_{MO} = 4\pi\sigma_0 R_{MO}^2 \qquad 2.11.3$$

Comparing this result with equation 2.11.1 we conclude that the World has a fractal structure with the theoretical fractal dimension $D = 2$, which is in good agreement with the value of $D = 2.2 \pm 0.2$ experimentally obtained by P. Teerikorpi *et al.* [20]. Note that the Olbers' paradox (dark night sky) can be explained only if the fractal dimension of the World $D \leq 2$ [Wikipedia, Olbers' paradox].

The upper cutoff of the fractal structure is the entire World, with its total mass of M_W and radius $R = R_{hom}$:

$$M_W = \frac{4\pi\sigma_0}{c^2} R^2 = 4\pi m_0 \times Q^2 = 9.0640 \times 10^{52}\, kg \qquad 2.11.4$$

$$R = a \times Q = 1.3459 \times 10^{26}\, m \qquad 2.11.5$$

The lower cutoff of the fractal structure is an extrasolar system (ESS) with total mass M_{ESS}, radius R_{ESS}, and number N_{ESS} in the following ranges:

$$M_{ESS} = 4\pi m_0 \times Q^{\frac{3}{2}} \times \left(Q^{-\frac{1}{8}} \Leftrightarrow 1\right) =$$

$$(1.0759 \times 10^{28} \Leftrightarrow 1.0396 \times 10^{33})\, kg \qquad 2.11.6$$

$$R_{ESS} = a \times Q^{\frac{3}{4}} \times \left(Q^{-\frac{1}{16}} \Leftrightarrow 1\right) =$$

$$(4.6367 \times 10^{13} \Leftrightarrow 1.4414 \times 10^{16})\, m \qquad 2.11.7$$

$$N_{ESS} \sim Q^{\frac{1}{2}} \times \left(1 \Leftrightarrow Q^{\frac{1}{8}}\right) \sim (10^{20} \Leftrightarrow 10^{25}) \qquad 2.11.8$$

N_{ESS} is the total number of extrasolar systems in the World. Note that an ESS receives all of its energy from its environment (Galaxy).

According to our Model, all macroobjects of the World (galaxies, stars, planets) have cores made up of Dark Matter particles. The theory of fermion compact stars (FCS) made up of Dark Matter particles is well developed. Scaling solutions are derived for a free and an interacting Fermi gas in Section 2.10.

Table 2 describes the parameters of FCS made up of different fermions.

The calculated parameters of FCS show that

- White Dwarf Shells (WDS) around the nuclei made of strongly interacting WIMPs or neutralinos (Section 2.14) compose cores of stars in extrasolar systems;
- Dissociated DIRACs to Monopoles form cores of star clusters;
- Dissociated ELOPs to Preons constitute cores of galaxies;
- Sterile neutrinos make up cores of galaxy clusters;
- Tauonic neutrinos reside in the cores of galaxy superclusters.

Table 2

Fermion	Fermion mass $m_f, MeV/c^2$	Macroobject mass M_{max}, kg	Macroobject radius R_{min}, m	Macroobject density $\rho_{max}, kg/m^3$
Muonic neutrino	7.50×10^{-9}	3.0×10^{52}	1.3×10^{26}	3.0×10^{-27}
Tauonic neutrino	4.50×10^{-8}	8.4×10^{50}	3.7×10^{24}	3.8×10^{-24}
Sterile neutrino	3.73×10^{-3}	1.2×10^{41}	5.4×10^{14}	1.8×10^{-4}
Preon	0.170	5.9×10^{37}	2.6×10^{11}	7.8×10^{2}
Monopole	35.01	1.4×10^{33}	6.2×10^{6}	1.4×10^{12}
Interacting WIMPs	9,596	1.9×10^{30}	8.6×10^{3}	7.2×10^{17}
Interacting neutralinos	$1{,}315\times10^{3}$	1.9×10^{30}	8.6×10^{3}	7.2×10^{17}
Electron-proton (white dwarf)	0.511-938.3	1.9×10^{30}	1.6×10^{7}	1.2×10^{8}
Neutron (star)	939.6	1.9×10^{30}	8.6×10^{3}	7.2×10^{17}

Interestingly, the calculated radius of an FCS made up of muonic neutrinos exactly equals to the radius of the World, while its mass would equal the combined mass of all the World macroobjects.

Although there are no free Dirac's monopoles and preons in the World, they can arise in the cores of FCS as the result of DIRACs and ELOPs gravitational collapse with density increasing up to the nuclear density ($\sim 10^{17}\ \frac{kg}{m^3}$) and/or at high temperatures, with subsequent dissociation of dipoles to monopoles and preons.

To summarize, 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. In our Model, all macroobjects consist of all particles under consideration, in the same proportion as they exist in the World's Medium. There are no compact stars made up solely of DM fermionic particles, for instance.

2.12. Fractal Structure of the World

The Model provides us with a facility to calculate the masses, sizes, and numbers of the World's cluster structures that follows fractal self-similar behavior. Galaxy clusters (GC) have total mass M_{GC}, radius R_{GC}, and number N_{GC} in the following ranges:

$$M_{GC} = 4\pi m_0 \times Q^{\frac{15}{8}} \times \left(Q^{-\frac{1}{8}} \Leftrightarrow 1\right) =$$

$$= (9.7072 \times 10^{42} \Leftrightarrow 9.3801 \times 10^{47})\ kg \qquad 2.12.1$$

$$R_{GC} = a \times Q^{\frac{15}{16}} \times \left(Q^{-\frac{1}{16}} \Leftrightarrow 1\right) =$$

$$= (1.3928 \times 10^{21} \Leftrightarrow 4.3297 \times 10^{23})\ m \qquad 2.12.2$$

$$N_{GC} \sim Q^{\frac{1}{8}} \times \left(1 \Leftrightarrow Q^{\frac{1}{8}}\right) \sim (10^5 \Leftrightarrow 10^{10}) \qquad 2.12.3$$

Galaxies (G) have total mass M_G, radius R_G, and number N_G in the following ranges:

$$M_G = 4\pi m_0 \times Q^{\frac{7}{4}} \times \left(Q^{-\frac{1}{8}} \Leftrightarrow 1\right) =$$

$$= (1.0046 \times 10^{38} \Leftrightarrow 9.7073 \times 10^{42})\ kg \qquad 2.12.4$$

$$R_G = a \times Q^{\frac{7}{8}} \times \left(Q^{-\frac{1}{16}} \Leftrightarrow 1\right) =$$

$$= (4.4807 \times 10^{18} \Leftrightarrow 1.3928 \times 10^{21})\ m \quad 2.12.5$$

$$N_G \sim Q^{\frac{1}{4}} \times \left(1 \Leftrightarrow Q^{\frac{1}{8}}\right) \sim (10^{10} \Leftrightarrow 10^{15}) \quad 2.12.6$$

For star clusters (SC) we obtain total mass M_{SC}, radius R_{SC}, and number N_{SC} in the following ranges:

$$M_{SC} = 4\pi m_0 \times Q^{\frac{13}{8}} \times \left(Q^{-\frac{1}{8}} \Leftrightarrow 1\right) =$$

$$= (1.0396 \times 10^{33} \Leftrightarrow 1.0046 \times 10^{38})\ kg \quad 2.12.7$$

$$R_{SC} = a \times Q^{\frac{13}{16}} \times \left(Q^{-\frac{1}{16}} \Leftrightarrow 1\right) =$$

$$= (1.4414 \times 10^{16} \Leftrightarrow 4.4806 \times 10^{18})\ m \quad 2.12.8$$

$$N_{SC} \sim Q^{\frac{3}{8}} \times \left(1 \Leftrightarrow Q^{\frac{1}{8}}\right) \sim (10^{15} \Leftrightarrow 10^{20}) \quad 2.12.9$$

When stars and galaxies are distributed in a hierarchy of disk-shape clusters, the calculated radii R_{MO} should be multiplied by $\sqrt{2}$.

The calculated ranges of radii, masses, and numbers of the World, GC, G, SC, and ESS are in good agreement with literature estimates. Our calculations show that the distance separating the galaxies is approximately 10^{21} m, which is in good agreement with experimentally measured distances. The distance from the Milky Way to the Large Magellanic Cloud, for instance, is about 1.5×10^{21} m [Wikipedia, List of nearest galaxies].

Within a galaxy, we calculate the distances between the stars to be about 10^{16} m. The distance from the Sun to the Proxima Centauri is about 4×10^{16} m [Wikipedia, List of nearest stars].

The central macroobject (CMO) of a galaxy has a core made up of preons. Our calculations show that its mass is smaller than 5.9×10^{37} kg, and its radius is greater than 2.6×10^{11} m. From the movement of S2 star it was estimated that our own Milky Way's central object mass is about 4.1 million solar masses (8.2×10^{36} kg), and its radius is no larger than 6.7×10^{12} m [Wikipedia, Sagittarius A^*].

In our Model it is natural to define surface S_{MO} as the boundary between macroobject and surrounding environment. In case of our Solar system such a surface is named Heliosphere [Wikipedia, Heliosphere]. We will refer to such surfaces as Macroobject Boundary (MOB). The radii R, R_{GC}, R_G, R_{SC}, R_{ESS} introduced above are really radii of corresponding Macroobject boundaries.

According to the developed Model, CMOs have cores made up of fermionic DM particles possessing radii R_{CORE} described in Tables 1 & 2. In case of extrasolar systems, the cores are made up of interacting neutralinos or WIMPs surrounded with white dwarf shells (WDS).

Surrounding the cores, there is a transitional region in which the density decreases rapidly to the point of the zero level of the fractal structure [21] characterized by radius R_f and energy density ρ_f that satisfy the following equation for $r \geq R_f$:

$$\rho(r) = \frac{\rho_f R_f}{r} \quad 2.12.10$$

According to Yu. Baryshev: *For a structure with fractal dimension $D = 2$ the constant $\rho_f R_f$ may be actually viewed as a new fundamental physical constant* [21].

In our Model, it is natural to connect this constant with the temperature invariant surface enthalpy σ_0 :

$$\rho_f R_f = C\sigma_0 \qquad 2.12.11$$

Taking $C = 4$ allows us to explain the so-called "Pioneer anomaly".

The Pioneer anomaly is the observed deviation from predicted accelerations of the Pioneer 10 and Pioneer 11 spacecraft after they passed about 20 astronomical units ($3 \times 10^9\ km; 2 \times 10^9\ mi$*) on their trajectories out of the Solar System. The apparent anomaly was a matter of tremendous interest for many years.*

Both Pioneer spacecraft are escaping the Solar System but are slowing under the influence of the Sun's gravity. Upon very close examination of navigational data, the spacecraft were found to be slowing slightly more than expected.

When all known forces acting on the spacecraft were taken into consideration, a very small but unexplained force remained. It appeared to cause an approximately constant sunward acceleration of $a_P = 8.74 \pm 1.33 \times 10^{-10} \frac{m}{s^2}$ *for both spacecraft. The magnitude of the Pioneer effect* a_P *is numerically quite close to the product of the speed of light* c *and the Hubble constant* H_0 *hinting at cosmological connection. This anomaly is now believed to be accounted for by thermal recoil forces.* [Wikipedia, Pioneer anomaly].

Let us calculate an acceleration a_P at the distance $r_P \gg R_f$ due to the additional mass of the fractal structure $M_{FS}(r_P) \propto r_P^2$ with the equation for the gravitational parameter G from Section 4 :

$$a_P = \frac{GM_{FS}}{r_P^2} = \frac{c^4}{8\pi\sigma_0 R} \times 2\pi \frac{4\sigma_0}{c^2} = \frac{c^2}{R} = cH_0 = 6.68 \times 10^{-10} \frac{m}{s^2} \qquad 2.12.12$$

which is in good agreement with the experimentally measured value. It is important to notice that the calculated acceleration is constant and equals to cH_0 hinting at cosmological connection.

As for the values of R_f and ρ_f, let us take

$$R_f = \alpha^{-1} R_{CORE} \qquad 2.12.13$$

and

$$\rho_f = 4\sigma_0 \frac{\alpha}{R_{CORE}} \qquad 2.12.14$$

Equation 2.12.10 fits naturally into our Model, since the evolution of all spherical structures of the World is progressing in a quasi-stationary mode (Section 2.13). The ball of radius R_f is absorbing energy from the environment, and the distribution of energy outside of the ball follows equation 2.12.10. The calculations carried out for our Sun using equations 2.12.13 and 2.12.14 are in agreement with the experimentally measured characteristics of the Sun. Taking the value of the solar core radius $R_{CORESun} \cong 1.6 \times 10^8\ m$ (see 2.14.16) we obtain

$$R_f \cong 2.2 \times 10^{10}\ m \qquad 2.12.15$$

which is in agreement with estimated sizes of the Heliosphere. *The Heliosphere, which is the cavity around the Sun filled with the solar wind plasma, extends from approximately 20 solar radii* ($\sim 1.4 \times 10^{10}\ m$) *to the outer fringes of the Solar System* [Wikipedia, Sun].

As a side note, Johann Georg von Soldner in 1801 calculated *"The deflection of a light ray from its rectilinear motion, by the attraction of a celestial body at which it nearly passes by"* [22]. The transition region between solar core and the beginning of the Heliosphere, in which the density decreases rapidly to the point of the zero level of the fractal structure, may cause an additional deflection of a light ray due to the gravitational refraction.

According to 2.12.14, the mass density ρ_{fm} at radius R_f is

$$\rho_{fm} = \frac{4\sigma_0}{c^2 R_f} \cong 7.2 \times 10^{-11} \frac{kg}{m^3} \qquad 2.12.16$$

and the minimum mass density ρ_{fmin} at the boundary of a macroobject is:

$$\rho_{fmin} = 4\sigma_0 (\frac{3M_{Sun}c^2}{4\pi\sigma_0})^{-\frac{1}{2}} \cong 1.5 \times 10^{-15} \frac{kg}{m^3} \qquad 2.12.17$$

Mass of the fractal structure around Sun M_V at distances $R_V \gg R_f$ is

$$M_V = 8\pi\sigma_0 R_V^2 \qquad 2.12.18$$

At distance $R_V = 1.8 \times 10^{13}\ m$ away from the Sun (approximate distance to Voyager 1 [23]),

$$M_V \cong 3.3 \times 10^{27} kg \qquad 2.12.19$$

that is $\sim 0.15\%\ M_{Sun}$. This additional mass can explain the observed deceleration of Voyagers. Note that the distances traveled by Voyagers ($\sim 10^{13}\ m$) are much smaller than the radius of the MOB R_{MOB}:

$$R_{MOB} = (\frac{3M_{Sun}c^2}{4\pi\sigma_0})^{\frac{1}{2}} \cong 1.1 \times 10^{15}\ m \qquad 2.12.20$$

The strongly inhomogeneous fractal spatial distribution of matter at scales from extrasolar system to the World, i.e. over twenty orders of magnitude in scale, has profound cosmological significance.

2.13. Evolution of the World's Fractal Structure

We will analyze the evolution of the World's fractal structure concentrating on three important types of macroobjects: extrasolar systems, galaxies, and the World.

As discussed in Section 2.11, the total macroobject energy E_{MO} enclosed in surface S_{MO} is proportional to the area of that surface:

$$E_{MO} = \sigma_0 S_{MO} \qquad 2.13.1$$

where σ_0 is the surface enthalpy. All macroobjects receive all of their energy from their environment.

When stars and galaxies are distributed in a hierarchy of spherical clusters of radius R_{MO}, the energy E_{MO} is:

$$E_{MO} = 4\pi\sigma_0 R_{MO}^2 \qquad 2.13.2$$

It was shown above (Sections 2.10, 2.11) that masses of all macroobject cores and ESS are proportional to $Q^{\frac{3}{2}}$ and are increasing in time $\propto t^{\frac{3}{2}}$. The total energy arriving to extrasolar systems from the environment (enclosing galaxies) is consumed solely by ESS.

All larger cosmological cluster structures are receiving more energy than required for increase of the mass of their components (CMO and ESS). The remainder of that energy is spent on creation of new macroobjects. Consider a galaxy. Its total mass M_G is proportional to $Q^{\frac{7}{4}}$ and is increasing in time $\propto t^{\frac{7}{4}}$:

$$M_G \sim 4\pi m_0 \times Q^{\frac{7}{4}} \qquad 2.13.3$$

CMO and ESS, however, are consuming energy $\propto t^{\frac{3}{2}}$ only.

The World, galaxies, and extrasolar systems have the following volumes:

$$V_W = V_0 \times Q^3 \propto t^3 \qquad 2.13.4$$

$$V_G \propto V_0 \times Q^{\frac{21}{8}} \propto t^{\frac{21}{8}} \qquad 2.13.5$$

$$V_{ESS} \propto V_0 \times Q^{\frac{9}{4}} \propto t^{\frac{9}{4}} \qquad 2.13.6$$

where $V_0 = \frac{4\pi}{3} a^3$ is the volume of the World's Nucleus at the Beginning ($Q = 1$).

The quasi-stationary expansion of them is taking place at different rates:

$$\frac{dV_W}{dt} = 3\frac{V_W}{t} \qquad 2.13.7$$

$$\frac{dV_G}{dt} = \frac{21}{8}\frac{V_G}{t} \qquad 2.13.8$$

$$\frac{dV_{ESS}}{dt} = \frac{9}{4}\frac{V_{ESS}}{t} \qquad 2.13.9$$

The World, galaxies, and ESS have the following total energies:

$$E_W = 4\pi E_0 \times Q^2 \propto t^2 \qquad 2.13.10$$

$$E_G \propto 4\pi E_0 \times Q^{\frac{7}{4}} \propto t^{\frac{7}{4}} \qquad 2.13.11$$

$$E_{ESS} \propto 4\pi E_0 \times Q^{\frac{3}{2}} \propto t^{\frac{3}{2}} \qquad 2.13.12$$

and are consuming energy at the following rates:

$$\frac{dE_W}{dt} = 2\frac{E_W}{t} \qquad 2.13.13$$

$$\frac{dE_G}{dt} = \frac{7}{4}\frac{E_G}{t} \qquad 2.13.14$$

$$\frac{dE_{ESS}}{dt} = \frac{3}{2}\frac{E_{ESS}}{t} \qquad 2.13.15$$

We see that the expansion rates are 1.5 times greater than energy consumption rates. Hence average densities of galaxies and extrasolar systems are decreasing with time:

$$\rho_G \propto \rho_0 \times Q^{-\frac{7}{8}} \propto t^{-\frac{7}{8}} \propto \rho_{cr} \times Q^{\frac{1}{8}} \qquad 2.13.16$$

$$\rho_{ESS} \propto \rho_0 \times Q^{-\frac{3}{4}} \propto t^{-\frac{3}{4}} \propto \rho_{cr} \times Q^{\frac{1}{4}} \qquad 2.13.17$$

and are about 5 and 10 orders of magnitude higher than the critical density ρ_{cr}, respectively.

The energy consumption rates are greater for galaxies relative to ESS, and for the World relative to galaxies. It follows that new stars and star clusters can be created inside of a galaxy, and new galaxies and galaxy clusters can arise in the World. Formation of galaxies and stars is not a process that concluded ages ago; instead, it is ongoing.

The amount of time Δt_{DG} necessary for the World to accumulate sufficient energy to create a new dwarf galaxy with mass M_{DG}

$$M_{DG} = 4\pi m_0 Q^{-\frac{1}{8}} \times Q^{\frac{7}{4}} \qquad 2.13.18$$

is:

$$\Delta t_{DG} = \frac{1}{2} t Q^{-\frac{1}{8}} \times Q^{-\frac{1}{4}} = 248.8\ s \qquad 2.13.19$$

Similarly, the amount of time Δt_G necessary to accumulate enough energy for a large new galaxy having maximum possible mass

$$M_{Gmax} = 4\pi m_0 \times Q^{\frac{7}{4}} \qquad 2.13.20$$

is:

$$\Delta t_G = \frac{1}{2} t \times Q^{-\frac{1}{4}} = 2.4040 \times 10^7\ s\ \cong 0.76\ yr \qquad 2.13.21$$

Similar calculations carried out for extrasolar systems show that minimum time Δt_{BD} to create brown dwarf with mass M_{BD}

$$M_{BD} = 4\pi m_0 Q^{-\frac{1}{8}} \times Q^{\frac{3}{2}} \qquad 2.13.22$$

and minimum time Δt_{ESS} needed to create an extrasolar system with maximum mass

$$M_{ESS} = 4\pi m_0 \times Q^{\frac{3}{2}} \qquad 2.13.23$$

are:

$$\Delta t_{BD} = \frac{4}{7} t Q^{-\frac{1}{8}} \times Q^{-\frac{1}{4}} = 284.3\ s \qquad 2.13.24$$

$$\Delta t_{ESS} = \frac{4}{7} t \times Q^{-\frac{1}{4}} = 2.7475\ \times 10^7\ s\ \cong\ 0.87\ yr \qquad 2.13.25$$

The time needed for creation of a main sequence star like our Sun is about $500\ \Delta t_{BD} \cong 40\ hrs$, which is consistent with the estimates of star generation in MS1358arc Galaxy made by M. Swinbank *et al*. [24]. Within the star-forming regions of this infant galaxy, new stars were being created at a rate of about 50 main sequence stars per year – around 100 times faster than had been previously thought.

2.14. Extrasolar Systems

There are two primary types of stars: main-sequence stars and red stars. They differ in their surface temperatures and radii:

- Red stars have cool surface temperatures: 3,500 ⟺ 4,500 K for Hypergiants, Supergiants, Giants [Wikipedia, Hypergiant, Red supergiant, Red giant], lower for Red dwarfs (2,300 ⟺ 3,800 K) [Wikipedia, Red dwarf], and significantly lower for Brown dwarfs (300 ⟺ 1,000 K) [Wikipedia, Brown dwarfs]. These stars have enormous range of radii: from 1,650 R_{Sun} for Hypergiants down to 0.08 R_{Sun} for Red dwarfs, and lower still for Brown dwarfs.

- Main-sequence stars have surface temperatures in the range of 3,000 ⟺ 45,500 K, and radii in the range from $35\ R_{Sun}$ for the most massive known star R136a1 [Wikipedia, R136a1] down to $0.1\ R_{Sun}$ for least heavy stars [Wikipedia, Main sequence].

As we have shown above (2.13.17), extrasolar systems (ESS) have average density ρ_{ESS} that is about 10 orders of magnitude higher than the critical density:

$$\rho_{ESS} \propto \rho_{cr} \times Q^{\frac{1}{4}} \tag{2.14.1}$$

The range of ESS masses M_{ESS} is about five orders of magnitude:

$$M_{ESS} = 4\pi m_0 \times Q^{\frac{3}{2}} \left(Q^{-\frac{1}{8}} \Leftrightarrow 1\right) \sim$$

$$\sim (10^{28} \Leftrightarrow 10^{33})\ kg \tag{2.14.2}$$

One third of this mass resides in macroobjects constituting an extra-solar system. Most of that mass lies in the star itself. The star and other macroobjects are composed of all particles under consideration.

Extrasolar systems form from clouds of particles. Due to gravitational instability, a gravitational collapse takes place. The heaviest particles, neutralinos or WIMPs, sink first and form the core of a new star.

In our opinion, the difference between main-sequence stars and red stars lies in composition of stellar cores. Main-sequence cores are made up of neutralinos, while red star cores consist of WIMPs. As we have shown in Section 2.10, in both cases the cores' maximum mass and minimum radius equals to that of a neutron star. The fermions, however, have drastically different interaction strength of annihilation: $\frac{1}{\alpha}$ in case of WIMPs and $\frac{1}{\alpha^2}$ in case of neutralinos.

The Core temperature is therefore much higher in main-sequence stars whose cores are made up of neutralinos. Ignition of chain reactions developing in the surrounding shells happens much more efficiently in these stars.

Let's analyze red stars with cores made up of WIMPs, with the surrounding white dwarf and preon shells.

Taking into account the 100x increase of maximum stable mass of cores made up of strongly interacting WIMPs (see 2.10.9), we calculate the total maximum core mass M_{CORE}:

$$M_{CORE} = \frac{1}{\beta^2} M_S \cong 1.93 \times 10^{30} kg \tag{2.14.3}$$

It follows that the energy density of WIMPs in the World ρ_{WIMP} equals to

$$\rho_{WIMP} = \frac{1}{\beta^2} \rho_{cr} \tag{2.14.4}$$

Calculations based on results of Section 2.10 show that the maximum stellar mass M_{Smax} is

$$M_{Smax} = M_0 = 3.4654 \times 10^{32} kg\ (\cong\ 174\ M_{Sun}) \tag{2.14.5}$$

Stars must be massive enough to support core densities equal to the nuclear density in order to initiate strong interaction between WIMPs. The minimum stellar mass M_{Smin} equals to

$$M_{Smin} = \sqrt{6}\alpha^4 \beta^4 M_{Smax} \cong$$

$$\cong 7.8 \times 10^{28} kg\ (\cong\ 0.039\ M_{Sun}) \qquad 2.14.6$$

M_{Smin} is over four orders of magnitude smaller than M_{Smax}. These numbers are in good agreement with the commonly accepted range of red stellar masses $(0.075 \Leftrightarrow 150\ M_{Sun})$.

The smallest true stars (red dwarfs) have masses of *less than half that of the Sun (down to about 0.075 solar masses, below which stellar objects are brown dwarfs) and a surface temperature of less than 4,000 K. Red dwarfs are by far the most common type of star in the Galaxy* [Wikipedia, Red dwarf].

Minimum radius of a stellar core $R_{COREmin}$ is:

$$R_{COREmin} = \frac{1}{\beta^2} L_g \cong 8.6\ km \qquad 2.14.7$$

The next heaviest particles – protons, joined by electrons – will follow WIMPs during the gravitational collapse, and form the White Dwarf Shell (WDS) around the core made of strongly interacting WIMPs. The mass of the WDS is proportional to the ratio of protons in the World:

$$M_{WDS} = 1.5 \frac{\rho_p}{\rho_{cr}} M_S \qquad 2.14.8$$

Using the following equation (see 2.10.4 for reference):

$$M_{WDS} = \frac{\pi}{6} \frac{M_P^3}{m_p^2} \qquad 2.14.9$$

we obtain the maximum mass $M_{WDScold}$ of a cold WDS:

$$M_{WDScold} \cong 1.93 \times 10^{30} kg\ (\cong\ M_{Sun}) \qquad 2.14.10$$

Taking into account the proton-proton chain reaction with the interaction strength equal to β, we can estimate the increase of the maximum stable mass of the WDS in accordance with theory developed by G. Narain *et al.* [17]:

$$M_{WDShot} = \left(1 + \frac{\beta}{2}\right) M_{WDScold} \cong 1.49 \times 10^{31} kg \qquad 2.14.11$$

Calculated value of M_{WDShot} is consistent with the expected protons mass obtained from the maximum star mass (3.4654×10^{32} kg) with 7.2% concentration of protons (≅ 2.50 ×10^{31} kg).

The minimum radius of cold WDS is

$$R_{WDScold} = \frac{L_g}{\alpha\beta} \cong 1.6 \times 10^7\ m \qquad 2.14.12$$

Taking into account the proton-proton chain reaction for the minimum radius of WDS in accordance with the paper of G. Narain *et al.* [17] we obtain:

$$R_{WDShot} = \left(1 + \frac{\beta}{4}\right) R_{WDScold} \cong 7.0 \times 10^7 m \qquad 2.14.13$$

The calculated parameters of red stars can explain the characteristics of brown dwarfs, red dwarfs, and subgiants that are slightly brighter than main-sequence stars, but not as bright as true giant stars. As a side note, *subgiants are the only type of stars other than main-sequence stars believed capable of hosting life-bearing planets* [Wikipedia, Subgiant].

Enormous radii of Hypergiants (up to 1,650 $R_{Sun} \cong 10^{12}\ m$) and huge luminosity of giant stars can be explained by an additional shell of preons – particles whose charge equals to $\frac{1}{3}e$. They compose hot high density plasma with surface temperature in the range of 3,500 ⟺ 4,500 K. The minimum radius of preon shell $R_{min} \cong 2.6 \times 10^{11}\ m$ (see **Table 2**).

The analysis of main-sequence stars whose cores are made up of neutralinos with surrounding white dwarf and preon shells shows that their cores have the same maximum mass and minimum radius as those of red stars, but much higher temperature, due to considerably greater interaction strength of annihilation of neutralinos as compared to WIMPs. The characteristics of the white dwarf shell are close to those of red stars. Much higher core temperature, however, enables main-sequence stars to have much greater surface temperature. The hottest observed star has a surface temperature of 45,500 K [Wikipedia, Main sequence].

The maximum stellar mass remains the same ($\cong 174\ M_{Sun}$). According to Wikipedia [List of most massive stars]: *Studying the Arches cluster, which is the densest known cluster of stars in our galaxy, astronomers have confirmed that stars in that cluster do not occur any larger than about 150* M_{Sun}*. One theory to explain rare ultramassive stars that exceed this limit, for example in the R136 star cluster (up to 265* M_{Sun}*), is the collision and merger of two massive stars in a close binary system. If any stars still exist above* $(150 - 200)\ M_{Sun}$*, they would challenge current theories of stellar evolution.*

Strongly interacting Fermi gas of neutralinos has practically constant value of minimum radius in the huge range of masses M_N from

$$M_{Nmax} = \frac{\pi}{6}(\alpha\beta)^{-2}\alpha^2 M_F = \frac{1}{\beta^2}M_0 \qquad 2.14.14$$

down to

$$M_{Nmin} = \alpha^8 M_{Nmax} \qquad 2.14.15$$

M_{Nmin} is more than seventeen orders of magnitude smaller than M_{Nmax}.

We use equations 2.10.2 and 2.10.22 to calculate WDS radius of the Sun, keeping in mind that its mass is 174 smaller than the maximum stellar mass:

$$R_{WDSSun} = \sqrt[3]{6\frac{M_{Smax}}{M_{Sun}}}R_{WDScold} \cong 1.6 \times 10^8\ m \qquad 2.14.16$$

R_{WDSSun} is about 0.23 solar radii, which is in good agreement with solar core radius discussed in literature (0.2 ⟺ 0.25 solar radii).

The developed star model explains the very low power production density produced by fusion inside of the Sun. Wikipedia humorously notes that the power output of the Sun *more nearly approximates reptile metabolism than a thermonuclear bomb* [Wikipedia, Sun]. In our Model, the core made up of strongly interacting neutralinos is the supplier of proton-electron pairs into WDS and igniter of the proton-proton chain reaction developing in the surrounding WDS with small interaction strength $\beta \cong 13.4$. The energy to support neutralinos annihilation and proton fusion is coming from outside of the star (Galaxy).

With respect to the developed model of FCS (Section 2.10), the masses of the cores and WDS are increasing in time $\propto t^{\frac{3}{2}}$:

- New neutralinos and WIMPs freely penetrate through the entire stellar envelope and get absorbed into the core.

- New protons and electrons (as well as other elementary particles and stardust grains which condensed thermally within stellar gases as they are ejected from the stars, Section 2.17) are generated in the core as the result of neutralinos and WIMPs annihilation, and enter the WDS. In our opinion, the stardust grains emitted from the sun and all stars are in fact "primary solar rays," which in turn produce secondary radiations, as Nikola Tesla named them in the Dynamic Theory of Gravity [46].

The radii of the core and WDS are increasing in time $\propto t^{\frac{1}{2}}$. Consequently, the density and fusion power production density remain constant in time.

Consider the closed spherical surface around the WDS. Its radius is increasing in time $\propto t^{\frac{1}{2}}$, and its area is increasing in time $\propto t$. Stellar luminosity is thus increasing in time $\propto t$. Taking into account that the age of the World is $\cong$ 14.2 Byr and the age of solar system is $\cong$ 4.6 Byr, it is easy to find that the young Sun's output was only 67.6% of what it is today. Literature commonly refers to the value of 70%. So-called "Faint young Sun" paradox is thus resolved [Wikipedia, Faint young Sun paradox].

The described star creation picture is consistent with a new image from ESO (European Southern Observatory) which *shows a dark cloud where new stars are forming, along with a cluster of brilliant stars that have already emerged from their dusty stellar nursery. This cloud is known as Lupus 3 and it lies about 600 light-years from Earth in the constellation of Scorpius (The Scorpion) which is one of the closest such stellar nurseries to the Sun.*

The bright stars are young stars that have not yet started to shine by nuclear fusion in their cores and are still surrounded by glowing gas. They are probably less than one million years old. The Lupus 3 region is both fascinating and a beautiful illustration of the early stages of the life of stars [26].

An important consequence for Solar system, and in fact for all other stars in the World, is that they will never burn their "fuel" out. On the contrary, stars accumulate more fuel with time, and output more power.

As Nikola Tesla said: *All this energy (sometimes viewed as "Zero Point Energy") comes from the environment giving life to matter, forming a "closed circuit" through one way or the other (being "accessed" more efficiently or less based on the methodology). It is omnipresent, day or night, and is "re-emitted" by every star in our universe naturally including our sun* [46].

The existence of supermassive objects in galactic centers is now commonly accepted. Although it is believed that the central mass is a supermassive black hole, it has not yet been firmly established. Alternative models for the supermassive dark objects in galactic centers, formed by self-gravitating non-baryonic matter composed of fermions and bosons, are widely discussed in literature.

The heaviest macroobjects include a high-density preon plasma shell around their cores:

- Macroobjects with a cold preon shell emit strong radio waves. Such objects are good candidates for the compact astronomical radio sources at centers of galaxies like Sagittarius A* in the Milky Way Galaxy [Wikipedia, Sagittarius A*].
- Red Giants are macroobjects with hot preon shells.
- Macroobjects with a very hot preon shell are candidates for Active Galactic Nuclei (AGN).

Note that the temperature of the preon shell depends on the composition of the macroobject core. Macroobjects whose cores are made up mostly of preons remain cold. Macroobjects with cores made up of WIMPs and WDS produce hot preon shells. Macroobjects whose cores consist of neutralinos and WDS have very hot preon shells.

The radius of the AGN is about four orders of magnitude larger than the radius of WDS (see **Table 2**). The area of the closed spherical surface around the AGN is more than 8 orders of magnitude greater than the surface area of WDS. Luminosity of the AGN is then at least 8 orders of magnitude higher than the luminosity of the largest star.

The described model of AGN can explain the fact that *the most luminous quasars radiate at a rate that can exceed the output of average galaxies, equivalent to two trillion (2×10^{12}) suns* [Wikipedia, Quasar].

New protons and electrons (as well as other elementary particles and stardust grains) are penetrating from the core into WDS as the result of neutralinos and WIMPs annihilation, and then emanating from the star itself. The Sun produces solar wind and "primary solar rays"; hottest macroobjects such as an AGN may be emitting protons at relativistic speeds.

The Universe's light-element abundance is another important criterion by which the Big Bang hypothesis is verified. It is now known that the elements observed in the Universe were created in either of two ways. Light elements (namely deuterium, helium, and lithium) were produced in the first few minutes of the Big Bang, while elements heavier than helium are thought to have their origins in the interiors of stars [Wikipedia, Big Bang Nucleosynthesis].

According to the World – Universe Model, nucleosynthesis of all elements occurs inside stars during their evolution (Stellar nucleosynthesis). The theory of this process is well developed, starting with the publication of a celebrated B^2FH review paper in 1957 [2].

With respect to our Model, Stellar nucleosynthesis theory should be enhanced to account for annihilation of heavy dark matter particles (WIMPs and neutralinos). This process outputs sufficiently high energy and temperature to produce all elements inside stellar cores. Annihilation of dark matter particles inside the stars accelerates with time, as stars gain mass.

2.15. Brown Dwarfs

According to Wikipedia, Brown Dwarfs are sub-stellar objects whose masses range from 13 to 80 Jupiter masses (M_{Jup}) [Wikipedia, Brown Dwarfs].

In our opinion, Brown Dwarfs (BD) differ from red stars in that the density of their cores is smaller than nuclear density. Consequently, WIMPs annihilation does not take place.

As we have shown in Section 2.10, the maximum mass and minimum radius of a compact star made up of weakly interacting WIMPs can be calculated with the following parameters A_1 and A_2:

$$A_1 = \frac{\pi}{6}\sqrt{6}(\alpha\beta)^2 \quad 2.15.1$$

$$A_2 = \pi\sqrt[6]{6}(\alpha\beta)^{-\frac{2}{3}} \quad 2.15.2$$

Parameter A_1 in the scaling solution defines the maximum mass of the core $M_{COREmax}$ made up of warm WIMPs, and consequently the maximum mass of brown dwarf M_{BDmax}:

$$M_{COREmax} = \sqrt{6}\alpha^4\beta^2 M_0 \cong 4.33 \times 10^{26}\ kg \quad 2.15.3$$

$$M_{BDmax} = \beta^2 M_{COREmax} \cong 7.77 \times 10^{28}\ kg\ (\cong 41\ M_{Jup}) \quad 2.15.4$$

Parameter A_2 defines the minimum radius of the BD core $R_{COREmin}$ made up of warm WIMPs:

$$R_{COREmin} = A_2 \alpha^2 \frac{L_g}{\pi} \cong 280\ m \qquad 2.15.5$$

The minimum mass of the BD M_{BDmin} equals to the minimum star mass:

$$M_{BDmin} = M_{Smin} = M_0 \times Q^{-\frac{1}{8}} \cong$$
$$3.6 \times 10^{27}\ kg\ (\cong 1.9\ M_{Jup}) \qquad 2.15.6$$

M. C. Liu *et al.* discovered the reddest known field dwarf PSO J318.5-22 at a distance of $24.6 \pm 1.4\ pc$ with an age of $12^{+8}_{-4}\ Myr$, temperature of $1160^{+30}_{-40}\ K$, and mass of $6.5^{+1.3}_{-1.0}\ M_{Jup}$, *making it one of the lowest mass free-floating objects in the solar neighborhood. PSO J318.5-22 shares a strong physical similarity to the young dusty planets around HR 8799 and 2MASS J1207-39, as seen in its colors, absolute magnitudes, spectrum, luminosity, and mass* [42]. With respect to our Model, PSO J318.5-22 should be classified as a brown dwarf.

2.16. Planets

By Wikipedia definition, *Planet is a celestial body orbiting a star or stellar remnant that is massive enough to be rounded by its own gravity, is not massive enough to cause thermonuclear fusion, and has cleared its neighbouring region of planetesimals.* [Wikipedia, Planet].

Let's see how planetary system formation occurs.

As described above, extrasolar systems arise from clouds of all particles under consideration with mass in the range of

$$M_{Cl} = 4\pi m_0 \times Q^{\frac{3}{2}} \times \left(Q^{-\frac{1}{8}} \Leftrightarrow 1\right) \qquad 2.16.1$$

and density

$$\rho_{Cl} \sim \rho_{cr} \times Q^{\frac{1}{4}} \qquad 2.16.2$$

As a result of gravitational instability, gravitational collapse takes place and one third of M_{Cl} is concentrating at the center of the cloud, increasing the density of the core up to the nuclear density.

The heaviest particles – neutralinos and WIMPs – are the first in this stream of matter. When their density achieves the nuclear density, self-annihilation process ignites. As the result, the Stellar Core (SC) grows up to 10^4 and 10^2 times respectively, taking additional mass of neutralinos and WIMPs from oncoming stream.

Concurrently, a White Dwarf Shell (WDS) form around the SC. WDS is comprised of next heaviest particles – protons, accompanied by electrons. The total mass of WDS equals to $\cong 2.4\ \%$ of the cloud mass.

Expansion of the hot SC and WDS is progressing explosively fast, in a process not unlike boiling. Drops of the boiling SC and WDS are ejected from the forming star and give birth to planets.

The following two facts support the creation picture outlined above:

- The analysis of a mass – radius ratio for compact stars made of strongly interacting fermions shows that the radius remains approximately constant for a wide range of compact stars masses;

- The analysis of a mass – radius ratio for the lowest mass white dwarfs shows the same behavior – radius does not depend on mass. It happens because at the low mass end the Coulomb pressure (which is characterized by constant density $\propto \frac{M}{R^3}$ and thus $R \propto M^{\frac{1}{3}}$) starts to compensate the degeneracy: $R \propto M^{-\frac{1}{3}}$. The two effects nearly cancel each other out, so $R \propto M^0$ – no dependency at all.

As discussed above, the maximum mass of the hot neutralinos and WIMPs core $M_{CORE} \cong 1.93 \times 10^{30}\ kg$; the maximum mass of a star $M_{Smax} = 3.4654 \times 10^{32}\ kg$; and the minimum radius $R_{min} \cong 8.6\ km$.

The radius of the hot core remains practically constant (≅ 8.6 km) whether the core belongs to a star or to a planet. The masses of planets formed around red stars and main-sequence stars differ:

- Planets formed around red stars have the smallest mass of $\sim 10^{-6} M_{Sun}$, 8 orders of magnitude smaller than maximum star mass $\cong 174\ M_{Sun}$.
- Planets formed around main-sequence stars may be as light as $\sim 10^{-15} M_{Sun}$, 17 orders of magnitude smaller than the maximum star mass. Consequently, all spherically-shaped objects, down to Mimas in Solar system, contain hot neutralinos cores with WDS.

Planets can arise only around main sequence and red stars. Due to the less violent nature of their formation, brown dwarfs do not create planets. There have been observations of a number of BDs possessing planets; with respect to our Model, the masses of such BDs should exceed 0.039 M_{Sun}, which would classify them as red stars.

2.17. Cosmic Dust

According to Wikipedia, *Cosmic dust was once solely an annoyance to astronomers, as it obscures objects they wish to observe. When infrared astronomy began, those previously annoying dust particles were observed to be significant and vital components of astrophysical processes.*

Cosmic dust is made of dust grains and aggregates of dust grains. These particles are irregularly-shaped with porosity ranging from fluffy to compact.

Most of the influx of extraterrestrial matter that falls onto the Earth is dominated by meteoroids with diameters in the range 50 to 500 micrometers, of average density $2.0\ \frac{g}{cm^3}$ *(with porosity ~ 40 %).*

Stardust grains (also called presolar grains by meteoriticists) are contained within meteorites, from which they are extracted in terrestrial laboratories. Stardust condensed thermally within stellar gases as they were ejected from the stars [Wikipedia, Cosmic dust].

Stardust grains have diameters D_{gr} in the range ~1 to 250 nanometers [38] with masses as low as $10^{-23}\ kg$ [39]. *Diamonds are the smallest presolar grains that have been identified; they are typically about 2 nanometers in diameter and only contain on order of one thousand atoms* [40].

P. H. Siegel has this to say about cosmic dust [27]:

Results from the NASA Cosmic Background Explorer (COBE) Diffuse Infrared Background Experiment (DIRBE) and examination of the spectral energy distributions in observable galaxies, indicate that approximately one-half of the total luminosity and 98% of the photons emitted since the Big Bang fall into sub-millimeter and far-IR. Much of this energy is being radiated by cool interstellar dust.

The sizes of cosmic dust particles D_{dp} are roughly equal to the Fermi length L_F:

$$D_{dp} \sim L_F = a \times Q^{\frac{1}{4}} = 1.6532 \times 10^{-4}\, m \qquad 2.17.1$$

and their mass m_{dp} is close to the Planck mass:

$$m_{dp} \sim (10^{-9} \Leftrightarrow 10^{-7})\, kg$$

$$(M_P = 2.1767 \times 10^{-8}\, kg) \qquad 2.17.2$$

The density of dust particles ρ_{dp} is close to the rock density ρ_{rock} :

$$\rho_{dp} \sim \rho_{rock} = \frac{6}{\pi}\frac{M_P}{L_F^3} = 9.2008 \times 10^3\, \frac{kg}{m^3} \qquad 2.17.3$$

As discussed in Section 3.3, masses of two gravitationally interacting objects m_1 and m_2 must satisfy the following expression:

$$m_1 m_2 \geq \frac{1}{2} M_P^2 = 2 m_0^2 \times Q \qquad 2.17.4$$

Cosmic dust particles with masses around M_P are the smallest building blocks that participate in star creation. Formation of a new star starts with a gravitational instability of the dust cloud and subsequent gravitational collapse, with the resulting macroobject (Nucleus) possessing mass about M_{Nuc}:

$$M_{Nuc} = m_o \times Q \;\cong\; 10^{12}\, kg \qquad 2.17.5$$

Then all particles heavier than m_0 (neutralinos, WIMPs, protons, DIRACs) will be attracted to this Nucleus, increasing its mass and attracting lighter particles as described above. The size of this Nucleus is:

$$R_{Nuc} \sim 10^{-2}\, m \qquad 2.17.6$$

A dust particle of mass $B_1 M_P$ and radius $B_2 L_F$ is absorbing energy from the Medium at the following rate:

$$\frac{d}{dt}(B_1 M_P c^2) = \frac{B_1 M_P c^2}{2t} \qquad 2.17.7$$

where B_1 and B_2 are parameters.

The absorbed energy will increase the particle's temperature, until equilibrium is achieved: power absorption equals to the power irradiated by the surface in accordance with the Stefan-Boltzmann law

$$\frac{B_1 M_P c^2}{2t} = \sigma_{SB} T_{st}^4 \times 4\pi B_2^2 L_F^2 \qquad 2.17.8$$

where σ_{SB} is the Stefan-Boltzmann constant and k_B is the Boltzmann constant:

$$\sigma_{SB} = \frac{2\pi^5 k_B^4}{15 h^3 c^3} \qquad 2.17.9$$

Applying the World equation 2.11.2 to our particle:

$$B_1 M_P c^2 = 4\pi B_2^2 L_F^2 \sigma_0 \qquad 2.17.10$$

we calculate its stationary temperature T_{st} to be

$$k_B T_{st} = (\frac{15}{4\pi^5})^{\frac{1}{4}} \frac{hc}{L_F}$$

$$T_{st} = 28.95\ K \qquad 2.17.11$$

This result is in an excellent agreement with experimentally measured value of $29\ K$ [41].

The size of cosmic grains D_{gr} roughly equals to the smallest microobject length L_{micro}:

$$D_{gr} \sim L_{micro} = a \times Q^{\frac{1}{8}} = 1.7109 \times 10^{-9}\ m = 1.7109\ nm \qquad 2.17.12$$

and their mass m_{gr} is close to the smallest microobject mass m_{micro} :

$$m_{gr} \sim m_{micro} = m_0 \times Q^{\frac{1}{8}} = 1.2062 \times 10^{-23}\ kg \qquad 2.17.13$$

The density of dust grains ρ_{gr} is close to the rock density ρ_{rock} :

$$\rho_{gr} \sim \rho_{rock} = \frac{6}{\pi} \frac{m_{micro}}{L_{micro}^3} = 9.2008 \times 10^3\ \frac{kg}{m^3} \qquad 2.17.14$$

The calculated numbers are in a good agreement with experimentally measured values of the smallest presolar grains [39, 40].

Compare the mass of the heaviest particle in our model – neutralino:

$$m_N = 1.3149950\ \frac{TeV}{c^2} = 2.3441924 \times 10^{-24}\ kg \qquad 2.17.15$$

with the mass of the smallest microobject – cosmic dust grain:

$$m_{micro} = 6.7663\ \frac{TeV}{c^2} = 1.2062 \times 10^{-23}\ kg \qquad 2.17.16$$

$$\frac{m_{micro}}{m_N} = 5.1455 \qquad 2.17.17$$

2.18. World Expansion

One of the long-standing questions of Cosmology revolves around the observed expansion of the World. Furthermore, the expansion of the World appears to be accelerating. It is commonly accepted that the mysterious Dark Energy is the agent responsible for this acceleration. In this section we introduce an alternative explanation of this phenomenon.

In our Model, there is no gravitational interaction between microobjects (protons, electrons, DM particles, etc.). At least one of the parties participating in gravitational interaction must be a macroobject with mass $m \geq M_P$. More precisely, the product of the two objects' masses must equal to at least Planck mass squared (Section 3.3):

$$m_1 m_2 \geq \frac{1}{2} M_P^2 \qquad 2.18.1$$

Consequently, the particles constituting the Medium of the World do not participate in gravitational interaction with each other.

The motion of macroobjects in the Medium is governed by three separate forces.

- Outward force: the force that the Medium applies to macroobjects, pushing the objects away from the World center (the location of the original fluctuation).
- Gravity: the force that macroobjects exert on each other, pulling them back together.

- Friction: the force due to the motion of macroobjects through the Medium, slowing them down.

The three forces are in equilibrium, and macroobjects maintain constant speeds.

From the preceding chapters recall that the World consists of homogenous Medium with mass density

$$\rho_M = \frac{2\rho_{cr}}{3c^2} \qquad 2.18.2$$

and the World's Boundary with the Universe has an antimatter surface density

$$\rho_S = \frac{\sigma_0}{c^2} \qquad 2.18.3$$

Let us find the gravitoelectric potential U_W of the World. For a homogeneously charged ball with radius R, potential U_B equals to

$$U_B = \frac{2\pi\rho_M R^2}{4\pi\varepsilon_g}\left(1 - \frac{r^2}{3R^2}\right) = \frac{c^2}{2}(1 - \frac{r^2}{3R^2}) \qquad 2.18.4$$

where r is the distance from the center of the ball.

For a homogeneously charged surface of the ball, potential U_S inside of the sphere with the radius R is:

$$U_S = \frac{4\pi R^2 \rho_S}{4\pi\varepsilon_g R} = \frac{c^2}{2} \qquad 2.18.5$$

The potential of the World is:

$$U_W = c^2(1 - \frac{r^2}{6R^2}) \qquad 2.18.6$$

The gravitoelectric field $\boldsymbol{E}_g$ is:

$$\boldsymbol{E}_g = \frac{r}{3t^2}\frac{\boldsymbol{r}}{r} = a_g(r)\frac{\boldsymbol{r}}{r} \qquad 2.18.7$$

where $a_g(r) = \frac{r}{3t^2}$ is acceleration at distance r from the center of the ball.

The further away an object from the center of the World, the higher the acceleration. Its maximum value occurs at the Front where $r = R$,

$$a_g(R) = \frac{c}{3t} = \frac{1}{3}cH_0 \cong 2.2 \times 10^{-10}\ \frac{m}{s^2} \qquad 2.18.8$$

The accelerated movement of macroobjects does not however imply an accelerated expansion of the World. The Front of the World is advancing with constant speed c!

Since all interactions propagate with finite speed that does not exceed c, the above effect manifests itself mostly close to the Front and is negligible in the vicinity of the center of the World.

The idealized Medium of the World considered in the above equations is frictionless. Macroobjects moving through such Medium do not lose momentum and are indeed accelerating. We ignored the effects of friction, as well as gravity between individual macroobjects.

In the actual Medium, the outward force equals to the sum of gravity and friction. Macroobjects will then move with constant speeds.

Let's calculate the friction coefficient k_{fr} of the Medium:

$$mE_g - G\frac{m}{r^2} \times \frac{4\pi}{3} r^3 \times \frac{1}{3}\frac{\rho_{cr}}{c^2} = k_{fr} v = k_{fr} \frac{r}{R} c \qquad 2.18.9$$

$$k_{fr} = \frac{m}{6t} \qquad 2.18.10$$

The friction force F_{fr} for any object with momentum p then equals to

$$F_{fr} = \frac{p}{6t} = \frac{p}{6} H_0 \qquad 2.18.11$$

The dependence of the Medium friction coefficient on time $k_{fr} \propto t^{-1}$ can be easily explained by the dependence of a dynamic viscosity of the Medium η_M

$$\eta_M = \rho_M \nu_M \qquad 2.18.12$$

on its density $\rho_M \propto t^{-1}$, while kinematic viscosity of the Medium ν_M remains constant:

$$\nu_M = ac \qquad 2.18.13$$

Consequently, macroobjects maintain constant momentum during the expansion of the World.

2.19. Cosmological Redshift

Wikipedia has this to say about cosmological redshift [Redshift]:

In the early part of the twentieth century, Hubble and others made the first measurements of the galaxy's redshifts beyond the Milky Way. They initially interpreted these redshifts as due solely to the Doppler Effect, but later Hubble discovered a rough correlation between the increasing redshifts and the increasing distance of galaxies. Theorists immediately realized that these observations could be explained by different mechanisms for producing redshifts.

Let us analyze the movement of photons as they travel from distant galaxies to Earth in the time-varying Medium.

As we have shown in Section 2.6, energy of photons remains constant in the ideal frictionless Medium. In the actual Medium with a friction coefficient for photons

$$k_{ph} \sim t^{-1} \qquad 2.19.1$$

the equation for the photon's momentum p_{ph} is:

$$\frac{dp_{ph}}{dt} = -\delta \frac{p_{ph}}{t} \qquad 2.19.2$$

where δ is a parameter. Solving equation 2.19.2 we obtain

$$p_{ph} t^{\delta} = const \qquad 2.19.3$$

Consider a photon with initial momentum p_{emit} emitted at time t_{emit}. The photon is continuously losing momentum as it moves through the Medium until time t_{obsv} when it is observed. The observer will measure λ_{obsv}, compare it with well-known wavelength λ_{emit}, and calculate a redshift:

$$z = \frac{\lambda_{obsv} - \lambda_{emit}}{\lambda_{emit}} \qquad 2.19.4$$

By definition, $\lambda = \frac{h}{p}$. When $\delta = 1$ we obtain:

$$p_{obsv} t_{obsv} = p_{emit} t_{emit} \qquad 2.19.5$$

$$1+z=\frac{\lambda_{obsv}}{\lambda_{emit}}=\frac{p_{emit}}{p_{obsv}}=\frac{t_{obsv}}{t_{emit}} \quad 2.19.6$$

Recall that t_{emit} and t_{obsv} are cosmic times (ages of the World at the moments of emitting and observing), both measured from the Beginning of the World. t_{obsv} equals to the present age of the World A_t. If the photon travelled for time t_{ph}, then

$$t_{obsv}=t_{emit}+t_{ph} \quad 2.19.7$$

$$t_{ph}=t_{obsv}-t_{emit}=t-t_{emit} \quad 2.19.8$$

The cosmological redshift is then described by a nonlinear equation on t_{ph}:

$$1+z=\frac{1}{1-\frac{t_{ph}}{t}} \quad 2.19.9$$

As an example, a photon travelling for 7.11 Byr (half of the World's age) will have a redshift of $1+z=2$. Photon travelling for 12.64 Byr will have a redshift of $1+z=9$. The difference is due to the dependence of the Medium friction on time: it was 9 times greater at $t_{emit}=1.58\,Byr$ than it is now at $t\approx 14.22\,Byr$.

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

$$d=\frac{c}{H_0}z=Rz \quad 2.19.10$$

The relationship of distance d to the redshift z for large values of z is not presently conclusive, active research is conducted in the area.

In our Model, the distance to galaxies equals to:

$$d=\frac{c}{H_0}\frac{z}{1+z}=R\frac{z}{1+z} \quad 2.19.11$$

which reduces to 2.19.10 for $z \ll 1$ and $d=R$ for $z \to \infty$.

Experimental observations measuring light from distant galaxies and supernovae seem to imply that the World is expanding at an accelerated pace, as is evident from the observed redshift. The time varying friction of the Medium offered above provides an alternative interpretation of these observations.

M. Lopez-Corredoira has this to say about the loss of energy by photons [25]:

The idea of loss of energy of the photon in the intergalactic medium was first suggested in 1929 by Zwicky. Nernst in 1937 had developed a model which assumed that radiation was being absorbed by luminifereous ether. But there are two problems: 1) all images of distant objects look blurred if the intergalactic space produces scattering; 2) the scattering effect and the consequent loss of energy is frequency dependent.

Different mechanisms were proposed to avoid blurring and scattering. A paper by M. Lopez-Corredoira provides an excellent review of such mechanisms [25].

Laio A. *et al.* showed that the shift of photon frequency in low density plasma (which is the case in our Model) could come from quantum effects derived from standard quantum electrodynamics [28].

According to E. J. Lerner, quantum mechanics indicates that a photon gives up a tiny amount of energy as it collides with an electron, but its trajectory does not change [29].

There is another way to explain the absence of the blurring and scattering. Back in 1839 James McCullagh proposed a theory of rotationally elastic medium, i.e. the medium in which every particle resists absolute rotation [30]. This theory produces equations analogous to Maxwell's electromagnetic equations. In our opinion, the Medium of the World is in fact such a rotationally elastic medium. We propose to review the interaction of photons with the Medium in light of this very unique theory.

3. Particle Physics

3.1. Analysis of Maxwell's Equations

In speaking of the Energy of the field, however, I wish to be understood literally. All energy is the same as mechanical energy, whether it exists in the form of motion or in that of elasticity, or in any other form. The energy in electromagnetic phenomena is mechanical energy.

James Clerk Maxwell

Maxwell's equations, together with the Lorentz force law, form the foundation of classical electrodynamics, classical optics, and electric circuits [Wikipedia, Maxwell's equations]. We'll subsequently refer to Maxwell equations and Lorentz law jointly as Maxwell-Lorentz equations (MLE). The value of MLE is even greater because J. Swain showed that *linearized general relativity admits a formulation in terms of gravitoelectric and gravitomagnetic fields that closely parallels the description of the electromagnetic field by Maxwell's equation* [31].

Hans Thirring pointed out this analogy in his "On the formal analogy between the basic electromagnetic equations and Einstein's gravity equations in first approximation" paper published in 1918 [32]. It allows us to use formal analogies between the electromagnetism and relativistic gravity. *The equations for Gravitoelectromagnetism were first published in 1893, before general relativity, by Oliver Heaviside as a separate theory expanding Newton's law* [Wikipedia, Gravitomagnetism].

Maxwell's equations vary with the unit system used. Although the general shape remains the same, various definitions are changed, and different constants appear in different places. We'll start our discussion with MLE in SI units. We will not rewrite well-known equations, but only provide the relationships between physical quantities used in MLE for electromagnetism and gravitoelectromagnetism in the Tables 3 and 4.

In Maxwell-Lorentz equations, electrodynamic constant c is defined as the ratio of the absolute electromagnetic unit of charge to the absolute electrostatic unit of charge. It is easy to see that the dimension of products (Charge × Magnetic Flux) and (Impedance × Charge squared) equals to that of the Plank constant.

From the above Tables it becomes clear that the dimensions of all physical quantities depend on the choice of the charge and mass dimensions (Coulomb & kilogram in SI units). In other unit systems the dimensions are different. For instance, in Gaussian units (CGSE):

- $[q_e] = cm^{\frac{3}{2}} g^{\frac{1}{2}} s^{-1}$
- $[Z_e] = cm^{-1} s$

In CGSM:

- $[q_m] = cm^{\frac{1}{2}} g^{\frac{1}{2}}$
- $[Z_m] = cms^{-1}$

We seem to possess a substantial degree of freedom when it comes to choosing the dimension of charge. For an arbitrary charge transformation parameter K, we can

- Multiply the charge and mass and all physical quantities on the left side of Tables 3 and 4 by an arbitrary parameter K
- Divide impedances by K^2
- Divide magnetic fluxes and all physical quantities on the right side of Tables 3 and 4 by K.

Following such a transformation, all physically measurable parameters such as force, energy density, and energy flux density remain the same, and have the same mechanical dimensions.

By definition, 1 Coulomb equals to one tenth of the absolute electromagnetic unit of charge. It follows that in SI we use electromagnetic unit of charge e in the electrostatic Coulomb law instead of the electrostatic unit $\frac{e}{c}$. This seems a bit odd.

Likewise, when describing Newtonian Law of gravitation, we use m – the inertial mass, instead of gravitoelectrostatic charge mc – the gravitational mass. The gravitoelectromagnetic charge is then mc^2. Similarly to the electromagnetic field, the gravitoelectrodynamic constant c is the ratio of the absolute gravitoelectromagnetic unit of charge to the absolute gravitoelectrostatic unit of charge.

Table 3. Electromagnetism

Charge	Impedance of Electromagnetic Field	Magnetic Flux
q, C	$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = \mu_0 c\ , \Omega$	ϕ_q, Wb
Electric Current	Magnetic Parameter	Electric Potential
I_q, A	$\mu_{0,}\ Hm^{-1}$	U_q, V
Magnetic Field Intensity	Electric Parameter	Electric Field
$\boldsymbol{H}_q, Am^{-1}$	$\varepsilon_0 = (\mu_0 c^2)^{-1}, \phi m^{-1}$	$\boldsymbol{E}_q, Vm^{-1}$
Electric Flux Density	Electrodynamic Constant	Magnetic Flux Density
$\boldsymbol{D}_q, Cm^{-2}$	c, ms^{-1}	$\boldsymbol{B}_q, Wbm^{-2}$

All elementary particles in the World are fully characterized by their four-momentum $\left(\frac{E}{c}, \boldsymbol{p}\right)$ that satisfies the following equation:

$$(\frac{E}{c})^2 - \boldsymbol{p}^2 = Inv = (mc)^2 \qquad 3.1.1$$

where the invariant is, in fact, the gravitoelectrostatic charge mc squared, and E is the gravitoelectromagnetic charge.

Table 4. Gravitoelectromagnetism

Mass	Impedance of Gravitational Field	Gravitomagnetic Flux
m, kg	$Z_g = \sqrt{\frac{\mu_g}{\varepsilon_g}} = \mu_g c$	$\phi_m, m^2 s^{-1}$
Mass Current	Gravitomagnetic Parameter	Gravitoelectric potential
I_m, kgs^{-1}	$\mu_g = \frac{4\pi G}{c^2}$	$U_m, m^2 s^{-2}$
Gravitomagnetic Field Intensity	Gravitoelectric Parameter	Gravitoelectric Field
$\boldsymbol{H}_m, kgm^{-1}s^{-1}$	$\varepsilon_g = (\mu_g c^2)^{-1}$	$\boldsymbol{E}_m, ms^{-2}$
Gravitoelectric Flux Density	Gravitoelectrodynamic Constant	Gravitomagnetic Flux Density
$\boldsymbol{D}_m, kgm^{-2}$	c, ms^{-1}	$\boldsymbol{B}_m, s^{-1}$

The inertial mass and the gravitational mass are not the same physical quantity. Instead, they are proportional to each other, and their ratio equals to the gravitoelectrodynamic constant c. The classical theory offers no compelling reason why the gravitational mass mc has to equal the inertial mass m, commonly referred to as "rest mass."

Analogous to electromagnetism, we can think of m as a gravitocapacitor. Then, $E = mc^2$ describes the accumulation of energy by gravitocapacitor with capacity m, rather than transformation of energy to mass.

When a gravitoelectrostatic charge of a particle equals to momentum p_{DB}, gravitomagnetic flux ϕ_{DB} is

$$\phi_{DB} = \frac{h}{p_{DB}} = \lambda_{DB} \qquad 3.1.2$$

known as de Broglie wavelength. The notion of "wavelength" is thus a macroscopic notion, namely, gravitomagnetic flux of particles characterized by four-momentum only.

3.2. Magnetic Monopole, Magnetic Dipole

Maxwell's equations of electromagnetism relate the electric and magnetic fields to each other and to the motions of electric charges. The standard equations provide for electric charges, but they posit no magnetic charges [Wikipedia, Magnetic monopole].

Let's start from the original equations. The Dirac's equation introduces the magnetic monopole:

$$\frac{e\mu}{4\pi\varepsilon_0} = n\frac{hc}{4\pi} \qquad 3.2.1$$

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

$$\frac{e^2}{4\pi\varepsilon_0} = \frac{\alpha hc}{2\pi} \qquad 3.2.2$$

for $n = 1$ we obtain the minimum magnetic charge $\mu = \frac{e}{2\alpha}$.

Impedance of electromagnetic field Z_0 equals to

$$Z_0 = \frac{1}{\varepsilon_0 c} = \frac{h}{e\mu} \qquad 3.2.3$$

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

$$\mu_0 = \frac{h}{e\mu c} \qquad 3.2.4$$

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

$$[H_q] = \frac{Cm}{m^2 s} = \frac{[d_m]}{m^2 s} \qquad 3.2.5$$

where d_m is electromagnetic dipole of the electromagnetic charge q. It looks like magnetic field intensity H_q is, in fact, the current density of electromagnetic dipoles d_m. Using the constitutive relation

$$B_q = \mu_0 H_q \qquad 3.2.6$$

we can express the magnetic flux with the following equation:

$$\phi_q = \mu_0 H_q S = \mu_0 I_{d_m} \qquad 3.2.7$$

where S is a magnetic flux area, I_{d_m} is current, and H_q is the current density of electromagnetic dipoles d_m.

Magnetic flux quantum ϕ_0 can then be expressed as follows:

$$\phi_0 = \frac{h}{2e} = \mu_0 I_{d_m} = \frac{h}{e\mu c}\frac{\mu c}{2} \qquad 3.2.8$$

and the quant of electromagnetic dipole current I_{d_m} is:

$$I_{d_m} = \frac{\mu c}{2} = \frac{\frac{\mu a_0}{2}}{\tau_0} \qquad 3.2.9$$

where τ_0 is the atomic time:

$$\tau_0 = \frac{a_0}{c} \qquad 3.2.10$$

It means that the magnetic flux ϕ_q is the magnetic current of the electromagnetic dipoles:

$$d_m = \frac{\mu a_0}{2} \qquad 3.2.11$$

While the magnetic field intensity H_q is the current density of electromagnetic dipoles d_m, the electric flux density D_q is the current density of electrostatic dipoles

$$d_e = \frac{\mu a_0}{2c} \qquad 3.2.12$$

To summarize, electrostatic and electromagnetic monopoles are not the subjects of Maxwell-Lorentz equations; instead, currents and current densities of the electrostatic and electromagnetic dipoles are. We will subsequently refer to electrostatic and electromagnetic dipoles as simply Magnetic Dipoles (MDs). Previously, we have also used the term "DIRAC" to refer to these particles (Section 2.9.)

So-called "auxiliary" magnetic field intensity and electric flux density are indeed real physical characteristics of the electromagnetic field. They refer to current density of magnetic dipoles.

DIRACs have negligible electrostatic and electromagnetic charges, since the separation between charges is very small ($\frac{a_0}{2}$). They do, however, possess a substantial electromagnetic dipole momentum d_{em} that equals to half of the Bohr magneton μ_B:

$$d_{em} = \frac{\mu_B}{2} = 4.63700484(10) \times 10^{-24} \ \frac{J}{T} \qquad 3.2.13$$

The same conclusion can be derived for ELOPs – magnetic dipoles made of two preons: they have negligible charge and a dipole momentum that we will assume to equal to the nuclear magneton μ_N:

$$\mu_N = \frac{eh}{4\pi m_p} = 5.05078324(13) \times 10^{-27} \ \frac{J}{T} \qquad 3.2.14$$

It is interesting to proceed with the same approach for the gravitoelectromagnetic field. It turns out that:

- The quant of the gravitoelectromagnetic dipole is $\frac{hc}{4\pi}$;
- The quant of the gravitoelectrostatic dipole is $\frac{h}{4\pi}$ (spin of fermions);
- The gravitomagnetic field intensity is the current density of MDs $\frac{hc}{4\pi}$;
- The gravitoelectric flux density is the current density of the MDs $\frac{h}{4\pi}$.

3.3. Dirac's Equation for Gravitoelectromagnetic Field

Recall Dirac's magnetic monopole equation:

$$\frac{e\mu}{4\pi\varepsilon_0} = n\frac{hc}{4\pi} \qquad 3.3.1$$

This equation is known as the Dirac quantization condition. Wikipedia [Magnetic monopole] says: *The hypothetical existence of a magnetic monopole would imply that the electric charge must be quantized in certain units; also, the existence of the electric charges implies that the magnetic charges of the hypothetical magnetic monopoles, if they exist, must be quantized in units inversely proportional to the elementary electric charge.*

The charge of Dirac's monopole equals to

$$\mu = n\frac{\varepsilon_0 hc}{e} = n\frac{e}{2\alpha} \qquad 3.3.2$$

and the minimum charge (*n=1*) is:

$$\mu = \frac{e}{2\alpha} \qquad 3.3.3$$

Taking into account the analogy between electromagnetic and gravitoelectromagnetic fields, we can rewrite the same equation for masses of a gravitoelectromagnetic field:

$$\frac{mM}{4\pi\varepsilon_g} = \frac{hc}{2\pi}\frac{mM}{M_P^2} = n\frac{hc}{4\pi} \qquad 3.3.4$$

Taking $n = 1$, we obtain the minimum product of the masses

$$mM = \frac{1}{2}M_P^2 = 2.36904 \times 10^{-16}\ kg^2 \qquad 3.3.5$$

Two particles or microobjects will not exert gravity on one another when both of their masses are smaller than the Planck mass. Planck mass can then be viewed as the mass of the smallest macroobject capable of generating the gravitoelectromagnetic field, and serves as a natural borderline between classical and quantum physics. In our opinion, cosmic dust particles with masses around M_P are the smallest building blocks of all macroobjects.

Incidentally, in his "Interpreting the Planck mass" paper [33], B. Hammel showed that the Plank mass is *a lower bound on the regime of validity of General Relativity*.

The Planck mass plays a key role in our Model. Using the following equation,

$$Q^{\frac{1}{2}} = \frac{M_P}{2m_0} \qquad 3.3.6$$

masses of all macroobjects of the World can be expressed in terms of M_P as follows:

$$M_W = 4\pi m_0 \times Q^2 = \frac{\pi}{4}\frac{M_P^4}{m_0^3} \qquad \text{World}$$

$$M_{ESS} \propto m_0 \times Q^{\frac{3}{2}} \propto \frac{M_P^3}{m_0^2} \qquad \text{Extrasolar systems}$$

$$M_B \propto \frac{M_P^2}{m_a} \propto \frac{M_P^3}{m_0^2} \qquad \text{Boson stars}$$

$$m_{dp} \propto M_P \qquad \text{Dust particles}$$

The sizes of macroobjects can be expressed in terms of M_P as well:

$$R = a \times Q = \frac{M_P^2}{4m_0^2}a \qquad \text{World}$$

$$L_{ESS} \propto L_g = a \times Q^{\frac{1}{2}} = \frac{M_P}{2m_0}a \qquad \text{Extrasolar systems, Boson stars}$$

$$D_{dp} \propto L_F = a \times Q^{\frac{1}{4}} = (\frac{M_P}{2m_0})^{\frac{1}{2}}a \qquad \text{Dust particles}$$

Neutralino is the heaviest particle in our model: $m_N = 2.3441924 \times 10^{-24}\ kg$. The smallest mass of a macroobject with which a neutralino would interact M_{min} equals to

$$M_{min} = \frac{1}{2}\frac{M_P^2}{m_N} = 1.0106 \times 10^8\ kg \qquad 3.3.7$$

M_{min} is then the smallest mass of a macroobject produced by a Medium fluctuation that could initiate a gravitational collapse of particles.

Two smaller objects whose masses are close to M_P could initiate a gravitational collapse as well. Cosmic dust particles discussed above could be playing a significant role in this process.

Let's calculate the magnitudes of fluctuations required to produce macroobjects possessing the minimum mass M_{min}.

For galaxies with an average density

$$\rho_G \propto \rho_{cr} \times Q^{\frac{1}{8}} \tag{3.3.8}$$

the minimum size of a fluctuation is

$$R_{Gmin} \cong 3 \times 10^9\ m \tag{3.3.9}$$

which is much smaller than the size of a galaxy ($\sim 10^{21}\ m$).

For extra-solar systems with an average density

$$\rho_{ESS} \propto \rho_{cr} \times Q^{\frac{1}{4}} \tag{3.3.10}$$

the minimum size of a fluctuation is

$$R_{ESSmin} \cong 6.6 \times 10^7\ m \tag{3.3.11}$$

which is much smaller than the size of extra-solar system ($\sim 10^{16}\ m$). R_{ESSmin} is about 10 times smaller than the radius of the Sun $\cong 7 \times 10^8\ m$.

To produce a dust particle with mass m_{dpmin}

$$m_{dpmin} = M_p = 2.1767 \times 10^{-8}\ kg \tag{3.3.12}$$

the minimum size of a fluctuation in galaxies is:

$$r_{Gmin} \cong 1.8 \times 10^4\ m \tag{3.3.13}$$

and in ESS

$$r_{ESSmin} \cong 4 \times 10^2\ m \tag{3.3.14}$$

These calculations are true for present conditions of the Medium, but the properties of the Medium are changing with time. Let's consider how the first macroobjects arose.

At the Beginning when the radius of the World was equal to a and the density ρ_{cr0} equaled to

$$\rho_{cr0} = 3\rho_0 \tag{3.3.15}$$

the extrapolated total energy inside of the Nucleus of the World was equal to

$$E_{W0} = 4\pi E_0 \tag{3.3.16}$$

which is sufficient to produce DIRACs and lighter particles only.

The conditions for generating the very first ensemble of particles actualized when the size of the World was about the Compton length of a preon. The total energy at that time was equal to:

$$E_W\left(Q = \frac{3}{\alpha}\right) = \frac{36\pi E_0}{\alpha^2} \tag{3.3.17}$$

The conditions for generating the first objects actualized when the size of the World was about the Bohr radius multiplied by 2π. The total energy at that time was equal to:

$$E_W\left(Q = \frac{1}{\alpha^2}\right) = \frac{4\pi E_0}{\alpha^4} \tag{3.3.18}$$

and the Planck mass was equal to twice the mass of WIMPs:

$$M_P = 2m_{WIMP} = 2\frac{m_0}{\alpha} \tag{3.3.19}$$

At that time, neutralinos (the heaviest particles in our model with mass $m_N = \frac{m_0}{\alpha^2}$) could initiate a gravitational collapse of particles heavier than $2m_0$ (neutralinos, WIMPs, protons, Dirac's bidipoles with mass $2m_0$) with the resulting microobject – nucleus. All lighter particles would then be attracted to the nucleus, increasing its mass and initiating the main-sequence star formation.

Two smaller particles – Dirac's dipoles (DIRACs) and bidipoles, whose masses are m_0 and $2m_0$, could initiate a gravitational collapse as well, resulting in nucleus of a red star.

3.4. Elementary Charge

Conceptually, Maxwell's equations describe how electric charges and electric currents act as sources for the electric and magnetic fields. Further, it describes how a time varying electric field generates a time varying magnetic field and vice versa [Wikipedia, Maxwell's equations].

Maxwell's equations produce only two physically measurable quantities: energy density ρ_E, and energy flux density $\boldsymbol{j}_E$. Other notions – electrical field, magnetic field, etc. – describe the behavior of the Medium, and are only used to calculate ρ_E and $\boldsymbol{j}_E$.

Maxwell's equations then take densities ρ_q and current densities $\boldsymbol{j}_q$ of electric charges as inputs, and calculate the energy density and energy flux density of the electromagnetic field. While the dimensions of charges are our choice, the dimensions of the output characteristics of the electromagnetic field are solid – energy density and energy flux density.

Based on these speculations, it seems reasonable to use Energy for the dimension of the electromagnetic charge, and Momentum for electrostatic charge. Maxwell's equations will then use the characteristics of an electromagnetic field having the same dimensions.

With this generalization of MLE, the notion of charge takes on a new physical meaning. We will use the electron rest energy E_e as the unit of electromagnetic charge. Positron possesses the same amount of energy. Electron-positron annihilation is simply a release of their combined energy. There is of course a difference between particle and anti-particle electromagnetic quants of energy. One way to explain this difference is the resonance effect of the ponderomotive forces between two pulsating spheres immersed in the Medium of the World.

Lord Kelvin and C.A. Bjerknes investigated this mechanism between 1870 and 1910. Bjerknes showed that when two spheres immersed in an incompressible fluid were pulsated, they exerted a mutual attraction which obeyed Newton's inverse square law if the pulsations are in phase. The spheres repelled when the phases differed by a half wave [34].

We apply this 140 years old mechanism to electric charges interaction. Recall the first line of Maxwell's equations for electromagnetic field:

$$e \qquad \frac{2\alpha h}{e^2} \qquad \frac{h}{2e} \tag{3.4.1}$$

Using the flexibility of the electromagnetic charge dimension we replace e with $e_g = 4\pi(\frac{L_F}{2\pi})^2$. Magnetic parameter μ_0

$$\mu_0 = \frac{2\alpha h}{ce^2} \tag{3.4.2}$$

transforms into μ_{0g}:

$$\mu_{og} = \frac{2\alpha h}{ce_g^2} = \frac{2\pi^2 \alpha}{3} \frac{\rho_{cr}}{c^2} = \frac{\rho_p}{c^2} \qquad 3.4.3$$

μ_{0g} precisely equals to the value of proton mass density in the Medium of the World (see 2.5.5).

It follows that we can treat the electromagnetic field with constant magnetic parameter μ_0 in the time varying gravitational Medium with the magnetic parameter μ_{0g} (which is the Medium's partial proton mass density proportional to t^{-1}) and the time varying electric charge e_g proportional to $t^{\frac{1}{2}}$ as a sphere with the radius $\frac{L_F}{2\pi}$ proportional to $t^{\frac{1}{4}}$.

Of course, we can return to the equation describing the electromagnetic field with the constant magnetic parameter using $\frac{L_F}{2\pi} \rightarrow r_e$ transformation:

$$4\pi r_e^2 \qquad \frac{2\alpha h}{c(4\pi r_e^2)^2} \qquad \frac{h}{8\pi r_e^2} \qquad 3.4.4$$

The electron can then be viewed as a pulsating sphere with radius r_e.

Energy irradiated by the pulsating spheres is compensated by the energy flux through the closed surfaces of objects from the surrounding Medium of the World.

In our Model, energy of an object equals to the area of a closed surface multiplied by the surface enthalpy σ_0:

$$E_e = 4\pi r_e^2 \sigma_0 \qquad 3.4.5$$

We use 3.4.5 to calculate the radius of an electron:

$$r_e = (\pi\alpha)^{\frac{1}{2}} a_0 = 0.15141105 a_0 \qquad 3.4.6$$

Electron radius r_e is about 6.6 times smaller than the classical electron radius a_0.

It is interesting to proceed with the same approach for the gravitoelectromagnetic field. The first line of Maxwell's equations for gravitoelectromagnetism is:

$$m \qquad \frac{4\pi G}{c^2} c \qquad \phi_m \qquad 3.4.7$$

Using the flexibility of the gravitoelectromagnetic charge dimension we replace m with $m_g = \frac{a^3}{2L_{Cm}}$, where L_{Cm} is a Compton length of mass m. Gravitomagnetic parameter μ_g

$$\mu_g = \frac{4\pi G}{c^2} \qquad 3.4.8$$

transforms into μ_{gg}:

$$\mu_{gg} = \frac{2}{3} \frac{\rho_{cr}}{c^2} = \frac{\rho_M}{c^2} \qquad 3.4.9$$

μ_{gg} precisely equals to the value of the Medium energy density ρ_M over c^2. The impedance of gravitational field $Z_{gg} = \mu_{gg} c$ is the energy current density of the Medium over c^2. These conclusions emphasize the physical meaning and significance of energy density ρ_{cr} as one of the main characteristic of the World.

Gravitomagnetic Flux ϕ_m transforms to mass current $I_m = \frac{I_E}{c^2}$, where I_E is energy current, and gravitomagnetic flux density B_m becomes energy current density over c^2.

The same approach can be used for all particles in the Medium: protons, electrons, photons, neutrinos, and dark matter particles, whose energy densities were discussed in Sections 2.7, 2.9.

To summarize, electromagnetic and gravitoelectromagnetic charge can be expressed as Energy, or alternatively as Area multiplied by σ_0.

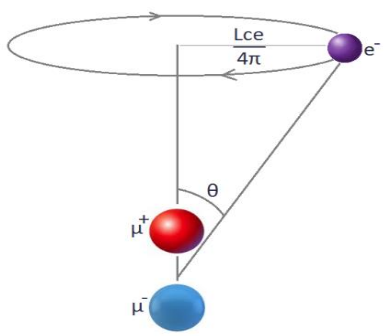
3.5. Model of an Electron

The main idea of quantization of an electron electric charge e is connected to the existence of a magnetic monopole with an electric charge μ which is located close enough to the electron. We transform this idea and propose the existence of a magnetic dipole close to the electron.

A model of an electron in a semi-classical approach can then be pictured as follows: pulsating sphere with radius r_e and an electromagnetic energy E_e is rotating around a stationary magnetic dipole axis at a distance $\frac{L_{Ce}}{4\pi}$ from the axis and $\frac{L_{Ce}}{4\pi \sin\theta}$ from the dipole, where θ is the angle between the dipole axis and the direction to the rotating electron that satisfies the following equation:

$$cos\,\theta = \pm\sqrt{\frac{1}{3}} \quad 3.5.1$$

The different signs ($\pm$) correspond to an electron ($+$) and a positron ($-$) rotating on the different sides of the stationary magnetic dipole. It is a well-known result of electromagnetic theory for stable rotation of the point charge around the stationary point dipole.



In this "Cone" model of an electron, the orbital angular momentum L equals to spin $s = \frac{h}{4\pi}$, and the orbital magnetic dipole momentum equals to $\frac{\mu_B}{2}$. The dipole momentum of the magnetic dipole also equals to $\frac{\mu_B}{2}$ (3.2.13). The total magnetic momentum then equals to μ_B – the Bohr magneton.

The classical model introduces *g*-factor with a value of 2 to explain the magnetic momentum of an electron. The Cone model avoids introduction of an additional arbitrary parameter.

Electrical potential U_d of a magnetic dipole is

$$U_d = \frac{\mu_B}{2}\frac{cos\,\theta}{4\pi\varepsilon_0 r^2} \quad 3.5.2$$

and interaction energy E_{ed} between the electron and the magnetic dipole is

$$E_{ed} = eU_d \quad 3.5.3$$

Taking b for the radius of an electron rotation, we obtain

$$E_{ed} = \frac{a\cos\theta\,(\sin\theta)^2}{16\pi^2 b^2} hc \qquad 3.5.4$$

We proceed to calculate the rotation radius b of an electron with spin $\frac{h}{4\pi}$ rotating with momentum $m_e v$:

$$b = \frac{h}{4\pi m_e v} \qquad 3.5.5$$

and

$$E_{ed} = \alpha E_e \cos\theta\,(\sin\theta)^2 \frac{v^2}{c^2} \qquad 3.5.6$$

When $v = c$:

$$E'_{ed} = \frac{2\sqrt{3}}{9}\,\alpha E_e \cong 1.4353\ keV \qquad 3.5.7$$

When $v = \alpha c$ (as it is in an atom):

$$E''_{ed} = \frac{2\sqrt{3}}{9}\alpha^3 E_e \cong 0.07643\ eV \cong 887\ K \qquad 3.5.8$$

Note that according to 3.5.8, the electron binding energy is quite low, and the energy required for removal of an electron from a magnetic dipole can easily be supplied by an application of an electric field or temperature.

The above "Cone" model is rough, as it does not take the mass of the dipole m_0 into account. Likewise, we have simplistically assumed that the dipole is stationary. It would be interesting to develop this model into a full-fledged theory, as the concept of "Cone" construction of charges around magnetic dipoles may come useful in other applications as well.

Magnetic Dipole – DIRAC – is a unique creature of the World. A DIRAC is comprised of two monopoles. The monopoles possess electrical charges of μ^+ and μ^-, and masses of $\frac{m_0}{2}$. The charge-to-mass ratio of a monopole equals to that of an electron. DIRACs have a spin of 0, and consequently they are bosons. In our opinion, fermions μ^+ and μ^- with masses $\frac{m_0}{2}$ are the smallest building blocks of a cluster structure of protons, WIMPs, neutralinos, constituent masses of Up and Down quarks, mesons, pions, etc.

More than 60 years ago, Y. Nambu proposed an empirical mass spectrum of elementary particles with a mass unit close to one quarter of the mass of a pion (about $\frac{m_0}{2} \cong 35\ MeV/c^2$) [35]. He noticed that meson masses are even multiples of a mass unit $\frac{m_0}{2}$, baryon (and also unstable lepton) masses are odd multiples, and mass differences among similar particles are quantized by $m_0 \cong 70\ MeV/c^2$. During the last 40 years M. H. Mac Gregor studied this property extensively [36].

3.6. Fractal Structure of Particles

We are all agreed that your theory is crazy. The question that divides us is whether it is crazy enough to have a chance of being correct.

Niels Bohr

In our Model, the masses of all particles of dark matter are proportional to basic mass m_0, and the coefficient of the proportionality is the fine-structure constant raised to different exponents. Each particle is $\frac{1}{\alpha}$ times heavier than the previous one, and in our Model, is indeed built out of lighter particles. We will now take a closer look at this phenomenon.

In order for a larger particle to be $\frac{1}{\alpha} \approx 137$ times heavier than the lighter one, it has to be composed of more than 137 lighter particles, taking binding energy into account. There is then nothing surprising about the value of the Fine Structure Constant not being an integer value.

The number of constituent particles is not presently known, but we do know that it must satisfy two criteria: it must be odd, since all particles under consideration are fermions, and it must be divisible by 3, since in our Model, heavier particles often consists of 3 clusters of lighter ones. The smallest number to satisfy these conditions is $141 = 3 \times 47$, and we will use it in subsequent equations as an example; but keep in mind that $147 = 3 \times 49$, $153, 159$ etc. would fit our Model just as well.

In our Model, sterile neutrino is the lightest particle of Dark Matter. An electron is $\frac{1}{\alpha}$ heavier and consists of 3 preons of 47 sterile neutrinos each. An ELOP is a dipole made up of two preons. Other Dark Matter particles are organized in a similar fashion.

We assume that Dirac's monopoles with mass $\frac{m_0}{2} \cong 35\ MeV/c^2$ are the basic building blocks of fractal cluster structures of different hadron particles. Protons, WIMPs, neutralinos, mesons, pions, constituent masses of Up and Down quarks are all built from Dirac's monopoles. Additionally, Dirac's monopoles are the agent responsible for the strong nuclear interaction.

All "elementary" particles of the World are fermions and they possess masses. Bosons such as photons, X-rays, and gamma rays are composite particles and consist of an even numbers of fermions.

An axion is the boson possessing the lowest mass m_a (see section 2.6). It consists of two interacting neutrinos (one of the possible super-weak interactions, see section 3.7), for example electron and muon neutrinos:

$$m_a = \left(\frac{\alpha}{\beta}\right)^{\frac{1}{2}} m_0 \times Q^{-\frac{1}{2}} < \frac{m_{\nu_e} m_{\nu_\mu}}{m_0} = \frac{1}{24} m_0 \times Q^{-\frac{1}{2}} \qquad 3.6.1$$

Gamma rays are usually distinguished from X-rays by their origin: *X-rays are emitted by electrons outside the nucleus, while gamma rays are emitted by the nucleus* [Wikipedia, Gamma ray]. A better way to distinguish the two, in our opinion, is the type of fermions composing the core of X-quants and Gamma-quants.

Super soft X-rays [Wikipedia, Super soft X-ray source] have energies in the 0.09 to 2.5 keV range, whereas soft Gamma rays have energies in the 10 to 5000 keV range. We assume that X-quants are composed of two interacting muonic and tauonic neutrinos. We will name this dineutrino "Xion". It possesses rest mass of $m_X \sim m_0 \times Q^{-\frac{1}{4}}$, which is decreasing with time: $m_X \propto t^{-\frac{1}{4}}$. New Physics with the dineutrinos in the Rare Decay $B \rightarrow K\nu\bar{\nu}$ is actively discussed in literature in the last years (see, for example [43, 44]).

Soft Gamma-quants are composed of two sterile neutrinos (*3.7 keV* each). Hard and super-hard Gamma-quants may be composed of two preons (0.17 MeV each), which are ELOPs in our Model, two Dirac's monopoles (*35 MeV* each) which are, in fact, DIRACs. Rest masses of Gamma-quants $m_G \sim 2\alpha^2 m_0$ remain constant with time. We will name these bosons "Gions".

As a result of electron-positron annihilation in the low energy case, two or three gamma ray photons are created. At the first step the interaction of electron and positron stimulates decomposition of their cluster structures into three preons each. The six preons combine into 3 ELOPs, which form the cores of gamma ray photons.

The reverse reaction, electron-positron creation, is a form of pair production from three ELOPs in the Medium of the World induced, for example, *by a super-strong intrinsic magnetic field and a circularly polarized electromagnetic wave propagating along the magnetic field lines in the magnetized pair plasma near the polar caps of the pulsar* [37].

3.7. Grand Unified Theory

The Grand Unified Theory is a model in particle physics in which at high energy, the three gauge interactions of the Standard Model which define Weak, Electromagnetic, and Strong interactions, are merged into one Single interaction characterized by one Larger gauge symmetry and thus one Unified Coupling constant [Wikipedia, Grand Unified Theory].

By definition: *a Coupling constant is a number that determines the strength of an interaction. Usually the Langrangian or the Hamiltonian of a system can be separated into a kinetic part and an interaction part. The Coupling constant determines the strength of the interaction part with respect to the kinetic part, or between two sectors of the interaction part* [Wikipedia, Coupling constant].

For example, the gravitational coupling parameter α_G can be defined as follows:

$$\alpha_G = \frac{2\pi G m_e^2}{hc} = (\frac{m_e}{M_P})^2 \quad 3.7.1$$

and the electromagnetic coupling constant α_{EM} as:

$$\alpha_{EM} = \frac{e^2}{2\varepsilon_0 hc} = \alpha \quad 3.7.2$$

α determines the strength of the electromagnetic force of electrons.

At an atomic scale, the strong interaction is about 100 times stronger than electromagnetic interaction, which in turn is about 10^{10} times stronger than the weak force, and about 10^{40} times stronger than the gravitational force, when forces are compared between particles interacting in more than one way.

All these definitions are based on **strength** of the force between a particular pair of particles, and depend on the choice of such particles. Clearly, the gravity between a pair of electrons will differ from that of a pair of protons.

A different way of comparing interactions is looking at their cross-sections. According to Wikipedia, *the concept of a Cross-section is used to express the likelihood of an interaction between particles* [Wikipedia, Cross section (physics)]. In our opinion, all fundamental interactions of the World should be described and compared using their **cross-sections**, which are the measure of the interaction likelihood, and don't depend on the choice of particles. The larger the cross-section, the faster an interaction occurs.

For example, an electromagnetically decaying neutral pion has a life of about 10^{-16} seconds; a weakly decaying charged pion lives for about 10^{-8} seconds, and a free neutron lives for about 15 minutes, making it the unstable subatomic particle with the longest known mean life.

Let's start with the gravitational interaction which is expressed by gravitational parameter G:

$$G = \frac{1}{4\pi\varepsilon_g} \qquad 3.7.3$$

Recall from Section 3.1 that we are free to choose an arbitrary charge transformation parameter K without affecting the outcome of force, energy density, and energy flux density calculations.

Let's choose $K = \frac{c}{h}$ and express mass m of an object in terms of Compton length L_{Cm} by multiplying m by K:

$$mK = m\frac{c}{h} = \frac{1}{L_{Cm}} \qquad 3.7.4$$

and divide the interaction parameter $G = \frac{1}{4\pi\varepsilon_g}$ by the same coefficient K squared:

$$G(\frac{h}{c})^2 = P \times Q^{-1} \qquad 3.7.5$$

where parameter $P = \frac{a^2 hc}{8\pi}$.

By dividing the left side of 3.7.5 by P we obtain the dimensionless gravitational coupling parameter α_G:

$$\alpha_G = Q^{-1} \qquad 3.7.6$$

Note that following this transformation, the dimension of the gravitoelectric field is "Energy," and the dimension of the gravitomagnetic flux density is "Momentum". Then the well-known fundamental invariant of the electromagnetic field

$$(\frac{\boldsymbol{E}_q}{c})^2 - \boldsymbol{B}_q^2 = Inv \qquad 3.7.7$$

transforms into the fundamental invariant of the gravitoelectromagnetic field:

$$(\frac{\boldsymbol{E}_m}{c})^2 - \boldsymbol{B}_m^2 = Inv \qquad 3.7.8$$

and resembles the fundamental invariant of the particles:

$$(\frac{E}{c})^2 - \boldsymbol{p}^2 = Inv = (mc)^2 \qquad 3.7.9$$

Let's use the same approach for electromagnetic interaction: divide the charge e by the magnetic dipole $\frac{\mu a_0}{2}$:

$$\frac{e}{\mu a_0/2} = \frac{8\pi\alpha}{a} \qquad 3.7.10$$

and multiply the interaction parameter $\frac{1}{4\pi\varepsilon_0}$ by the magnetic dipole squared:

$$\frac{1}{4\pi\varepsilon_0}(\frac{\mu a_0}{2})^2 = \frac{1}{16\pi^2\alpha}P \qquad 3.7.11$$

We calculate the dimensionless electromagnetic coupling parameter α_{EM}:

$$\alpha_{EM} = (16\pi^2\alpha)^{-1} \cong 0.8678 \qquad 3.7.12$$

Neglecting the difference between α_{EM} and value of 1, we can see that the ratio of the coupling parameters is

$$\frac{\alpha_G}{\alpha_{EM}} = Q^{-1} = 1.3156 \times 10^{-40} \qquad 3.7.13$$

because the cross-section of the gravitational interaction is Q times smaller than the cross-section of the electromagnetic interaction.

In particle physics, Fermi's interaction also known as Fermi coupling is an old explanation of the weak force, proposed by Enrico Fermi, in which four fermions directly interact with one another at one vertex. For example, this interaction explains beta decay of a neutron by direct coupling of a neutron with an electron, antineutrino, and a proton. The interaction could also explain muon decay via a coupling of a muon, electron-antineutrino, a muon- antineutrino and electron. The Feynman diagrams describe the interaction remarkably well [Wikipedia, Fermi's interaction].

The strength of Fermi's interaction is given by the Fermi's coupling parameter G_F:

$$\frac{8\pi^3 G_F}{(hc)^3} = \frac{\sqrt{2}}{8}\frac{g^2}{M_W^2} = 1.16637 \times 10^{-5}\, GeV^{-2} \qquad 3.7.14$$

Here g is the coupling parameter of the weak interaction, and M_W is the mass of the W boson.

In our Model, the following four fermions take part in beta decay of a neutron: a proton with mass m_p, an electron with mass m_e, a monopole with mass $\frac{m_0}{2}$, and an electron antineutrino with mass $\frac{m_F}{24}$. If we now use $\frac{m_p}{m_e}\frac{m_F/24}{m_0/2}$ in the Fermi's coupling parameter equation, then we can calculate the G_{Fth} to be

$$\frac{8\pi^3 G_{Fth}}{(hc)^3} = 16\pi^3 \frac{\sqrt{2}}{8}\frac{m_p}{m_e}\frac{m_F/24}{m_0/2}\frac{P}{(hc)^3} =$$

$$= 8\pi^3 \frac{\sqrt{2}}{8}\frac{\beta}{6\alpha}\frac{P}{(hc)^3} \times Q^{-\frac{1}{4}} = 1.16621 \times 10^{-5}\, GeV^{-2} \qquad 3.7.15$$

which is quite close to the presently adopted value of $G_{Fexp} = 1.16637 \times 10^{-5}\, GeV^{-2}$.

The accuracy of the above calculations depends on the accuracy of measurement of the gravitational parameter G, that is not better than 10^{-4} at present time.

The equality of G_{Fth} and G_{Fexp} yields an electron antineutrinos mass of $\frac{m_F}{24}$, that corresponds to its contribution to the energy density of the World's Medium (Section 2.7).

We find the cross-section of the weak interaction by multiplying $\frac{G_F}{(hc)^3}$ by $(hc)^3 \frac{8}{\sqrt{2}}\frac{6\alpha}{\beta}$:

$$\frac{8}{\sqrt{2}}\frac{6\alpha}{\beta} G_F (hc)^3 = G_F^* = P \times Q^{-1/4} \qquad 3.7.16$$

with the dimensionless weak interaction coupling parameter α_W:

$$\alpha_W = Q^{-1/4} \qquad 3.7.17$$

and the ratio of α_W to α_{EM}

$$\frac{\alpha_W}{\alpha_{EM}} = Q^{-1/4} = 1.0710 \times 10^{-10} \qquad 3.7.18$$

As for the strong interaction, the dimensionless coupling parameter α_S equals to the coupling parameter of the electromagnetic interaction α_{EM}:

$$\alpha_S = \alpha_{EM} = 1 \qquad 3.7.19$$

The difference in the strong and the electromagnetic interactions is not in the coupling parameters but in the **strength** of these interactions depending on the particles involved: electrons with charge e and monopoles with charge μ in electromagnetic and strong interactions respectively.

At the very Beginning ($Q = 1$) all extrapolated fundamental interactions of the World had the same cross-section $\frac{a^2}{4}$ and were characterized by the Unified coupling constant:

$$\alpha_U = \alpha_S = \alpha_{EM} = \alpha_W = \alpha_G = 1 \qquad 3.7.20$$

At that time, the energy density of the World ρ_{cr0} and the equivalent mass density $\frac{\rho_{cr0}}{c^2}$ were:

$$\rho_{cr0} = \frac{3hc}{a^4} = 6.0640 \times 10^{30} \ \frac{J}{m^3} \qquad 3.7.21$$

$$\frac{\rho_{cr0}}{c^2} = \frac{3m_0}{a^3} = 6.7470 \times 10^{13} \ \frac{kg}{m^3} \qquad 3.7.22$$

Note that the mass density at the Beginning is much smaller than the nuclear density $\sim 10^{17} \ \frac{kg}{m^3}$. The average energy and mass density of the World has since been decreasing, and their present values are given by

$$\rho_{cr} = \rho_{cr0} \times Q^{-1} = 7.9775 \times 10^{-10} \ \frac{J}{m^3} \qquad 3.7.23$$

$$\frac{\rho_{cr}}{c^2} = \frac{\rho_{cr0}}{c^2} \times Q^{-1} = 8.8760 \times 10^{-27} \ \frac{kg}{m^3} \qquad 3.7.24$$

The gravitational coupling parameter α_G is similarly decreasing:

$$\alpha_G = Q^{-1} \propto t^{-1} \qquad 3.7.25$$

The weak coupling parameter is decreasing as follows:

$$\alpha_W = Q^{-\frac{1}{4}} \propto t^{-\frac{1}{4}} \qquad 3.7.26$$

The strong and electromagnetic parameters remain constant in time:

$$\alpha_S = \alpha_{EM} = 1 \qquad 3.7.27$$

Our Model predicts two more types of interactions:

- Super weak with the coupling parameter α_{SW}:

$$\alpha_{SW} = Q^{-\frac{1}{2}} \qquad 3.7.28$$

- Extremely weak with the coupling parameter α_{EW} :

$$\alpha_{EW} = Q^{-\frac{3}{4}} \qquad 3.7.29$$

3.8. Micro World, Small World, Large World

Following the approach developed in Section 3.3, we can rewrite the same equations for masses of objects taking part in gravitational, extremely weak, super weak, and weak interactions:

$$GmM \quad = G_0 \frac{hc}{2\pi} \frac{mM}{M_P^2} \times Q^{-1} = n \frac{hc}{4\pi} \qquad 3.8.1$$

$$G_{EW}mM = G_0 \frac{hc}{2\pi} \frac{mM}{M_{EW}^2} \times Q^{-\frac{3}{4}} = n \frac{hc}{4\pi} \qquad 3.8.2$$

$$G_{SW}mM = G_0\frac{hc}{2\pi}\frac{mM}{M_{SW}^2} \times Q^{-\frac{1}{2}} = n\frac{hc}{4\pi}$$ 3.8.3

$$G_{W}mM \ = G_0\frac{hc}{2\pi}\frac{mM}{M_{W}^2} \times Q^{-\frac{1}{4}} \ = n\frac{hc}{4\pi}$$ 3.8.4

where G_0 is the extrapolated value of the gravitational parameter at the Beginning ($Q = 1$):

$$G_0 = \frac{c^4}{8\pi\sigma_0 a}$$ 3.8.5

Taking $n = 1$, we obtain the minimum products of the masses for the above interactions:

$$mM = \frac{1}{2}M_P^2 \ = 2m_0^2 \times Q \ = 2.3690 \times 10^{-16}\ kg^2$$ 3.8.6

$$mM = \frac{1}{2}M_{EW}^2 = 2m_0^2 \times Q^{\frac{3}{4}} = 2.2121 \times 10^{-26}\ kg^2$$ 3.8.7

$$mM = \frac{1}{2}M_{SW}^2 = 2m_0^2 \times Q^{\frac{1}{2}} = 2.0655 \times 10^{-36}\ kg^2$$ 3.8.8

$$mM = \frac{1}{2}M_{W}^2 = 2m_0^2 \times Q^{\frac{1}{4}} \ = 1.9286 \times 10^{-46}\ kg^2$$ 3

and the following values for the masses M_P , M_{EW} , M_{SW} , M_W :

$$M_P = 2.1767 \times 10^{-8}\ kg$$ 3.8.10

$$M_{EW} = 2.2526 \times 10^{-13}\ kg$$ 3.8.11

$$M_{SW} = 2.3312 \times 10^{-18}\ kg$$ 3.8.12

$$M_W = 2.4125 \times 10^{-23}\ kg$$ 3.8.13

From this point of view, cosmic dust grains (section 2.17) with mass $m_{gr} \sim m_{micro} = m_0 \times Q^{\frac{1}{8}}$ can exert weak interaction on one another; neutrinos with mass near $m_\nu = m_0 \times Q^{-\frac{1}{4}}$ can take part in the weak interaction with matter with mass about $M_P = 2m_0 \times Q^{\frac{1}{2}}$.

Following the approach developed in Section 2.10, we can rewrite the same equations for fermionic compact objects consisting of Dark Matter particles taking part in extremely weak, super weak, and weak interactions by replacing mass M_P for M_{EW} , M_{SW} , M_W respectively.

Let us find parameters of compact microobjects with masses $\lesssim M_P$. **Table 5** describes the parameters of microobjects made up of different fermions taking part in the weak interaction:

Table 5

Fermion	**Fermion mass** $m_f, MeV/c^2$	**Microobject mass** M_{max}, kg	**Microobject radius** R_{min}, m	**Microobject density** $\rho_{max}, kg/m^3$
Preon	0.170	8.0×10^{-8}	2.9×10^{-4}	7.8×10^{2}
Monopole	35.01	1.9×10^{-12}	6.9×10^{-9}	1.4×10^{12}
Interacting WIMPs	9,596	2.6×10^{-15}	9.5×10^{-12}	7.2×10^{17}
Interacting neutralinos	$1{,}315\times10^{3}$	2.6×10^{-15}	9.5×10^{-12}	7.2×10^{17}
Electron-proton (micro white dwarf)	0.511-938.3	2.6×10^{-15}	1.8×10^{-8}	1.2×10^{8}
Neutron (micro star)	939.6	2.6×10^{-15}	9.5×10^{-12}	7.2×10^{17}

The parameters calculated for the above microobjects show that

- Micro White Dwarf Shells (MWDS) around the nuclei made of strongly interacting WIMPs or neutralinos (Section 2.14) compose cores of micro stars;
- Dissociated DIRACs to Monopoles form cores of micro star clusters;
- Dissociated ELOPs to Preons constitute cores of micro galaxies.

These microobjects have mass $m_{micro} \propto t^{\frac{3}{8}}$, radius $r_{micro} \propto t^{\frac{1}{8}}$, and constant density in time, similar to fermionic compact stars (section 2.10).

The total mass of micro World M_{mW} is:

$$M_{mW} = 4\pi m_0 \times Q^{\frac{1}{2}} = 2\pi \times M_P = 13.677 \times 10^{-8}\, kg \qquad 3.8.14$$

and the radius of the micro World R_{mW} is:

$$R_{mW} = a \times Q^{\frac{1}{4}} = L_F = 1.6532 \times 10^{-4}\, m \qquad 3.8.15$$

Microobjects made up of preons have maximum mass larger than M_P, i.e. they are macroobjects. Their mass is sufficient to interact weakly with all microobjects and particles from neutralino with mass $m_N = 2.3441924 \times 10^{-24}\, kg$ to neutrinos with mass around $m_\nu = 1.3369051 \times 10^{-38}\, kg$:

$$M_{Preon} \times m_\nu \cong 1.1 \times 10^{-45}\, kg^2 > \frac{1}{2} M_W^2 = 1.9286 \times 10^{-46}\, kg^2 \qquad 3.8.16$$

Microobjects made up of preons interact super weakly with all microobjects and particles from neutralino to DIRACs with mass $m_{DIRAC} = m_0 = 1.2483143 \times 10^{-28}\, kg$:

$$M_{Preon} \times m_0 \cong 1.0 \times 10^{-35}\, kg^2 > \frac{1}{2} M_{SW}^2 = 2.0655 \times 10^{-36}\, kg^2 \qquad 3.8.17$$

and extremely weakly with all microobjects. All microobjects can interact super weakly with each other. Microobjects made up from monopoles and preons can interact extremely weakly with each other. Microobjects made up from preons with mass $\geq M_P$ can interact gravitationally.

Based on this analysis, one can see that micro galaxies with weak interaction parameter G_W are structured in a fashion similar to that of regular galaxies:

- Micro galaxy cores are made up of preons
- Micro star cluster cores are made up of monopoles
- Micro star cores are made up of interacting WIMPs or neutralinos

Boson micro objects made up of bosonic DM can be part of the Micro World too. Xions with mass $m_X \sim m_0 \times Q^{-\frac{1}{4}}$, Gions with mass $m_G \sim 2\alpha^2 m_0$, introduced in Section 3.6., and ELOPs with mass $m_{ELOP} = \frac{2}{3} m_e$ are good candidates for such compact micro objects.

We calculate maximum mass M_m, and minimum radius R_m of such objects:

$$M_{mX} \sim \frac{M_W^2}{m_X} = \frac{4m_0^2 \times Q^{\frac{1}{4}}}{m_0 \times Q^{-\frac{1}{4}}} = 4m_0 \times Q^{\frac{1}{2}} = 4.3534 \times 10^{-8}\, kg \qquad 3.8.18$$

$$R_{mX} \sim \frac{h}{m_X c} = a \times Q^{\frac{1}{4}} = L_F = 1.6532 \times 10^{-4}\, m \qquad 3.8.19$$

$$M_{mG} \sim \frac{M_W^2}{m_G} = \frac{4m_0^2 \times Q^{\frac{1}{4}}}{2\alpha^2 m_0} = 2m_N \times Q^{\frac{1}{4}} = 4.3777 \times 10^{-14}\ kg \qquad 3.8.20$$

$$R_{mG} \sim \frac{h}{m_G c} = \frac{a}{2\alpha^2} = \pi a_B = 1.6625 \times 10^{-10}\ m \qquad 3.8.21$$

$$M_{mELOP} \sim \frac{M_W^2}{m_{ELOP}} = \frac{4m_0^2 \times Q^{\frac{1}{4}}}{\frac{2}{3}\alpha m_0} = 6m_{WIMP} \times Q^{\frac{1}{4}} = 9.5837 \times 10^{-16}\ kg \qquad 3.8.22$$

$$R_{mELOP} \sim \frac{h}{m_{ELOP} c} = \frac{3}{2\alpha} a = \frac{3}{2} L_{Ce} = 3.6395 \times 10^{-12}\ m \qquad 3.8.23$$

Table 6 describes the parameters of small objects made up of different fermions taking part in the super weak interaction:

Table 6

Fermion	**Fermion mass** $\boldsymbol{m_f, MeV/c^2}$	**Macroobject mass** $\boldsymbol{M_{max}, kg}$	**Macroobject radius** $\boldsymbol{R_{min}, m}$	**Macroobject density** $\boldsymbol{\rho_{max}, kg/m^3}$
Sterile neutrino	3.73×10^{-3}	1.5×10^{11}	5.8×10^{4}	1.8×10^{-4}
Preon	0.170	7.2×10^{7}	2.8×10^{1}	7.8×10^{2}
Monopole	35.01	1.7×10^{3}	6.6×10^{-4}	1.4×10^{12}
Interacting WIMPs	9,596	2.3	9.2×10^{-7}	7.2×10^{17}
Interacting neutralinos	$1{,}315\times10^{3}$	2.3	9.2×10^{-7}	7.2×10^{17}
Electron-proton (small white dwarf)	0.511-938.3	2.3	1.7×10^{-3}	1.2×10^{8}
Neutron (small star)	939.6	2.3	9.2×10^{-7}	7.2×10^{17}

The total mass of small World M_{sW} is:

$$M_{sW} = 4\pi m_0 \times Q = 1.1924 \times 10^{13}\ kg \qquad 3.8.24$$

and the radius of the small World R_{sW} is:

$$R_{sW} = a \times Q^{\frac{1}{2}} = L_g = 1.5437 \times 10^{6}\ m \qquad 3.8.25$$

Xions with mass $m_X \sim m_0 \times Q^{-\frac{1}{4}}$ are good candidates for boson small objects with maximum mass M_{sX}, minimum radius R_{sX} and maximum density ρ_{sX} which is constant in time:

$$M_{sX} \sim \frac{M_{SW}^2}{m_X} = \frac{4m_0^2 \times Q^{\frac{1}{2}}}{m_0 \times Q^{-\frac{1}{4}}} = 4m_0 \times Q^{\frac{3}{4}} = 4.0650 \times 10^{2}\ kg \qquad 3.8.26$$

$$R_{sX} \sim \frac{h}{m_X c} = a \times Q^{\frac{1}{4}} = L_F = 1.6532 \times 10^{-4}\ m \qquad 3.8.27$$

$$\rho_{sX} = \frac{12 m_0 \times Q^{\frac{3}{4}}}{4\pi a^3 \times Q^{\frac{3}{4}}} = \frac{3}{\pi}\rho_0 = 2.1476329 \times 10^{13}\ \frac{kg}{m^3} \qquad 3.8.28$$

The same calculations can be performed for large objects made up of different fermions taking part in extremely weak interaction with the total mass of large World M_{lW} :

$$M_{lW} = 4\pi m_0 \times Q^{\frac{3}{2}} = 1.0396 \times 10^{33}\ kg \qquad 3.8.29$$

and the radius of the large World R_{lW} :

$$R_{lW} = a \times Q^{\frac{3}{4}} = 1.4414 \times 10^{16}\ m \qquad 3.8.30$$

3.9. Ball Lightning

According to Wikipedia, *Ball lightning is an unexplained atmospheric electrical phenomenon. Ball lightning has been described as transparent, translucent, multicolored, evenly lit, radiating flames, filaments or sparks, with shapes that vary between spheres, ovals, tear drops, rods, or disks.*

The properties of a "typical" ball lightning are:

- *They frequently appear almost simultaneously with cloud-to-ground lightning discharge*
- *They are generally spherical or pear-shaped with fuzzy edges*
- *Their diameters range from 1 – 100 cm, most commonly 10 – 20 cm*
- *Their brightness corresponds to roughly that of domestic lamp, so they can be seen clearly in daylight*
- *The lifetime of each event is from 1 second to over a minute with the brightness remaining fairly constant during that time*
- *It is rare that observers report the sensation of heat, although in some cases the disappearance of the ball is accompanied by the liberation of heat*

Peter Weiss has this to say about ball lightning [47]:

Of the many scientific theories of ball lightning, most depict the phenomenon as some kind of plasma, or hot gas of electrons and positively charged atomic or molecular ions. One major challenge to the plasma explanation for ball lightning is that plasma always expands unless great pains are taken to confine it. Fusion researches "build enormous [reactors called] tokamaks to do that sort of thing-to contain a plasma for a second" within a magnetic field for nuclear fusion experiments.

Turner says, "I don't think you can explain all the properties [of ball lightning] without accepting that it's an aerosol-related phenomenon." The notion that aerosols may be a part of ball lightning goes back to at least the 1970s, but it's currently winning unprecedented attention.

An attempt to explain ball lightning was made by Nikola Tesla in 1904 [48], but there is at present no widely accepted explanation for the phenomenon [Wikipedia, Ball lightning].

Tesla's Thoughts on Ball Lightning Production [49]:

"I hold the following explanation of the mode of production of the ball as being, most likely of all others which I have considered, the true one.

When sudden and very powerful discharges pass through the air, the tremendous expansion of some portions of the latter and subsequent rapid cooling and condensation gives rise to the creation of partial vacua in the places of greatest development of heat. These vacuous spaces, owing to the properties of the gas, are most likely to assume the shape of hollow spheres when, upon cooling, the air from all around rushes in to fill the cavity created by the explosive dilatation and subsequent contraction.

Suppose now that this result would have been produced by one spark or streamer discharge and that now a second discharge, and possible many more, follows in the path of the first. What will happen?

Before answering the question we must remember that, contrary to existing popular notions, the currents passing through the air have the strength of many hundreds and even thousands of amperes.

A single powerful streamer, breaking out from a well-insulated terminal, may easily convey a current of a several hundred amperes!

No wonder then, that a small mass of air is exploded with an effect similar to that of bombshell, as noted in many lightning discharges.

But to return now to the explanation of the fireball, let us now assume that such a powerful streamer or spark discharge, in its passage through the air, happens to come upon vacuous sphere or space formed in the manner described. This space, containing gas highly rarefied, may be just in the act of contracting , at any rate, the intense current, passing through the rarefied gas suddenly raises the same to an extremely high temperature, all the higher as the mass of the gas is very small…"

Tesla's hypothesis on the origin and maintenance of fireballs includes some points which are also to be found in the most recent theories, but it also bears the stamp of the time. For instance, Tesla considers that the initial energy of the nucleus is not sufficient to maintain the fireball, but that there must be an external source of energy.

According to Tesla "this energy comes from other lightnings passing through the nucleus", and the concentration of energy occurs because of the resistance of the nucleus, i.e. the greater energy-absorbing capacity of the rarefied gas than the surrounding gas through which the discharge passes [49].

The proposed ball lightning model is based on the following primary assumptions:

- Vacuous sphere or space forms in the manner described above. This space contains the cloud of all particles (protons, electrons, DM particles) and stardust grains with size and mass:

$$D_{gr} \sim L_{micro} = a \times Q^{\frac{1}{8}} = 1.7109 \times 10^{-9}\, m = 1.7109\, nm \qquad 3.9.1$$

$$m_{gr} \sim m_{micro} = m_0 \times Q^{\frac{1}{8}} = 1.2062 \times 10^{-23}\, kg \qquad 3.9.2$$

- Due to cloud instability, a collapse takes place. The heaviest microobjects, stardust grains, due to the weak interaction between them, sink first and form the nucleus of a new small star with mass up to $M_P \sim 10^{-8}\, kg$, size up to $L_F \sim 10^{-4}\, m$ and density about $\rho_{rock} \sim 10^4\, \frac{kg}{m^3}$.
- The next heaviest particles, neutralinos or WIMPs, will follow stardust grains due to super weak interaction with nucleus, and form the weakly interacting shell (WIS) around the nucleus with mass $\sim 10^{-9}\, kg$, size $\sim 10^{-3}\, m$ and density $\sim 1\, \frac{kg}{m^3}$. We took into account the equation 2.10.14 for compact objects with mass much smaller than the maximum mass and the density of air $\cong 1.2\, \frac{kg}{m^3}$.
- The next heaviest particles, protons, joined by electrons, will follow neutralinos or WIMPs due to super weak interaction with core and form the white dwarf shell with mass of ball lightning: $M_{BL} \cong 2.3 \times 10^{-4}\, kg$, radius $R_{BL} \cong 3.7 \times 10^{-2}\, m$ and density $\rho_{BL} \cong 1.2\, \frac{kg}{m^3}$.
- The shape and size of larger ball lightnings depend on number of cores generated in the cloud of particles and grains.
- All other particles involved could be in shells around the low density small white dwarf.

- The initial energy of the nucleus can be increased by absorbing particles and grains from the environment similar to the process inside of macro stars.

The main differences of our model from Tesla's view are as follows:

- We have cloud of particles and grains instead of highly rarefied gas.
- We assume weak and super weak interactions between grains and particles instead of the intense current, passing through the rarefied gas.

The proposed "low density small white dwarf" model describes the major properties of a "typical" ball lightning good enough.

3.10. Extreme Ball Lightning

Wallace Thornhill has this to say about extreme ball lightning [50]:

The term "extreme" distinguishes it from ordinary ball lightning produced in the laboratory. It spontaneously appears in the open-air, closed rooms, aircraft at altitude, and was seen in at least one submarine. It appears before, during or after lightning. About 5% are seen in clear weather.

However, VanDevender distinguished extreme ball lightning (EBL) by the following characteristics:

- *It glows in air;*
- *It originates from nothing visible;*
- *It lasts between 10 and 1200 seconds;*
- *It is lethal or potentially lethal;*
- *It causes significant damage;*
- *It contains energy estimated at 100,000 to 1 billion Joules, far in excess of the energy density attributable to chemicals or electrostatics;*
- *It penetrates walls, glass and metal, generally without leaving a hole;*
- *It leaves black streaks on corpses without the spasm of electrocution;*
- *It can excavate tons of earth.*

So EBL cannot be electrostatic. Many ideas have been suggested. Radio frequency excitation by a thunderstorm; polymer threads carrying large electric charges; tiny black holes; and antigravity. But to date, no theory addresses the characteristics of EBL. It is intriguing problem. VanDevender said, "It seems to require new physics."

My view is that explaining EBL doesn't require new physics. The clue comes from the observed ability of EBL to penetrate solid material. VanDevender noted that EBL "may be subatomic and electrically neutral to not violate impenetrability of matter." There is one stable subatomic particle that has the ability to pass through solids without any appreciable effect – the neutrino. But how can energy be stored in neutrinos?

In "Toward a Real Theory of Everything" I wrote, "the most collapsed form of matter is the neutrino, which has a vanishingly small mass. However, the neutrino must contain all of the charges required to form two particles – a particle and its antiparticle – in a process known as "pair production." This symmetry explains why a neutrino is considered to be its own anti-particle. A neutrino, in the presence of an atomic nucleus, may accept energy from a gamma ray to reconstitute a particle and its anti-particle. "Empty space" is full of neutrinos. They are the repositories of matter in the universe, awaiting the burst of gamma-radiation to expand them to form the stuff of atoms."

In this model of neutrino structure, neutrinos may have intermediate, unstable resonant states between their ground state and the state at which they split to form a particle and anti-particle (pair production). Therefore, EBL may be a rare phenomenon because it would require an exquisitely tuned resonant environment to "pump up" the internal energy of a population of neutrinos that happen to be "passing through".

It is known that pair production requires the presence of an atomic nucleus to catalyze the reaction. It seems likely that in the presence of an excited nucleus a neutrino may accept a lower level of energy than required for pair production and form a stable "heavy neutrino."

The model I envisage for EBL goes like this:

1. *A heavy element within environment has a resonance within the nucleus excited by lightning, cosmic rays or some other means.*
2. *Ubiquitous neutrinos drifting through the excited atoms accept energy resonantly from a number of such excited nuclei.*
3. *Following the usual relationship between mass and stored electrical energy, $E = mc^2$, the mass of the neutrino increases.*
4. *Such "heavy or excited neutrinos are distorted to form tiny electric dipoles, which will tend to clump together since they have zero net repulsive charge.*
5. *The heavy neutrinos in the EBL would need to have a total mass of a mere hundredth of a milligram to provide a gigajoule of energy.*
6. *Heavy neutrinos respond only weakly to gravity and have no buoyancy since they do not displace matter but pass right through it. This explains how EBL may pass through "walls, glass and metal, generally without leaving a hole," etc.*

We propose the following model to describe Extreme Lightning Balls:

- Vacuous sphere or space forms in the manner described above or in some other way. This space contains the cloud of all particles (protons, electrons, DM particles and boson particles – dineutrinos which we named Xion with mass $\sim 10^{-38}\ kg$, section 3.6.) and stardust grains with size $\sim 10^{-9}\ m$ and mass $\sim 10^{-23}\ kg$.
- Due to cloud instability, a collapse takes place. The heaviest microobjects, stardust grains, due to the weak interaction between them, sink first and form the nucleus of a new small star with mass about $M_P \sim 10^{-8}\ kg$, size about $L_F \sim 10^{-4}\ m$ and density about $\rho_{rock} \sim 10^4\ \frac{kg}{m^3}$.
- The next heaviest particles, neutralinos or WIMPs, will follow stardust grains due to super weak interaction with nucleus, and form the weakly interacting shell (WIS) around the core with mass $\sim 10^{-9}\ kg$, size $\sim 10^{-3}\ m$ and density $\sim 1\ \frac{kg}{m^3}$.
- The next particles, Xions, will follow neutralinos or WIMPs due to weak interaction with core and form the bosonic shell (BS) with mass of ball lightning: $M_{BL} \cong 10^{-4}\ kg$, radius $R_{BL} \cong 2.8 \times 10^{-2}\ m$ and density $\rho_{BL} \cong 1.1\ \frac{kg}{m^3}$. We assumed the same equation 2.10.14 for boson compact objects with mass much smaller than the maximum mass.
- The shape and size of bigger EBL depend on number of cores generated in the cloud of particles and grains.
- All other particles involved could be in shells around the dineutrino shell.

- The initial energy of the nucleus can be increased by absorbing particles and grains from the environment similar to the process inside of macro stars.

The main differences of our model from Thornhill's view are as follows:

- We have dineutrinos with mass $\sim 10^{-38}\, kg$ instead of Thornhill's neutrinos with a vanishingly small mass which become "heavy" when they accept energy resonantly from excited nuclei.
- We assume weak and super weak interactions between grains and particles (which are responsible for collapse and stability of ELB) instead of tiny electric dipoles of "heavy" neutrinos, which tend to clump together.

We agree with VanDevender who said "It seems to require new physics."

The proposed "dineutrino" model describes the major properties of EBL sufficiently well.

It is important to emphasize that the initial energy required for a BL/EBL creation is insufficient for its sustenance of up to 1200 seconds. Additional energy, therefore, must be consumed by a BL/EBL once it had been formed. Once we master the creation of BLs and EBLs in a controlled environment, we can concentrate our efforts on harvesting that energy.

4. The World

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

Albert Einstein

The constitution of the ether, if it ever would be discovered, will be found to be quite different from any thing 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.

James McCullagh

The World – Universe Model is developed around two fundamental parameters: Fine-Structure Constant α and dimensionless quantity Q. While α is a constant, Q increases with time, and in fact defines the size and the age of the World.

The Model is based on Maxwell's equations for the electromagnetism and gravitoelectromagnetism which contain a single constant – electrodynamic constant c; two parameters of the Medium – magnetic parameter μ_0 and gravitomagnetic parameter μ_g; and two measurable characteristics: energy density and energy flux density. All other notions are used for calculations of these two measurable characteristics.

Throughout our discussion we have paid close attention to energy density. Sometimes we used the notion of mass density to facilitate understanding of the Model and correlations of its results with the existent theories and models, but the two concepts were shown to be interchangeable.

For all particles under consideration we used four-momentum, but the final result of the statistical analysis was energy density.

The Fundamental quantities of the World are as follows:

- The surface enthalpy of the World – Universe Front σ_0;
- The electrodynamic and gravitoelectrodynamic constant c, which is the speed of the World – Universe Front;
- The radius of the World's Nucleus a;
- The dimensionless parameter Q, which is the size and age of the World measured in the basic units a and $\frac{a}{c}$ respectively.

All Fundamental quantities are connected to the physical characteristics of the World's Nucleus – the Beginning of the World.

Then all physical parameters of the World can be expressed in terms of these Fundamental quantities:

$H_0 = \frac{c}{a} \times Q^{-1}$	Hubble parameter
$A_t = \frac{a}{c} \times Q$	Age of the World
$R = a \times Q$	Size of the World
$\rho_0 = \frac{\sigma_0}{a}$	Basic energy density
$\rho_{cr} = \frac{3\sigma_0}{a} \times Q^{-1}$	Critical energy density
$E_0 = \sigma_0 a^2$	Basic energy
$E_W = 4\pi\sigma_0 a^2 \times Q^2$	Energy of the World
$h = \frac{\sigma_0 a^3}{c}$	Planck constant
$G = \frac{c^4}{8\pi\sigma_0 a} \times Q^{-1}$	Gravitational parameter
$\frac{8\pi G}{c^4} = \frac{1}{\sigma_0 a} \times Q^{-1}$	Einstein's parameter

All physical parameters of the World represented in natural units $c = a = \sigma_0 = 1$ can be expressed in terms of Q in various rational exponents, as well as small integer numbers and π.

An alternative set of basic parameters fully describes the World as well:

- The Hubble parameter H_0;
- The basic energy E_0;
- The basic energy density ρ_0;
- The dimensionless parameter Q.

All physical parameters of the World can be expressed through these basic parameters:

$A_t = H_0^{-1}$	Age of the World
$a = (\frac{E_0}{\rho_0})^{\frac{1}{3}}$	Size of the World's Core at the Beginning
$\sigma_0 = (E_0\rho_0^2)^{\frac{1}{3}}$	Surface enthalpy of the World-Universe Front

$c = H_0(\frac{E_0}{\rho_0})^{\frac{1}{3}} \times Q$ Electrodynamic constant

$R = (\frac{E_0}{\rho_0})^{\frac{1}{3}} \times Q$ Size of the World

$\rho_{cr} = 3\rho_0 \times Q^{-1}$ Critical energy density

$E_W = 4\pi E_0 \times Q^2$ Energy of the World

$h = \frac{E_0}{H_0} \times Q^{-1}$ Plank constant

$G = \frac{c^4}{8\pi(\rho_0 E_0^2)^{\frac{1}{3}}} \times Q^{-1}$ Gravitational parameter

$\frac{8\pi G}{c^4} = (\rho_0 E_0^2)^{-\frac{1}{3}} \times Q^{-1}$ Einstein's parameter

In our discussion we have often used well-known physical parameters, keeping in mind that all of them can be expressed through Fundamental quantities of the World.

We have developed the Fractal model of the World that describes the macroobjects possessing energies proportional to the total World's macroobjects energy $E_{MO} = \frac{1}{3}E_W$ with varying coefficients:

- World: 1
- Galaxy clusters: $Q^{-\frac{1}{8}}$
- Galaxies: $Q^{-\frac{1}{4}}$
- Globular clusters: $Q^{-\frac{3}{8}}$
- Extrasolar systems: $Q^{-\frac{1}{2}}$

The World consists of the Medium and macroobjects. The World has a preferred frame defined by the Medium. Cosmic Microwave Background radiation (CMB) is a component of the Medium. Based on the analysis of the CMB radiation, the speeds of the Milky Way and the Sun relative to CMB rest frame were measured to be 552 and 397 km/s respectively.

The World is not empty; instead, it must be treated as a Medium filled galaxies and stars. The Medium behaves as an ideal liquid with unique properties.

Long time ago it was realized that there are no longitudinal waves in the Medium, and hence the Medium could not be an elastic matter of an ordinary type. In 1839 James McCullagh proposed a theory of a rotationally elastic medium, i.e. a medium in which every particle resists absolute rotation [30].

The potential energy of deformation in such a medium depends only on the rotation of the volume elements and not on their compression or general distortion. This theory produces equations analogous to Maxwell's electromagnetic equations.

The World – Universe Model is based on Maxwell's equations, and McCullagh's theory is a good fit for description of the Medium.

In any homogeneous and isotropic cosmology including our Model with homogeneous and isotropic Medium, the Hubble's parameter H_0 and its inverse, the Hubble age of the World, and also the Hubble length defined as $\frac{c}{H_0}$, are absolute and not relative quantities. The Center-of-mass frame of the Hubble sphere can be regarded as a preferred frame.

In light of the Hubble effect, we apply the following transformation to Maxwell's equations: multiply the left side parameters of the **Table 4** by the parameter $\frac{a^3c}{2h}$, divide the impedance of the Medium by the same parameter, and leave the right side parameters of the **Table 4** alone:

$$q_g = \frac{a^3}{2L_{cm}} \qquad Z_W = \frac{1}{R} \times c = H_0 \qquad ac \tag{4.1}$$

As a result of this transformation:

- All parameters of the gravitoelectromagnetic field have dimensions of length and time; "mass" dimension has disappeared;
- All physical parameters of the World measured in terms of a and t_0 become scalars;
- Absolute size and age of the World equal to Q;
- The gravitoelectromagnetic charge has a dimension of "area", which is equivalent to energy, with coefficient that equals to the surface enthalpy σ_0;
- The impedance of the Medium equals to the Hubble's parameter for the whole World.

It follows that measuring the value of Hubble's parameter anywhere in the World and taking its inverse value allows us to calculate the absolute age of the World. The Hubble's parameter is then the most important characteristic of the World, as it defines the World's age.

The second important characteristic of the World is the gravitomagnetic parameter μ_W:

$$\mu_W = \frac{1}{R} \tag{4.2}$$

Taking its inverse value, we can define the absolute radius of the World.

We emphasize that the above two parameters are principally different characteristics of the Medium that are connected through the gravitoelectrodynamic constant c.

The World – Universe Model is the first unified model of the World that successfully describes all of its primary parameters and their relationships, ranging in scale from cosmological structures to elementary particles. The Model allows for precise calculation of values that were only measured experimentally earlier (age of the World, MBR temperature, etc.), and makes verifiable predictions. While the Model needs significant further elaboration, it can already serve as a basis for a new understanding of the World.

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Fundamental Parameter Q . Recommended Values of the Newtonian Parameter of Gravitation, Hubble's Parameter, Age of the World, and Temperature of the Microwave Background Radiation

ABSTRACT

This paper gives the self-consistent set of Q-dependent, time varying values of the basic parameters of the World: Fermi Coupling parameter, Newtonian parameter of Gravitation, Hubble's parameter, Age of the World, and Temperature of the Microwave Background Radiation. It describes in detail the adjustment of the values of the parameters based on the World-Universe Model. The obtained set of values is recommended for consideration in CODATA Recommended Values of the Fundamental Physical Constants 2014.

Keywords: World-Universe Model, Fundamental Parameter Q, Fermi Coupling Parameter, Gravitational Parameter, Hubble's Parameter, Temperature of Microwave Background Radiation, Size of the World, Age of the World, CODATA.

The constancy of the universe fundamental constants, including Fermi coupling constant G_F, Newtonian constant of gravitation G, Planck mass M_P, Planck length L_P, is now commonly accepted, although has never been firmly established as a fact. All conclusions on the constancy of G are model-dependent [1].

In our opinion, it is impossible to either prove or disprove the constancy of G. Consequently, variability of G with time can legitimately be explored. Alternative cosmological models describing the Universe with time varying G are widely discussed in literature (see e.g. [1] and references therein).

A commonly held opinion states that *gravity has no established relation to other fundamental forces, so it does not appear possible to calculate it indirectly from other constants that can be measured more accurately, as is done in some other areas of physics* [Wikipedia, Gravitational constant].

The World-Universe Model holds that there indeed exist relations between all Q-dependent, time varying parameters: G_F, G, M_P, L_P, H_0 (Hubble's parameter), R (Size of the World), A_τ (Age of the World), ρ_{cr} (Critical energy density of the World), T_{MBR} (Temperature of the microwave background radiation), m_a (Axion mass), m_ν (Neutrino mass), etc. [1].

In accordance with the World-Universe Model, the basic parameters of the World can be expressed as follows:

- Fermi coupling parameter G_F

$$\frac{G_F}{(\hbar c)^3} = \mathcal{K} \times \frac{m_p}{m_e} \frac{1}{E_0^2} \times Q^{-\frac{1}{4}} \tag{1}$$

where $\hbar$ is Dirac constant, c is the electrodynamic constant, m_p is the mass of a proton, m_e is the mass of an electron, $\mathcal{K} \sim 1$ is a coefficient (its exact value is discussed below), and basic energy unit E_0 equals to

$$E_0 = \frac{hc}{a} = 1.1219288 \times 10^{-11}\, J = 0.070025267\, GeV \tag{2}$$

where $h = 2\pi\hbar$ is Planck constant, a_0 is the classical radius of an electron, and $a = 2\pi a_0$;

- Newtonian parameter of gravitation G

$$G = \frac{a^2 c^4}{8\pi hc} \times Q^{-1} \tag{3}$$

- Hubble's parameter H_0

$$H_0 = \frac{c}{a} \times Q^{-1} \tag{4}$$

- Age of the World A_τ

$$A_\tau = \frac{a}{c} \times Q \tag{5}$$

- Size of the World R

$$R = a \times Q \tag{6}$$

- Temperature of the microwave background radiation T_{MBR}

$$T_{MBR} = \frac{E_0}{k_B} \left(\frac{15\alpha}{2\pi^3} \frac{m_e}{m_p}\right)^{\frac{1}{4}} \times Q^{-\frac{1}{4}} \tag{7}$$

where k_B is Boltzmann constant and α is the fine-structure constant.

In this work, we are going to:

- Find the value of the fundamental parameter Q based on CODATA's value of Newtonian parameter of gravitation G;
- Based on Q, predict the values of the temperature of the microwave background radiation T_{MBR}, Hubble's parameter H_0, and Age of the World A_τ with much higher precision than currently recommended values.

Wikipedia has this to say about G [Gravitational constant]:

The accuracy of the measured value of G has increased only modestly since the original Cavendish experiment. G is quite difficult to measure, as gravity is much weaker than other fundamental forces, and an experimental apparatus cannot be separated from the gravitational influence of other bodies. Published values of G have varied rather broadly, and some recent measurements of high precision are, in fact, mutually exclusive.

Table 1, borrowed from CODATA Recommended Values of the Fundamental Physical Constants, 2010, summarizes the results of measurements of the Newtonian constant of gravitation relevant to the 2010 adjustment [2]:

Observe that the values of G vary significantly depending on Method. The disagreement in the values of G obtained by the various teams far exceeds the Standard Uncertainties provided with the values.

Table 2 summarizes the recommended values of the Q-dependent parameters under consideration:

In accordance with equation (3), the calculated value of the parameter Q based on the average value of the gravitational parameter G from **Table 2** is

$$Q = 0.760000(91) \times 10^{40} \tag{8}$$

Table 1

Source	Identification[a]	Method	10^{11} G / $\mathrm{m^3\,kg^{-1}\,s^{-2}}$	Rel. stand. uncert u_r
Luther and Towler (1982)	NIST-82	Fiber torsion balance, dynamic mode	6.672 48(43)	6.4×10^{-5}
Karagioz and Izmailov (1996)	TR&D-96	Fiber torsion balance, dynamic mode	6.672 9(5)	7.5×10^{-5}
Bagley and Luther (1997)	LANL-97	Fiber torsion balance, dynamic mode	6.673 98(70)	1.0×10^{-4}
Gundlach and Merkowitz (2000, 2002)	UWash-00	Fiber torsion balance, dynamic compensation	6.674 255(92)	1.4×10^{-5}
Quinn et al. (2001)	BIPM-01	Strip torsion balance, compensation mode, static deflection	6.675 59(27)	4.0×10^{-5}
Kleinevoß (2002); Kleinvoß et al. (2002)	UWup-02	Suspended body, displacement	6.674 22(98)	1.5×10^{-4}
Armstrong and Fitzgerald (2003)	MSL-03	Strip torsion balance, compensation mode	6.673 87(27)	4.0×10^{-5}
Hu et al. (2005)	HUST-05	Fiber torsion balance, dynamic mode	6.672 28(87)	1.3×10^{-4}
Schlamminger et al. (2006)	UZur-06	Stationary body, weight change	6.674 25(12)	1.9×10^{-5}
Luo et al. (2009); Tu et al. (2010)	HUST-09	Fiber torsion balance, dynamic mode	6.673 49(18)	2.7×10^{-5}
Parks and Faller (2010)	JILA-10	Suspended body, displacement	6.672 34(14)	2.1×10^{-5}

[a]NIST: National Institute of Standards and Technology, Gaithersburg, MD, USA; TR&D: Tribotech Research and Development Company, Moscow, Russian Federation; LANL: Los Alamos National Laboratory, Los Alamos, New Mexico, USA; UWash: University of Washington, Seattle, Washington, USA; BIPM: International Bureau of Weights and Measures, S` evres, France; UWup: University of Wuppertal, Wuppertal, Germany; MSL: Measurement Standards Laboratory, Lower Hutt, New Zeland; HUST: Huazhong University of Science and Technology, Wuhan, PRC; UZur: University of Zurich, Zurich, Switzerland; JILA: JILA, University of Colorado and National Institute of Standards and Technology, Boulder, Colorado, USA.

From equation (1), we calculate the value of $\mathcal{K}$ based on the average value of the Fermi coupling parameter G_F from **Table 2**:

$$\mathcal{K} = 0.2908293(87) \tag{9}$$

Based on the value of Q calculated in (8), we obtain the value of the temperature of the microwave background radiation:

$$T_{MBR} = 2.725181(82)\,K \tag{10}$$

the value of the Hubble's parameter is

$$H_0 = 2.22790(27) \times 10^{-18}\, s^{-1} = 68.7457(83)\, \frac{km/s}{Mpc} \tag{11}$$

the age of the World is

$$A_\tau = 4.48854(54) \times 10^{17} s = 14.2233(17)\, Byr \tag{12}$$

and the size of the World is

$$R = 1.34563(16) \times 10^{26}\, m \tag{13}$$

Table 2

Quantity	Symbol	Numerical value	Unit	Relative std. uncert., ppm
Fermi coupling parameter	$\frac{G_F}{(\hbar c)^3}$	1.166364(5) x 10^{-5}	GeV^{-2}	4.3
Newtonian parameter of gravitation 2010	G	6.67384(80) x 10^{-11}	$m^3\, kg^{-1}\, s^{-2}$	120
Temperature of microwave background radiation	T_{MBR}	2.72548(57)	K	210
Hubble's parameter WMAP (9-years)	H_0	69.32(80)	km s-1 Mpc^{-1}	11540
Age of the World	A_τ	13.798(37)	Byr	2680

where ppm is one part per million.

The values of the discussed parameters recommended for consideration in CODATA Recommended Values of the Fundamental Physical Constants, 2014 are presented in **Table 3**.

As the result of the adjustment of the values of the parameters based on the World-Universe Model, we obtained a set of values with significantly higher accuracy for Hubble's parameter H_0, Age of the World A_τ, and Temperature of the Microwave Background Radiation T_{MBR}. The relationships between the fundamental parameters discussed in [1] allow us to calculate all of them based on the value of any two parameters known with the highest precision. At the moment, these are G and G_F with substantiated value of parameter $\mathcal{K}$ (see below).

Table 3

Quantity	Symbol	Numerical value	Unit	Relative std. uncert., ppm
Fundamental parameter	Q	0.760000(91) x 10^{40}		120
Fermi coupling parameter	$\frac{G_F}{(\hbar c)^3}$	1.166364(5) x 10^{-5}	GeV^{-2}	4.3
Newtonian parameter of gravitation 2010	G	6.67384(80) x 10^{-11}	$m^3\,kg^{-1}\,s^{-2}$	120
Temperature of microwave background radiation	T_{MBR}	2.725181(82)	K	30
Hubble's parameter	H_0	68.7457(83)	km s^{-1} Mpc^{-1}	120
Age of the World	A_τ	14.2233(17)	Byr	120

Further improvements in precision of G will allow us to further increase the precision of H_0, A_τ, and T_{MBR}.

One could, however, increase the precision of G itself based on other parameters. Recently, the precision of T_{MBR} seems to be improving the fastest. Once T_{MBR} is measured with relative standard uncertainty that is lower than 30 ppm, precision of G, H_0 and A_τ will all improve.

Detailed analysis of the results of measurements of the Newtonian constant of gravitation in **Table 1** shows that there are three groups of measurements. Inside each such group, the measurements are not mutually exclusive; however, measurements outside of a group contradict the entire group.

- The first such group consists of six measurements with the average value of
$$G_1 = 6.67401(19) \times 10^{-11}\, m^3 kg^{-1} s^{-2} \tag{14}$$
and relative standard uncertainty 28.5 ppm;
- The second one consists of four measurements with the average value of
$$G_2 = 6.67250(16) \times 10^{-11}\, m^3 kg^{-1} s^{-2} \tag{15}$$
and relative standard uncertainty 24 ppm;

- The third one consists of one measurement with the value of

$$G_3 = 6.67559(27) \times 10^{-11}\ m^3 kg^{-1} s^{-2} \tag{16}$$

and relative standard uncertainty 40 ppm.

Clearly, the relative uncertainty of any such group is better than the uncertainty of the entire result set. G_1, G_2, and G_3 have relative standard uncertainties that are about 4, 5, and 3 times smaller than the average value of G (see **Table 2**) respectively.

The measurements falling into the three groups are mutually exclusive; it is therefore likely that one group of measurements is correct, and the others are not. With the help of World – Universe Model, more precise measurement of T_{MBR} can help us narrow down the correct group of G measurements.

For the three groups of G measurements, parameter Q will take on the following values, respectively:

$$Q_1 = 0.759981(22) \times 10^{40} \tag{17}$$

$$Q_2 = 0.760153(18) \times 10^{40} \tag{18}$$

$$Q_3 = 0.759801(30) \times 10^{40} \tag{19}$$

Let's find the values of all discussed parameters based on the value of the T_{MBR} :

$$Q = \frac{15\alpha}{2\pi^3}\frac{m_e}{m_p}\left(\frac{E_0}{k_B T_{MBR}}\right)^4 = 0.760203 \times \left(\frac{2.725}{T_{MBR}}\right)^4 \times 10^{40} \tag{20}$$

$$G = \frac{a^2 c^4}{8\pi hc}\left(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p}\right)^{-1} \times \left(\frac{k_B T_{MBR}}{E_0}\right)^4 =$$

$$= 6.67206 \times \left(\frac{T_{MBR}}{2.725}\right)^4 \times 10^{-11}\ m^3 kg^{-1} s^{-2} \tag{21}$$

$$\mathcal{K} = \frac{G_F E_0^2}{(\hbar c)^3}\frac{m_e}{m_p}\frac{E_0}{k_B T_{MBR}}\left(\frac{15\alpha}{2\pi^3}\frac{m_e}{m_p}\right)^{\frac{1}{4}} = 0.290849 \times \left(\frac{2.725}{T_{MBR}}\right) \tag{22}$$

where 2.725 is the reference temperature of the microwave background radiation in K .

The values of T_{MBR} corresponding to the values of G_1 , G_2 , G_3 (14) (15) (16) are:

$$T_1 = 2.725199\ K \tag{23}$$

$$T_2 = 2.725045\ K \tag{24}$$

$$T_3 = 2.725360\ K \tag{25}$$

The right group of the measurements of G can be selected once the relative standard uncertainty of the measurement of T_{MBR} becomes significantly better than 30 ppm.

In accordance with the World-Universe Model [1] we can choose the following value for the parameter $\mathcal{K}$:

$$\mathcal{K} = \left(1800\alpha\frac{m_e}{m_p}\right)^{\frac{1}{4}} = \sqrt{30}\left(2\alpha\frac{m_e}{m_p}\right)^{\frac{1}{4}} = 0.29082535 \tag{26}$$

and rewrite equation (1) as

$$\frac{G_F}{(\hbar c)^3} = \sqrt{30}\left(2\alpha\,\frac{m_e}{m_p}\right)^{\frac{1}{4}}\frac{m_p}{m_e}\frac{1}{E_0^2} \times Q^{-\frac{1}{4}} \tag{27}$$

We now calculate the value of Q_F based on the average value of the Fermi coupling parameter G_F from **Table 2**:

$$Q_F = 0.759960(13) \times 10^{40} \tag{28}$$

The difference between Q_1 and Q_F equals to 21×10^{-6} which is smaller than the standard uncertainty of Q_1 , and the relative standard uncertainty of Q_F equals to 17 ppm that is about 1.7 times smaller than the relative standard uncertainty of Q_1 .

With this value of $\mathcal{K}$ we can make the choice of the first group of G measurements and significantly increase the precision of all Q-dependent parameters.

The value of G in this case equals to

$$G = 6.67420(11) \times 10^{-11}\ m^3 kg^{-1} s^{-2} \tag{29}$$

Compare to the CODATA recommended value of G published in 2010:

$$G = 6.67384(80) \times 10^{-11}\ m^3 kg^{-1} s^{-2} \tag{30}$$

The value of the temperature of the microwave background radiation is:

$$T_{MBR} = 2.725218(12)\ K \tag{31}$$

the value of the Hubble's parameter is:

$$H_0 = 2.228017(38) \times 10^{-18}\ s^{-1} = 68.7494(12)\ \frac{km/s}{Mpc} \tag{32}$$

the age of the World is:

$$A_\tau = 4.488296(77) \times 10^{17} s = 14.22255(24)\ Byr \tag{33}$$

and the size of the World is:

$$R = 1.345557(23) \times 10^{26}\ m \tag{34}$$

To summarize: parameters G_F , G , H_0 , A_τ and T_{MBR} are all inter-connected. Today, we can substantially increase the precision of H_0 , A_τ and T_{MBR} based on G . Looking forward, better precision in measurement of any parameter may potentially increase the precision of all others.

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