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A Cosmic Quantum Mechanics

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Abstract

We presented a model for unification of electricity and gravity. We have found a consistent description of all physical quantities pertaining to the system. We have provided limiting values for all physical values. These values are neither zero nor infinity. Our universe is described at all times by the four dimensional constants $c, \hbar, k, G$ only. The remnant of vacuum remains at all epochs with different values. The present cosmological hierarchy and puzzles are justified as due to the consequences of cosmic quantization developed in this work. The missing energy in the universe can be resolved if one considers the contribution of the gravito-electromagnetic counterparts besides the observed mass in the universe.

Keywords: *cosmology: quantum-unification, quantum mechanics, gravity.*

I. INTRODUCTION

Many attempts have failed to unify gravity with quantum mechanics. We propose here a new approach for unification of gravity, electricity and magnetism. It is based on the idea that the gravito-electric effects can not be ignored at large scale. This is achieved by defining an appropriate Planck constant that takes care of the large scale effect. In this sense, one considers the universe to have a quantum nature present at all levels. The quantum nature is manifested by gravitationally bound system only, which we call cosmic system. General relativity predicts a singularity at the Big Bang and within a Black Hole. A Black Hole is understood when quantum analysis is developed for it. We have found that all cosmic systems require a quantum treatment as well. So in a real quantum world such problems should not be present. Consequently, a quantum treatment should remove the singularity problem by allowing all physical quantities to have a limiting values; neither zero nor infinity. The electromagnetic contribution arising from gravitational system is very genuine and should be taken into consideration. Such a contribution could offset the difference between the presently observed and anticipated energy density of the universe. This amounts to say that the dark energy problem is no longer a problem.

The quantum nature of the whole universe is evident in the acceleration of the cosmic fluid that permeates the space time at different scales. In particular, at present time there should be a uniform acceleration of this cosmic fluid of the order of 10^{-10}m s^{-2} permeating the whole universe. Such a value is observed in Casimir experiment and by the Pioneer satellite.

In this work, we provide the limiting values of the universe at different stages. We have written all physical quantities representing the universe in terms of the four fundamental constants, viz., $c, \hbar, k, G$. The universe at different levels is gov-

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erned by this set of equations. Thus, the universe appears at these stages the way it understood because it is the only way it could. It turns out that some of the physical quantities are relativistic, quantum, gravitational and electromagnetic. This is evident from the way it depends on the corresponding constants. We remark that the speed of light does not depend of the size of the system under consideration. However, the Planck's constant depends on the size of the system since its unit is ML^2T^{-1}. Therefore, it is large for larger systems and small for smaller systems. Hence, we expect that its value for a macroscopic to be very large (large M and L). The inclusion of G into the model is to represent gravity (mass), or equivalently to represent space-time.

In a recent work, we have found that for every bound system (nucleus, atom, star, galaxy, and the whole universe) there is a characteristic Planck constant (Arbab, 2001a). Hence, a particular system interacts quantum mechanically with its corresponding Planck's constant. With this prescription all gravitational phenomena are interpreted in terms of quantum ones. With this remedy in mind, the gravitational systems are successfully described. Hence, any bound gravitational system exhibits the quantum nature (phenomena) if it is fully understood. We have seen that an object (mass) whether charged or not exhibits the electromagnetic phenomena. That is because an electromagnetic field is associated with every gravitational bound system. Thus, an (un)charged mass in a gravitational field interacts as if it were a charged mass placed in electromagnetic field. Its corresponding electromagnetic fields and voltage are $E = \left(\frac{c^7 k}{\hbar G^2}\right)^{\frac{1}{2}}$, $B = \left(\frac{c^5 k}{\hbar G^2}\right)^{\frac{1}{2}}$ and $V = \left(\frac{c^4 k}{G}\right)^{\frac{1}{2}}$.

At the present time, some cosmologists believe that a new gravitational phenomena is thought to show up in extra dimension. An extra dimension of $\sim 10^{-17}$cm is thought to allow an exponential increase in the strength of gravity to where it would match the strength of the electro-weak and strong forces at the remarkably modest energy of about 1 TeV. This is nearly 16 orders of magnitude below the Planck scale, which is 10^{19}GeV, the dogmatically assumed unification energy of all nature's forces. If the extra dimension concept is valid, then gravity should participate equally with the strong and electro-weak forces in the synthesis of exotic new quanta in the supersymmetry mass range. Arguments are advanced to support the thesis that at least one of these quanta should be endowed with a pseudo-gravity field, whose strength is equal to the electromagnetic field in its low energy form. We, however, have shown in an earlier work that the gravitational constant at Planck's time is the same as it is now (Arbab, 2001b).

Assuming all fundamental particles, with rest mass, harbor one or more of these quanta (in virtual form) at their cores, where vacuum tension is maximal, the result would be a short range warp 'bubble' enveloping all particles with mass. Periodic reversal of this quanta's field would give rise to cavity oscillator behavior, subjecting its host particle to an alternating polarity warp metric, whose intensity would match the electromagnetic field. If the phase of this periodicity synchronizes with the cyclical acceleration/deceleration forces of an electron in elliptical orbit about its nucleus, and the warp-field is always aligned along the electron/nucleus axis, then the electron would follow a sinusoidal, time-like geodesic through space-time, negating synchrotron radiation. The oscillations of this natural, micro-warp field are therefore proposed to be the essence of de Broglie matter waves, which are the basis of stable, non-radiating atomic orbits, and the starting point for wave mechanics.

The volumetric variations, within the warp 'bubble', are proposed to alternate between Minkowski space and the extra dimensions, giving rise to bipolar relativistic sync shifts (relativity of simultaneity), due to the resulting bi-directional linear translations between particles. Consequently, all fundamental particles will appear to rapidly oscillate between the past and future at de Broglie frequencies, but average to the local present.

For bound gravitational object, the space time inside the object and out side is different. Thus, particles moving inside these objects experience an acceleration which is different from those moving outside. For instance, the tension of space-time inside the nuclear region is enormously reduced, compared to the outside tension. This may elucidate the asymptotic free nature of quarks residing inside baryons. The surface tension of the nucleus is the same as that of the whole universe.

In 1984 DerSarkissian suggested that a cosmic version of ordinary quantum mechanics may be responsible for the observed physical properties of galaxies. Agob *et al* (1998) used a fractal space time has shown that the Solar System is a quantized system. They have found a cosmological Planck's constant for the galaxies of the order of $\hbar_g \sim 10^{67}$Js. With this huge value the expect a radio emission to dominate galaxies. A similar form of cosmic quantum mechanics was suggested independently by Cocke (1984). Recently (Arbab, 2004; 2001a) we have shown that the hierarchical problems of the matter buildup of the universe is resolved with the idea of large scale quantization. In this work, we provide the lower and upper limits of our physical quantities. They are neither zero nor infinity. Consequently, infinities can not occur in our physical world, i.e., no ultraviolet no infrared catastrophes in our theories. Thus, we notice that no fundamental constant can be set to zero ($\Lambda \neq 0, \hbar \neq 0$, etc) as this would violate the cosmic quantum hypothesis. Since the action of the universe is very large in comparison with Planck constant, one can use the WKB approximation to write down a field theoretic model for such an approach. This is feasible since our cosmic system anticipated to involve large numbers quantization.

II. THE MODEL

In order to unify gravity with electricity and magnetism one requires that only fundamental constant describing these domains should appear. These systems are described by the following constant:

$$G\ ,\ k\ ,c\ ,\hbar\ . \tag{2.1}$$

With this prescription, one can define the quantum effect of gravitational and electromagnetic systems. In order for gravity to unify with electricity, they should have once had same strength. This would mean that one had at some time the equation

$$Gm^2 = kq^2\ , \tag{2.2}$$

where $k = \frac{1}{4\pi\epsilon_0}$ is the electrical constant, which means that gravitational and electric forces between elementary particles with mass m and charge q were equal. We argue that this force however remains unchanged (conserved). Its value at Planck's time and today is the same; and all other forces are derived from it. Its value at Planck's time is

$$F_P = \frac{Gm_P^2}{r_P^2} \sim 10^{43}\text{N}, \tag{2.3}$$

and its value today is

$$F_0 = \frac{GM_0^2}{R_0^2} \sim 10^{43}\text{N}, \tag{2.4}$$

where $R_0 \sim 10^{26}$ m, $r_P \sim 10^{-35}$ m, $m_P \sim 10^{-8}$ kg and $M_0 \sim 10^{53}$ kg. It seems the gravitational force tiding the universe is conserved. In 1948 Casimir has found an attractive force between two plates of the form $F = \frac{8\pi\hbar c}{480L^4}A$, where A is the area of the plate and L is the separation between the two plates. If one calculates this force for the present time with the cosmic Planck's constant ($\hbar \sim 10^{87} J.s$, see the next section) and Planck's time, regarding the universe as a sphere, one finds the same value. This force is attributed as due to quantum vacuum fluctuations of the electromagnetic field. Hence, one realizes that such a quantum nature does still exist, and has now become sizable.

One can define a gravitational charge as

$$q = \sqrt{\frac{G}{k}}\ M\ , \tag{2.5}$$

for a system whose gravitational mass is M. Moreover, we have shown recently that the Planck constant for large scale system is defined by (Arbab, 2001a)

$$\hbar_c = \frac{GM_P^2}{c}\ , \tag{2.6}$$

where M_P is the cosmic Planck's mass. This equation represents a bi-pass from electric system to gravitational system. So if some phenomena is known in one system the corresponding quantity will be expected to take place for the other system. Space-time is connected by strings whose tension is defined by

$$T = \frac{c^4}{8\pi G}\ , \tag{2.7}$$

This value happens to be very huge. It implies that the space-time is incredibly stiff ($T \sim 10^{43}$N) and no stress-energy density can make it bend no matter how big it is. The string has a duality principle that for a physical quantity r the relation

$$r' = \frac{\hbar c}{r}\frac{1}{T}\ , \tag{2.8}$$

is also applicable. If the effective Planck's area is really increasing ass the universe expands, that suggests the universe will become more and more gravitationally quantized larger scales. The Planck's area is given by the product of the classical gravity radius and the quantum radius as

$$A = \frac{GM}{c^2}.\frac{\hbar}{M} = \left(\frac{G\hbar}{c^3}\right)\ . \tag{2.9}$$

Now we see that this area at Planck's time (A_{pl}) and at the present time (A_0) are respectively

$$A_\text{P} \sim 10^{-69}\text{m}^2\ , \tag{2.10}$$

and

$$A_0 \sim 10^{52}\text{m}^2\ , \tag{2.11}$$

respecting the above mentioned duality. Thus, the two theories would be applicable. We see that the same formula governs the microscopic as well as macroscopic worlds. Therefore, the two worlds are complementary to one another.

Now define the following physical quantities describing our system as follows:

A. Electromagnetic quantities

These quantities provide limiting values for accessible physical quantities. According to our hypothesis, one can write this in terms of our fundamental constant as

$$\mu_B = \left(\frac{G\hbar^2}{k}\right)^{\frac{1}{2}} , \tag{2.12}$$

This is defined formally by

$$\mu_B = IA , \tag{2.13}$$

where I is the current flowing around the loop whose area is A. Using eq.(9) the above equation yields,

$$I = \left(\frac{c^6}{Gk}\right)^{\frac{1}{2}} . \tag{2.14}$$

The electric field E is defined as

$$E = \left(\frac{c^7 k}{\hbar G^2}\right)^{\frac{1}{2}} . \tag{2.15}$$

The potential difference is given by

$$V = \left(\frac{c^4 k}{G}\right)^{\frac{1}{2}} . \tag{2.16}$$

The magnetic field is defined as

$$B = \left(\frac{c^5 k}{\hbar G^2}\right)^{\frac{1}{2}} . \tag{2.17}$$

The magnetic flux density is given by

$$\Phi = \left(\frac{k\hbar}{c}\right)^{\frac{1}{2}} . \tag{2.18}$$

The surface tension (space-time stiffness constant) is defined as

$$\gamma = \left(\frac{c^{11}}{\hbar G^3}\right)^{\frac{1}{2}} . \tag{2.19}$$

The surface energy is given by

$$U = \gamma A = \gamma \left(\frac{G\hbar}{c^3}\right)^{\frac{1}{2}} . \tag{2.20}$$

The surface mass density is defined as

$$S = \left(\frac{c^7}{\hbar G^3}\right)^{\frac{1}{2}} = \frac{\gamma}{c^2} . \tag{2.21}$$

The electric charge density is defined as

$$\rho_{\rm Q} = \left(\frac{c^{10}}{\hbar^2 G^3 k}\right)^{\frac{1}{2}} . \tag{2.22}$$

The magnetic (electric) field contribution to mass density is given by

$$\rho_{\rm m} = \left(\frac{c^5}{\hbar G^2}\right) . \tag{2.23}$$

This can be written as

$$\rho_{\rm m} = \left(\frac{B^2}{k}\right) . \tag{2.24}$$

The pressure is given by

$$P = \left(\frac{c^7}{G^2\hbar}\right). \tag{2.25}$$

The amount of energy emitted per unit time per unit area (energy flux) is given by

$$\Sigma = \left(\frac{c^8}{G^2\hbar}\right). \tag{2.26}$$

The moment of inertia of a gravitating mass about its center is given by

$$I_c = \left(\frac{G\hbar^3}{c^5}\right)^{\frac{1}{2}} . \tag{2.27}$$

The gravitational field is defined as

$$\phi = \left(\frac{c^2}{G}\right) . \tag{2.28}$$

The mass flow rate is defined by

$$Q = \left(\frac{c^3}{G}\right) . \tag{2.29}$$

The electric conductivity is defined by

$$\sigma = \left(\frac{c^5}{\hbar k^2 G}\right)^{\frac{1}{2}} . \tag{2.30}$$

The acceleration of the quantum fluid filling the space-time is giving by

$$a = \left(\frac{c^7}{G\hbar}\right)^{\frac{1}{2}} . \tag{2.31}$$

The acceleration of a charged particle (of charge q and mass m) in an electric field (E) is given by

$$a = \frac{q}{m}E , \tag{2.32}$$

where E is defined above. Using eq.(5) this equation yields

$$a = \left(\frac{G}{k}\right)^{\frac{1}{2}} E \ , \qquad (2.33)$$

valid for all gravitationally bound system. This acceleration coincides with the definition

$$a = \left(\frac{GM}{R^2}\right) \ , \qquad (2.34)$$

for a gravitational system with mass M and radius R. We remark here the space-time (vacuum) accelerate due to its very nature. This acceleration is required to allow the matter to be placed in it. That is because there is a limiting mass that can be placed at a given region. This is given by the quantity $\frac{c^2}{G}$ mentioned above. The energy embedded in this space time decays to give the matter we observe today. However, the decay (transfer) rate is limited to the value governed by the quantity $\frac{c^3}{G}$. The space-time accelerate to give more space for the created matter to be placed in. Thus, space-time (vacuum/quantum) should have a definite geometric structure. Thus, space-time represents a state of a minimum energy. Hence, energy can not be destroyed completely. The remnant of it will correspond to space-time. The minimum energy (ground state) may not be noticeable. But its effect can be observed by the way in which the primeval matter is created in the universe. So this minimum energy state would provide us with a universal reference for the motion of matter.
One can define a capacitance of a gravito-electromagnetic system as follows

$$C = \left(\frac{\hbar G}{k^2 c^3}\right)^{\frac{1}{2}} \ . \qquad (2.35)$$

The charge per unit length (λ_q) is given by EC, or

$$\lambda_q = EC = \left(\frac{c^4}{Gk}\right)^{\frac{1}{2}} . \qquad (2.36)$$

One can define a diffusion constant (area/sec) as

$$D = \left(\frac{G\hbar}{c}\right)^{\frac{1}{2}} . \qquad (2.37)$$

Using eq.(31) one finds that

$$Da = c^3 \ . \qquad (2.38)$$

This means that a highly accelerating object is less diffusing, and vice versa. One can also write the equation relating the electrical conductivity (σ) to the diffusion constant (D) as

$$D = \left(\frac{c^2}{k\ \sigma}\right) \ . \qquad (2.39)$$

Moreover one finds that the mass and the diffusion constant are "canonical conjugate" to each other, i.e.,

$$DM = \hbar \ . \qquad (2.40)$$

It has been emphasized by Kozlowska and Kozlowski (2003) that as time goes one the universe becomes more and more quantum on large scale by allowing $\hbar \to \infty$. They concluded that the prevailing thermal process for thermal phenomena in the universe (that taking place on large scale) is the diffusion.

III. PLANCKIAN DOMAIN

We calculate the above quantities at Planck's times. Now we see that

$$\mu_{B_P} = \left(\frac{G\hbar^2}{k}\right)^{\frac{1}{2}} \sim 10^{-44}\ \mathrm{J/T}\ , \qquad (3.1)$$

and

$$I_P = \left(\frac{c^6}{Gk}\right)^{\frac{1}{2}} \sim 10^{25}\ \mathrm{Amp}\ . \qquad (3.2)$$

The Planckian electric field intensity is given by

$$E_P = \left(\frac{c^7 k}{\hbar G^2}\right)^{\frac{1}{2}} \sim 10^{61}\ \mathrm{V/m}\ , \qquad (3.3)$$

which is a typical Planckian field. The Planckian magnetic field density is

$$B_P = \left(\frac{c^5 k}{\hbar G^2}\right)^{\frac{1}{2}} \sim 10^{53}\ \mathrm{T}. \qquad (3.4)$$

The Planckian magnetic flux density is given by

$$\Phi_P = \left(\frac{k\hbar}{c}\right)^{\frac{1}{2}} \sim 10^{-17}\mathrm{Wb}. \qquad (3.5)$$

The magnetic (electric) field contribution to mass density is given by

$$\rho_{mP} = \left(\frac{B^2}{k}\right) \sim 10^{97}\mathrm{kg/m^3}\ . \qquad (3.6)$$

The surface tension of the universe at Planck's time is given by

$$\gamma_P = \left(\frac{c^{11}}{\hbar G^3}\right)^{\frac{1}{2}} \sim 10^{78}\mathrm{N/m}. \qquad (3.7)$$

The surface mass density at Planck's time is defined as

$$S_P = \left(\frac{c^7}{\hbar G^3}\right)^{\frac{1}{2}} \sim 10^{61}\text{kg/m}^2 \ . \qquad (3.8)$$

The pressure exerted at Planck's time is given by

$$P_P = \left(\frac{c^7}{G^2\hbar}\right) \sim 10^{112}\text{N/m}^2. \qquad (3.9)$$

The electric Planckian charge density is given by

$$\rho_{\text{Q}_\text{P}} = \left(\frac{c^{10}}{\hbar^2 G^3 k}\right)^{\frac{1}{2}} \sim 10^{86}\ \text{C/m}^3, \qquad (3.10)$$

which is a enormously huge quantity. The acceleration of the quantum fluid filling the space-time at Planck's time is given by

$$a_P = \left(\frac{c^7}{G\hbar}\right)^{\frac{1}{2}} \sim 10^{51}\text{m/s}^2. \qquad (3.11)$$

The amount of energy emitted per unit time per unit area (energy flux) during Planck's time is given by

$$\Sigma_P = \left(\frac{c^8}{G^2\hbar}\right) \sim 10^{120}\text{W/m}^2. \qquad (3.12)$$

IV. NUCLEAR DOMAIN

From an earlier work (Arbab, 2001b) we have shown that inside the nuclear region, the Newton's constant (G_N) is given by

$$G_N \sim 10^{40} G \ . \qquad (4.1)$$

We see that the Planck's area inside the nuclear domain is given by

$$A_N = \left(\frac{G_N\hbar}{c^3}\right) \sim 10^{-30}\ \text{m}^2 \ . \qquad (4.2)$$

This gives a range of about 1 Fermi, that is a typical distance for nucleons. Now we see that

$$\mu_{\text{B}_\text{N}} = \left(\frac{G_N\hbar^2}{k}\right)^{\frac{1}{2}} \sim 10^{-24}\ \text{J/T} \ , \qquad (4.3)$$

and

$$I_\text{N} = \left(\frac{c^6}{G_N k}\right)^{\frac{1}{2}} \sim 10^5\ \text{Amp} \ . \qquad (4.4)$$

The nuclear electric field intensity is given by

$$E_\text{N} = \left(\frac{c^7 k}{\hbar G_N^2}\right)^{\frac{1}{2}} \sim 10^{20}\ \text{V/m} \ , \qquad (4.5)$$

which is a typical nuclear field. The nuclear magnetic field density is

$$B_\text{N} = \left(\frac{c^5 k}{\hbar G_N^2}\right)^{\frac{1}{2}} \sim 10^{12}\ \text{T}. \qquad (4.6)$$

The nuclear magnetic flux density is given by

$$\Phi_\text{N} = \left(\frac{k\hbar}{c}\right)^{\frac{1}{2}} \sim 10^{-17}\text{Wb}. \qquad (4.7)$$

The magnetic (electric) field contribution to mass density is given by

$$\rho_{\text{mN}} = \left(\frac{B^2}{k}\right) \sim 10^{15}\text{kg/m}^3 \ . \qquad (4.8)$$

We see that the nuclear density is independent of the number of nucleons present.

The surface tension of a nuclear medium is given by

$$\gamma_\text{N} = \left(\frac{c^{11}}{\hbar G_N^3}\right)^{\frac{1}{2}} \sim 10^{18}\text{N/m}. \qquad (4.9)$$

The surface mass energy of the nucleus is given by

$$U_N = \gamma\left(\frac{G_N\hbar}{c^3}\right)^{\frac{1}{2}} \sim 10^{-12}\text{J} \sim 10\ \text{MeV}. \qquad (4.10)$$

This coincides with the typical value for the binding energy per nucleons. We would like to remark here the scale (λ_{QCD}) for quantum chromodynamics (QCD) is found o be in this range ($\lambda_{QCD} = 66 \pm 10 MeV$).

The gravitational field inside the nuclear region is

$$\phi_N = \left(\frac{c^2}{G_N}\right) \sim 10^{-13}\text{kg/m} \ . \qquad (4.11)$$

This defines the maximal mass that can be placed inside the nuclear gravitational field. Thus the maximal mass which can be placed over a distance of 10^{-15}m is 10^{-28}kg. Therefore, the mass of the nucleus we come to know toady is the only possible mass that the nucleus can hold. That is because the space-time tension inside the nuclear region is exceedingly weak (i.e. $T \sim 10^3$N), in comparison with the tension outside (which is $\sim 10^{43}$N). The diffusion constant for nuclear domain is

$$D_N = \left(\frac{G_N\hbar}{c}\right)^{\frac{1}{2}} \sim 10^{-7}\text{m}^2/\text{s} \ . \qquad (4.12)$$

Therefore, during the nuclear time the diffused area of the nuclear constituents is 10^{-30}m^2. This is a typical area of nuclear size. The surface mass density inside the Nuclear region is defined as

$$S_N = \left(\frac{c^7}{\hbar G_N^3}\right)^{\frac{1}{2}} \sim 10^2 \text{kg/m}^2 \ . \tag{4.13}$$

The pressure exerted by nuclear medium(quantum) is given by

$$P_N = \left(\frac{c^7}{G_N^2 \hbar}\right) \sim 10^{32} \text{N/m}^2. \tag{4.14}$$

The electric nuclear charge density is given by

$$\rho_{\text{Q}_\text{N}} = \left(\frac{c^{10}}{\hbar^2 G_N^3 k}\right)^{\frac{1}{2}} \sim 10^{26} \ \text{C/m}^3, \tag{4.15}$$

thus having the same magnitude as the nuclear mass density. This implies that inside the nucleus both electricity and gravity dominate. We calculate here the electric field of an electron whose radius is $\sim\ 10^{-15}$m. This is given by $E = \frac{ke^2}{r} \sim 10^{20}$ Vm^{-1} and its mass density is $\rho = \frac{m_e}{r^3} \sim 10^{14}$ kg m^{-3}, and its charge density is $\rho_e = \frac{e}{r^3} \sim 10^{26}$C m^{-3}. Comparing these values with the above data one sees that an electron as a single system resembles a nucleus.

The nuclear tension is given by

$$T_N = \frac{c^4}{8\pi G_N} \sim 10^3 \text{N} \ . \tag{4.16}$$

This coincides with the value calculated for the quarks confined in side hadrons. It is s thought that a quark-antiquark is made if one tries to separate strongly interacting particles, in which case the string tension is broken.

The acceleration of the quantum fluid filling the space-time inside the nucleus is given by

$$a_N = \left(\frac{c^7}{G_N \hbar}\right)^{\frac{1}{2}} \sim 10^{31} \text{m/s}^2. \tag{4.17}$$

The charge per unit length in the nuclear region is given by

$$\lambda_q = \left(\frac{c^4}{G_N k}\right)^{\frac{1}{2}} \sim 10^{-3} \text{C/m}. \tag{4.18}$$

Thus, for a nuclear dimension one has a charge of an order $10^{-3} \times 10^{-15} \sim 10^{-18}$C, which is the charge of the nucleus.

The amount of energy emitted per unit time per unit area (energy flux) in the nuclear region is given by

$$\Sigma_N = \left(\frac{c^8}{G_N^2 \hbar}\right) \sim 10^{40} \text{W/m}^2. \tag{4.19}$$

The diffusion constant the nuclear medium is given by

$$D_N = \left(\frac{G_N \hbar_c}{c}\right)^{\frac{1}{2}} \sim 10^{-7} \ \ \text{m}^2/\text{s} \ . \tag{4.20}$$

One can define a coefficient of viscosity for the nuclear medium as

$$\eta_N = \left(\frac{c^9}{G_N^3 \hbar}\right)^{\frac{1}{2}} \sim 10^9 \text{Ns/m}^2. \tag{4.21}$$

This value suggests that the nuclear constituents move freely in this nuclear medium. This may elucidate the fact that quarks are free inside hadrons.

V. STAR DOMAIN

For such a system (Globular Cluster) one has a corresponding Planck's constant $\hbar_S \sim 10^{52}$ Js. We see that the Planck's area inside the star domain is given by

$$A_S = \left(\frac{G\hbar_S}{c^3}\right) \sim 10^{17} \ \text{m}^2 \ . \tag{5.1}$$

This gives a range of about 10^8m, that is a typical distance for stars. Now we see that

$$\mu_{\text{B}_\text{S}} = \left(\frac{G\hbar_S^2}{k}\right)^{\frac{1}{2}} \sim 10^{42} \ \text{J/T} \ , \tag{5.2}$$

and

$$I_\text{S} = \left(\frac{c^6}{Gk}\right)^{\frac{1}{2}} \sim 10^{25} \ \text{Amp} \ . \tag{5.3}$$

The nuclear electric field intensity is given by

$$E_\text{S} = \left(\frac{c^7 k}{\hbar_S G^2}\right)^{\frac{1}{2}} \sim 10^{17} \ \text{V/m} \ , \tag{5.4}$$

which is a typical nuclear field. The nuclear magnetic field density is

$$B_\text{S} = \left(\frac{c^5 k}{\hbar_S G^2}\right)^{\frac{1}{2}} \sim 10^9 \ \text{T}. \tag{5.5}$$

The star magnetic flux density is given by

$$\Phi_\text{S} = \left(\frac{k\hbar_S}{c}\right)^{\frac{1}{2}} \sim 10^{27} \text{Wb}. \tag{5.6}$$

The magnetic (electric) field contribution to mass density is given by

$$\rho_{\mathrm{mS}} = \left(\frac{B^2}{k}\right) \sim 10^8 \mathrm{kg/m^3}\ . \quad (5.7)$$

The surface tension of a star medium is given by

$$\gamma_{\mathrm{S}} = \left(\frac{c^{11}}{\hbar_S G^3}\right)^{\frac{1}{2}} \sim 10^{35} \mathrm{N/m}. \quad (5.8)$$

The electric nuclear charge density is given by

$$\rho_{\mathrm{Q_S}} = \left(\frac{c^{10}}{\hbar_S^2 G^3 k}\right)^{\frac{1}{2}} \sim 0.1\ \mathrm{C/m^3}, \quad (5.9)$$

This implies that inside the stars electricity is considerable. The acceleration of the quantum fluid filling the space-time inside the stars domain is given by

$$a_S = \left(\frac{c^7}{G\hbar_S}\right)^{\frac{1}{2}} \sim 10^8 \mathrm{m/s^2}. \quad (5.10)$$

The coefficient of viscosity in this region is

$$\eta_S = \left(\frac{c^9}{G^3\hbar_S}\right)^{\frac{1}{2}} \sim 10^{27} \mathrm{Ns/m^2}. \quad (5.11)$$

VI. GALACTIC DOMAIN

For such a system one has a Planck's constant $\hbar_G \sim 10^{68}$ Js. We see that Planck's area inside the galactic domain is given by

$$A_G = \left(\frac{G\hbar_G}{c^3}\right) \sim 10^{33}\ \mathrm{m^2}\ . \quad (6.1)$$

This gives a range of about 10^{17} m, that is a typical distance for galaxies. Now we see that

$$\mu_{\mathrm{B_G}} = \left(\frac{G\hbar_G^2}{k}\right)^{\frac{1}{2}} \sim 10^{58}\ \mathrm{J/T}\ , \quad (6.2)$$

and

$$I_{\mathrm{G}} = \left(\frac{c^6}{Gk}\right)^{\frac{1}{2}} \sim 10^{25}\ \mathrm{Amp}\ . \quad (6.3)$$

The galactic electric field intensity is given by

$$E_{\mathrm{G}} = \left(\frac{c^7 k}{\hbar_G G^2}\right)^{\frac{1}{2}} \sim 10^{10}\ \mathrm{V/m}\ , \quad (6.4)$$

which is a typical galactic field. The galactic magnetic field density is

$$B_{\mathrm{G}} = \left(\frac{c^5 k}{\hbar_G G^2}\right)^{\frac{1}{2}} \sim 10^2\ \mathrm{T}. \quad (6.5)$$

The galactic magnetic flux density is given by

$$\Phi_{\mathrm{G}} = \left(\frac{k\hbar_G}{c}\right)^{\frac{1}{2}} \sim 10^{35} \mathrm{Wb}. \quad (6.6)$$

The magnetic (electric) field contribution to mass density is given by

$$\rho_{\mathrm{mG}} = \left(\frac{B^2}{k}\right) \sim 10^{-5} \mathrm{kg/m^3}\ . \quad (6.7)$$

The surface tension of a galactic medium is given by

$$\gamma_{\mathrm{G}} = \left(\frac{c^{11}}{\hbar_G G^3}\right)^{\frac{1}{2}} \sim 10^{27} \mathrm{N/m}. \quad (6.8)$$

The electric galactic charge density is given by

$$\rho_{\mathrm{Q_G}} = \left(\frac{c^{10}}{\hbar_G^2 G^3 k}\right)^{\frac{1}{2}} \sim 10^{-33}\ \mathrm{C/m^3}, \quad (6.9)$$

which is a vanishing small quantity. The diffusion constant (area/sec) for this system is

$$D_G = \left(\frac{G\hbar_G}{c}\right)^{\frac{1}{2}} \sim 10^{25}\ \mathrm{m^2/s}. \quad (6.10)$$

This can be compared with value obtained by Agob *et al.*, which is 1.9×10^{26} $\mathrm{m^2/s}$.

The acceleration of the quantum fluid filling the space-time inside the galaxies is given by

$$a_G = \left(\frac{c^7}{G\hbar_G}\right)^{\frac{1}{2}} \sim 10^{-1} \mathrm{m/s^2}. \quad (6.11)$$

The coefficient of viscosity in this region is

$$\eta_G = \left(\frac{c^9}{G^3\hbar_G}\right)^{\frac{1}{2}} \sim 10^{18} \mathrm{Ns/m^2}. \quad (6.12)$$

VII. COSMIC DOMAIN

Here the system is described by the Planck's constant $\hbar_c \sim 10^{87}$ Js. We see that the Planck's area inside the nuclear domain is given by

$$A_c = \left(\frac{G\hbar_c}{c^3}\right) \sim 10^{52}\ \mathrm{m^2}\ . \quad (7.1)$$

This gives a range of about 10^{26}m, that is a typical distance for our present universe. Now we see that

$$\mu_{\mathrm{B_c}} = \left(\frac{G\hbar_c^2}{k}\right)^{\frac{1}{2}} \sim 10^{77}\ \mathrm{J/T}\ , \quad (7.2)$$

and

$$I_c = \left(\frac{c^6}{Gk}\right)^{\frac{1}{2}} \sim 10^{25} \text{ Amp} . \quad (7.3)$$

The cosmic electric field intensity is given by

$$E_c = \left(\frac{c^7 k}{\hbar_c G^2}\right)^{\frac{1}{2}} \sim 1 \text{ V/m} , \quad (7.4)$$

which is a typical cosmic field. The cosmic magnetic field density is

$$B_c = \left(\frac{c^5 k}{\hbar_c G^2}\right)^{\frac{1}{2}} \sim 10^{-8} \text{ T}. \quad (7.5)$$

The cosmic magnetic flux density is given by

$$\Phi_c = \left(\frac{k\hbar_c}{c}\right)^{\frac{1}{2}} \sim 10^{44}\text{Wb}. \quad (7.6)$$

The magnetic (electric) field contribution to mass density is given by

$$\rho_{\text{mc}} = \left(\frac{B^2}{k}\right) \sim 10^{-26}\text{kg/m}^3 . \quad (7.7)$$

The surface tension of a cosmic medium is given by

$$\gamma_c = \left(\frac{c^{11}}{\hbar_c G^3}\right)^{\frac{1}{2}} \sim 10^{18}\text{N/m} . \quad (7.8)$$

The surface energy of the universe is given by

$$U_c = \gamma \left(\frac{G\hbar_c}{c^3}\right)^{\frac{1}{2}} \sim 10^{70}\text{J} . \quad (7.9)$$

The amount of energy emitted per unit time per unit area in whole universe is given by

$$\Sigma_c = \left(\frac{c^8}{G^2\hbar_c}\right) \sim 1\text{W/m}^2. \quad (7.10)$$

We see that the vacuum energy flux today is incredibly small in comparison with one at Planck's time. It is 120 orders of magnitude smaller. The gravitational field is defined as

$$\phi_c = \left(\frac{c^2}{G}\right) \sim 10^{27}\text{kg/m} . \quad (7.11)$$

This defines the maximal mass that can be placed in gravitational field. Thus the maximal mass which can be placed over a distance of 10^{26}m is 10^{53}kg. Therefore, the mass of the universe we observe toady is the only possible mass that the universe can hold.

The mass flow rate is defined by

$$Q_c = \left(\frac{c^3}{G}\right) \sim 10^{35}\text{kg/sec}. \quad (7.12)$$

This implies the universe developed its entire mass during a time of 10^{18}sec. We therefore see that the universe appears the way it is, because it is a highly constrained system.

The surface mass density of the whole Universe at the present time is defined as

$$S_c = \left(\frac{c^7}{\hbar_c G^3}\right)^{\frac{1}{2}} \sim 10^2\text{kg/m}^2 . \quad (7.13)$$

The pressure exerted by vacuum(quantum) at the present time is given by

$$P_c = \left(\frac{c^7}{G^2\hbar_c}\right) \sim 10^{-9}\text{N/m}^2. \quad (7.14)$$

Comparing this with the Planck value one finds

$$\frac{P_P}{P_c} = \left(\frac{\hbar_c}{\hbar}\right) \sim 10^{122} . \quad (7.15)$$

Hence, not only the cosmological constant today is 122 orders of magnitude, but several other cosmic quantities. One therefore should not be puzzled by the smallness of the cosmological constant, but by the whole other cosmic quantities as well. This is a manifestation of a cosmic quantization of our universe at all levels. It therefore very natural to observe these hierarchies in our physical world. I think because of these hierarchies our universe is unique, and without them we might not have a universe lasting for 10 - 15 billion of years!

The electric cosmic charge density is given by

$$\rho_{Q_c} = \left(\frac{c^{10}}{\hbar_c^2 G^3 k}\right)^{\frac{1}{2}} \sim 10^{-36} \text{ C/m}^3, \quad (7.16)$$

Again, this implies that the present universe can't be dominated by electricity today. The acceleration of the quantum fluid filling the space-time at present's time is given by

$$a_c = \left(\frac{c^7}{G\hbar_c}\right)^{\frac{1}{2}} \sim 10^{-10} \text{ m/s}^2. \quad (7.17)$$

We therefore expect all objects to have experienced a uniform acceleration due to expansion of the cosmic fluid filling the whole universe. Thus, every object will experience this acceleration as far as it floats on space-time. However, such an acceleration is observed in Casimir experiments and recently observed by Pioneer satellite. The diffusion constant for the cosmic domain is given by

$$D_c = \left(\frac{G\hbar_c}{c}\right)^{\frac{1}{2}} \sim 10^{34} \ \ \mathrm{m^2/s}\ . \qquad (7.18)$$

Therefore, during the cosmic time the diffused area of the cosmos constituents is $10^{52}\mathrm{m}^2$. This is a typical area of cosmic size. It has been emphasized by Kozlowska and Kozlowski (2003) that as time goes one the universe becomes more and more quantum on large scale by allowing $\hbar \to \infty$. They concluded that the prevailing thermal process for thermal phenomena in the universe (that taking place on large scale) is the diffusion.
One can define a coefficient of viscosity for the cosmic medium as

$$\eta_c = \left(\frac{c^9}{G^3\hbar_c}\right)^{\frac{1}{2}} \sim 10^9\mathrm{Ns/m^2}. \qquad (7.19)$$

This means that today the cosmos are moving freely and that the ideal fluid approximation is valid for the present era. We however, see that the viscosity coefficient for the nuclear medium and cosmos are the same. This implies that the quantity $G^3\hbar_c = G_N^3\hbar$ is conserved. Thus the universe at the very large and the very small scales is governed by the same rules and shows a similarity as regards to its surface mass density, surface tension and viscosity. This is because we have the interrelations: $\gamma = c\eta$, $\eta = cS$. One also can write, using eqs.(7), (37) and (73), the relation that

$$D = \left(\frac{T}{\eta}\right)\ . \qquad (7.20)$$

This shows that the diffusion constant is inversely proportional to viscosity coefficient. Using eqs.(38), (7), (19) and (37), eq.(116) yields

$$\eta = \left(\frac{c}{G}\right) a \quad \text{and} \quad \gamma = \left(\frac{\mathrm{c}^2}{\mathrm{G}}\right) \mathrm{a}\ , \qquad (7.21)$$

which would mean that space time accelerates faster in a more viscous medium than a less one. The viscosity of the universe at Planck's time was very enormous ($10^{70}\mathrm{Ns/m^2}$) due to existence of so many interacting particles which mimics a viscous flow. Since the viscosity of the present universe is very small ($10^9\mathrm{Ns/m^2}$), which is 61 orders of magnitude smaller than its Planck value, one would expect that this phenomena had played a great role in bringing the homogeneous and isotropic universe we come to observe now.

VIII. THE HIERARCHICAL UNIVERSE

We see from our analysis that the hierarchical structure of our universe is due to that fact that the present cosmic quantities are related by the Planckian ones by a factor that depends on Planck constants of the two systems. This factor takes into account the smallness and the vastness of the atomic and cosmic realms when compared to each other. However, since $G_P = G_0$ (Arbab, 2001b), one defines this factor as:

$$N = \sqrt{\left(\frac{\hbar_c}{\hbar}\right)} \ \sim 10^{61} \quad , \qquad (8.1)$$

so that the mass, density, acceleration and pressure of the universe are

$$M_0 = (N)\, M_P, \qquad \rho_0 = \left(\frac{1}{N^2}\right) \rho_P, \qquad (8.2)$$
$$a_0 = \left(\frac{1}{N}\right) a_P, \qquad P_0 = \left(\frac{1}{N^2}\right) P_P,$$

and; the radius, age, viscosity and electric field of the universe are

$$R = (N)\, R_P, \qquad t_0 = (N)\, t_P, \qquad (8.3)$$
$$\eta_0 = \left(\frac{1}{N}\right) \eta_P, \qquad E_0 = \left(\frac{1}{N}\right) E_P\ .$$

Hence, the present cosmic quantities are big(or small) when measured in Planckian units. The main reason behind this is that the universe is a very quantum (restricted) system. We observe that most of the present quantities are 120 orders of magnitude smaller than their Planckian counterparts. There must be some conspiracy between the fundamental constants that can maintain a critical universe at all times. We therefore, argue that the physical laws that govern the universe at its birth are still lingering behind.

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