J.Phy.Ast.

Print-ISSN: 2320-6756
Online-ISSN: 2320-6764

Journal of
Physics & Astronomy

WWW.MEHTAPRESS.COM

Full Paper

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Received: January 07, 2014
Accepted: April 04, 2014

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Quantum volume of discrete space and its growth rate

Abstract

In the present theoretical work limited to stationary mass, we have attempted to derive an expression for the quantum volume of discrete space and its growth rate by combining gravity and electromagnetic field using Gauss's law of gravitation, Einstein's mass energy equivalence, deBroglie hypothesis and Heisenberg's uncertainty principle. It is found the gravity is a composite effect of electromagnetic field and the space is an artifact of basic natural forces that symmetrically increases with constant rate $9.81972 \times 10^{-61}\ m^3\ s^{-1}$. It is observed that the space-time line is straight whose reverse extrapolation brings the space zero at Planck's time $t_p \approx 5.39106\ (32) \times 10^{-44}\ s$ if t_p is at origin indicates the universe may have come into quantum existence with volume thrice of quantum volume within framework of physical laws when it already had an age $\approx 10^{-43}\ s$ otherwise, space and time have the same origin. The unification reveals charge and matter do exist simultaneously and both are dregs of EM field. The sizes of electron and proton are also calculated and reported in terms of quantum mass and quantum length.

Key Words

Minimum space volume; Growth rate of space; Mass; Charge; Gravity.

INTRODUCTION

The unification of the fundamental forces of nature into a single force, which occupied Einstein's attention for much of his later life, is very much a current focus of research is at an encouraging and speculative stage. In 1687, Issac Newton has unified celestial and terrestrial mechanics and showed the same laws of motion and the law of gravitation applies to both the domains. H.C. Oersted, in 1820, showed that electric and magnetic phenomena are inseparable aspects of a unified domain of electromagnetism. Michael Faraday, in 1830, unified the electric and magnetic fields in his electromagnetic induction laws. In 1873, J.C. Maxwell has unified electricity, magnetism and optics together and showed that light is an electromagnetic wave. S.L. Glasbow, Abdus Salam and S. Weinberg, in 1979, have unified weak and electromagnetic forces. The Minkowski metric equation $ds^2 = c^2dt^2 - dx^2 - dy^2 - dz^2$ unified the space-time geometrically[1].

In Newtonian gravity, the universal gravitational constant G simply measures the strength of the gravitational field while it takes on a deeper significance in general relativity that it quantifies how much the other fields affect the geometry of space-time i.e. the curvature of the space-time metric interacts with other field like the gravitational field via Einstein's equation of gravitation[2,3]

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

The Einstein tensor $G_{\mu\nu}$ depends on the curvature of the metric, $g_{\mu\nu}$ is metric tensor, while the stress-energy tensor $T_{\mu\nu}$ describes the energy and momentum flow due to all other fields and inverse of square root of cosmological constant $\Lambda = 3L^{-2}$ approximates the size of universe $L = 10^{26}\ m$[4,5]. Einstein assumed the size of the universe is constant in his general relativity while it is expanding infinitely in accordance with the Hubble's law.

In 1893, Oliver Heaviside[6] made an analogy of Maxwell's four equations known as gravitoelectromagnetic equations in the gravitation to study energy propagation

in gravitational field. He had proposed the gravitational Poynting vector contained the magnetic component of gravitation hidden in tensor equations of Einstein's general relativity theory. Scientists have predicted gravitoelectric and gravitomagnetic fields[7-11], in the same way around a mass that a moving electric charge is the source of electric and magnetic fields using Oliver Heaviside's equations. Although researchers have had attempted to establish the unified theory, yet there is no complete theory that add the gravity with electromagnetic field. Calculations based on the Einstein's general relativity estimates 99% of the material in the universe is dark matter[12]. Using cosmological constant Λ, Wesson[13] has calculated the quantum mass $\cong 2 \times 10^{-68}$ *kg*.

The black hole size $R \approx 2.95M / M_{\odot}\ km$ equivalent to universe mass $M \approx 5\times10^{22} M_{\odot}$ is nearly equal to size of universe indicates the only equivalent black hole of universe mass occupies whole space of universe, which is not in reality! This shows the space is very large compared to the present theoretically estimated size and it may have originated long before the Big Bang occurrence. Thus, origin of space seems to be reconsidered and the universe needs to be resized.

Survey of literatures divulges that no work however, is available on the minimum volume of space and its growth rate that amalgamates gravity and electromagnetic field. In the present theoretical approach, an attempt has been made to find the quantum volume of discrete space by combining gravity with electromagnetic field using Gauss's law of gravitation, Einstein's mass energy equivalence, de-Broglie hypothesis, Faraday's laws of induction and Heisenberg's uncertainty principle. It is found that gravity is a composite effect of electromagnetic field and the space is relic of basic natural forces and increases symmetrically with constant rate $9.81972 \times 10^{-61}\ m^3\ s^{-1}$. Space-time plot is a straight line extending infinity indicates irreversible expanding nature of the universe in analogous of the Hubble's law. It is reported that the space may have begun about $\approx 5.4 \times 10^{-44}\ s$ before applicability of physical laws. Present calculation estimates the universe should take $\cong 10^{138}\ s$ to expand in present size in absence of other interactions. The charge and matter do exist simultaneously and both are dregs of EM field. The size of electron and proton are also calculated in terms of quantum mass and reported.

EINSTEIN-GAUSS'S LAW OF GRAVITATION

Every rest mass has its own intrinsic gravitational field. Due to distribution of gravitational field lines with which every mass interacts with other mass via exchange of gravitational field particles gravitons[14,15] and accordingly attracts each other. In accordance with the gauss's law of gravitation, the surface integration of gravitational field intensity over a closed surface enclosing the mass is $-4\pi G$ times the total mass m enclosed within the surface i.e.

$$\Phi_G = \iint_S \vec{g} \cdot d\vec{A} = -4\pi G m \qquad (1)$$

Negative sign indicates the inward nature of gravitational field. The gravitational flux is always negative but it is never positive in contrast with Gauss's law of electricity, where the flux can be either positive or negative that depends on the nature of the net electric charges. The difference is because charge can be either positive or negative while mass can only be positive.

RELATION BETWEEN GRAVITATIONAL FIELD AND POYNTING VECTOR VALUE

In accordance with the de Broglie hypothesis, all matters were initially in the form of energy and EM radiation. From Einstein's mass-energy equivalence relation, the whole energy contained in the mass m is

$$E = mc^2 \qquad (2)$$

Derived in inertial reference system, which is independent of the gravity, the mass energy equivalent is valid in all reference frames as the total energy of matter is independent of choices of inertial and noninertial reference frames in accordance with the conservation of energy. Therefore, combination of equation (1) and equation (2) reduces to

$$\Phi_G = -\frac{4\pi G}{c^2} E \qquad (3)$$

The quantity $E = \int P dt = \int \vec{A}.\vec{S} dt = \iint_S d\vec{A} \cdot \int \left(\vec{E} \times \vec{H}\right) dt$

then, equation (3) becomes

$$\Phi_G = -\frac{4\pi G}{c^2} \iint_S d\vec{A} \cdot \int \left(\vec{E} \times \vec{H}\right) dt \qquad (4)$$

Using equation (4) and equation (1) in the first rank of tensor gravity i.e. vector form, we get

$$\therefore \vec{g} = -\frac{4\pi G}{c^2} \int \left(\vec{E} \times \vec{H}\right) dt = -\frac{4\pi G}{c^2} \int \vec{S} dt \qquad (5)$$

Clearly, the gravitational field linearly depends in opposite direction of Poynting vector of electromagnetic field and it is sediment of Poynting vector over a time. Thus, electromagnetic field carries the gravitational field. Time dependent sinusoidal electric and magnetic fields are

$$\vec{E} = \vec{E}_0 \sin \omega t$$

$$\vec{H} = \vec{H}_0 \sin \omega t$$

Insertion of above two relations in equation (5) reduces the gravitational field value of both fields in one

time-period T as

$$\vec{g} = -\frac{4\pi GT}{2c^2}\left(\vec{E}_0 \times \vec{H}_0\right) \quad (6)$$

Or

$$\vec{g} = -\frac{4\pi GT}{c^2}\left(\vec{E}_{rms} \times \vec{H}_{rms}\right) = -\frac{4\pi G}{c^2}\vec{S}_{rms}T \quad (7)$$

SPACE-TIME RELATION

In accordance with Heisenberg's Uncertainty Principle, product of energy and time would never be less than value of reduced Planck's constant $Et \geq \hbar$. Therefore,

$$\vec{A} \cdot \vec{S}_{rms}T^2 \geq \hbar \quad (8)$$

Replacement of $\vec{S}_{rms}T$ from equation (7) using equation (8) gives

$$-\vec{g} \cdot \vec{A}T = \frac{4\pi G\hbar}{c^2} \quad (9)$$

Since the speed $\vec{v} = \vec{g}T$ cannot exceed the light speed c in vacuum, then $\vec{c} = \vec{g}T$. Therefore,

$$-\vec{c} \cdot \vec{A} = \frac{4\pi G\hbar}{c^2} \quad (10)$$

Since $\vec{g}$ and $\vec{A}$ are in opposite directions and the quantity vA is the expansion rate of the space, then equation (10) becomes

$$\frac{dV}{dt} = \frac{4\pi G\hbar}{c^2} = 9.81972(22)\times 10^{-61} m^3 s^{-1} \quad (11)$$

Integration of above equation gives

$$V = V_0 + S_\square t \quad (12)$$

Here $S_\square = \frac{4\pi G\hbar}{c^2} = 9.81972(22)\times 10^{-61} m^3 s^{-1}$ is space expansion constant. Evidently, expansion of universe is symmetric with constant rate. Derived from energy of dark matter, the space is a complex product of basic natural forces. No laws of Physics are applicable in the time less than Planck's time[16], $t_P = \sqrt{\frac{G\hbar}{c^5}} = 5.39106(32)\times 10^{-44} s$ therefore, the volume of space at Planck's time is

$$V_\square = 4\pi\sqrt{\frac{G^3\hbar^3}{c^9}} = 3V_P = 5.29386(99)\times 10^{-104} m^3 \quad (13)$$

Noticeably, the volume of space is three times the Planck's volume $V_P = \frac{4}{3}\pi\ell_P^3$ at Planck's time, which is finite and immeasurable quantifies the space. The Planck's length $\ell_P = \sqrt{\frac{G\hbar}{c^3}} = 1.616199(97)\times 10^{-35} m$ is the quantum length where ideas about gravity and space-time cease to be valid. Any length less than Planck's length is beyond applicability of laws of physics[16-18]. In accordance with Einstein estimation, the size of an extremely small point so called as the world point[19], which is a physical entity in space-time continuum is a metric limit as the notion of distance disappears into world point, is of the order of 10^{-23} m[20]. If quantum volume exists then, it indicates the presence of extremely small immeasurable ultimate particles that may occupy the quantum volume.

Figure 1 is the space-time plot, which is a straight line with intercept on space axis extending infinity, indicates irreversible expanding nature of the universe in analogous of the Hubble's law. Reverse extrapolation of space-time line brings the space zero at time $-t_p$ if Planck's time is at origin. Thus, the space creation may have begun $\approx 5.4\ 10^{-44}$ s before applicability of physical laws and may have come into quantum existence with volume thrice of quantum volume within framework of laws of physics.

The unconditional integration of equation (11) yields the following equation

$$V = S_\square t \quad (14)$$

Obviously, without limiting Planck's time consideration, the inclined straight space-time plot, Figure 2, indi-

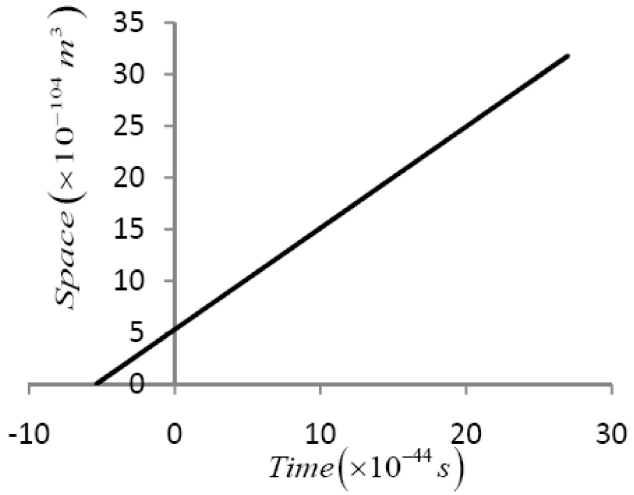

Figure 1 : Space-time plot with quantum time.

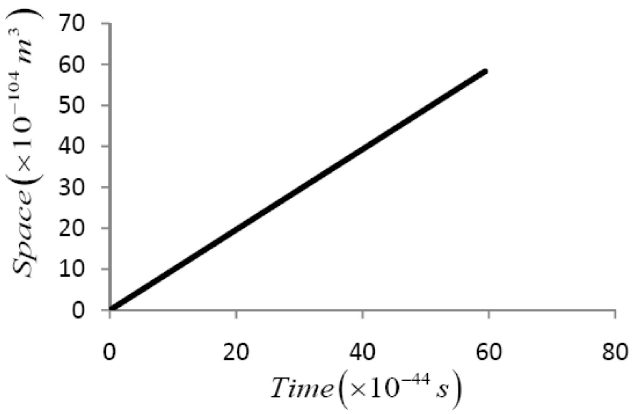

Figure 2 : Space-time plot without quantum time.

cates the space and time have the same origin.

After acquisition of adequate size of space, accumulation of masses may have made Big Bang before its occurrence otherwise, it could not get sudden enormous mass in its undersized. If present universe size[13] is of the order of 10^{26} *m*, then its volume ~10^{78} m^3 estimates the universe should take ≅ 10^{138} *s* i.e. ≅ 3.23×10^{130} *yrs* to take the present size in absence of other interactions.

THE GRAVITATIONAL FIELD INTENSITY ON THE SURFACE OF PLANCK'S SPHERE AT PLANCK'S TIME

The gravitational field intensity equivalent to the energy $E = \hbar / T$ confined within Planck's sphere in Planck's time is therefore,

$$|\vec{g}| = \frac{4\pi G\hbar}{c^2 AT} = \frac{G\hbar}{c^2 \ell_P^2 t_P} = \sqrt{\frac{c^7}{G\hbar}} = 5.57645 \times 10^{51}\, ms^{-2} \qquad (15)$$

This is the gravitational field associated with the limiting energy over Planck's sphere and may be perhaps the maximum limit of gravitational field intensity of a mater in the framework of physical laws.

RELATION BETWEEN GRAVITATIONAL FLUX AND ELECTROMAGNETIC FLUX

If all energy converts into kinetic energy *K* then equation (2) becomes

$$\therefore \Phi_G = -\frac{4\pi G}{c^2} K \qquad (16)$$

Clearly, gravitational flux is proportional to the kinetic energy. The time rate of change of gravitational flux is proportional to mechanical power i.e.

$$\frac{d\Phi_G}{dt} = -\frac{4\pi G}{c^2} P \qquad (17)$$

The mechanical power linearly depends on time rate of change of gravitational flux i.e.

$$P = -\frac{c^2}{4\pi G}\frac{d\Phi_G}{dt} = -\frac{c^2}{4\pi G}\frac{d}{dt}\left(\vec{g}\cdot\vec{A}\right) = -\frac{c^2}{4\pi G}\left[\vec{g}\cdot\left(\frac{d}{dt}\vec{A}\right)+\left(\frac{d}{dt}\vec{g}\right)\cdot\vec{A}\right] \qquad (18)$$

Obviously, rate of change of gravitational flux induces power in absence of predominant other interactions. In other way, rate of energy derived from dark matter converts into mass, energy and its gravitation field by the spontaneous law.

For electrical power $P = \mathscr{E} I$, then

$$\frac{d\Phi_G}{dt} = -\frac{4\pi G}{c^2}\mathscr{E} I \qquad (19)$$

From Maxwell's displacement current and Faraday's laws of EM induction, we have

$$I = I_d = \varepsilon_0 \frac{d\Phi_E}{dt} \text{ and } \mathscr{E} = -\frac{d\Phi_B}{dt} \qquad (20)$$

Introduction of values of displacement current I_d and electromotive force $\mathscr{E}$ in equation (19) yields following relation

$$\frac{d\Phi_G}{dt} = \frac{4\pi\varepsilon_0 G}{c^2}\frac{d^2}{dt^2}\left(\Phi_E \Phi_B\right) \qquad (21)$$

First order time rate of gravitational flux is proportional to second order time derivative of either of the electric and magnetic fluxes or their composite.

Integration of above relation yields to

$$\Phi_G = \frac{4\pi\varepsilon_0 G}{c^2}\frac{d}{dt}\left(\Phi_E \Phi_B\right) \qquad (22)$$

Clearly, either of time variable electric and magnetic field or their composite variation is the source of gravitational field i.e. wherever is the mass there is either both electric and magnetic fields or exists either of the fields. Gravitational, electrical and magnetic fields are interchangeable.

CHARGE-GRAVITY RELATION

Mass and its total electric charge i.e. sum of magnitudes of positive and negative electric charges are interrelated as $m = kq$ with constant $k = 10^{-11}$ kgC^{-1} for electron and $k = 10^{-8}$ kgC^{-1} for the proton. Therefore,

$$\therefore \Phi_G = -4\pi G k q \qquad (23)$$

Clearly, electric charge and gravitational field flux are equivalent.

THE QUANTUM MASS AND THE SIZES OF ELECTRON AND PROTON

Wesson[13] has derived an expression for the quantum mass by combining the cosmological constant with Planck's constant and light speed that estimates a quantum of mass of approximately 2×10^{-68} *kg*. This indicates the existence of an extremely small indivisible and immeasurable particle whose mass quantifies all mass particles. If this may be the quantum mass then, every mass is an integral multiple of this quantum mass. The mass of electron and proton are nearly 4.55×10^{37} and 8.3×10^{40} times the quantum mass, respectively. Every length is an integral multiple of the quantum length- Planck's length that measures the size as $r = \sqrt[3]{\frac{m}{m_{quantum}}}\ell_P$. Therefore, respective sizes of electron and proton would approximately be $r_{el} = 3.57$

$\times 10^{12}\ \ell_p \sim 5.76986 \times 10^{-23}\ m$ and $r_{pr} = 4.36207 \times 10^{13}\ \ell_p \sim 7.05 \times 10^{-22}\ m$, in terms of the quantum length (Planck's length).

Recently, CERN team has announced the existence of Higgs boson as the mass particle on 4th July 2012 whose mass is 131 times the proton mass[21]. The Higgs boson gets its mass from the self-interaction in the Higgs field, arisen through a mechanism of spontaneous symmetry breaking by the Higgs field of a certain universal symmetry. The Higgs mechanism does not predict the mass of the Higgs boson itself but rather a range of masses[22,23]. The Higgs particles may be acquiring its mass in terms of quantum of mass due to unknown mechanism until now.

MASS-FREQUENCY RELATION AND THEIR LIMIT OF UNCERTAINTY

Combination of the Heisenberg's uncertainty relation $Et \geq \hbar$ and Einstein's mass-energy relation $E = mc^2$ gives

$$mt \geq R \text{ and } m \geq R\nu \qquad (24)$$

$$R = \frac{\hbar}{c^2} \approx 1.172 \times 10^{-51}\ kgs$$

Clearly, this seems to set the new limit that simultaneous measurement of mass and time is not possible microscopically for $\leq R$ and every radiation bears certain mass.

RESULTS AND CONCLUSIONS

Present theoretical approach limited to the stationary mass may be a part attempt towards the unification of all forces sometimes known as Theories of Everything TOE- the theory that seeks to complete the job by adding gravity. Gravitational and electromagnetic field energies combine giving it the ability to fully explain and link together basic natural forces. The calculation is in the limit of constancy of light speed and its ultimate values of speed, Planck's length and Planck's time in the symmetric nature of universe. Electromagnetic and gravitational fields are equivalent i.e. wherever electromagnetic field is there is gravitational field and vice versa. Unification of gravitational and electromagnetic fields affirms charge and matter exist together and both are dregs of EM field. Mass-charge-space creation and energy annihilation is a simultaneous and spontaneous reversible universe process and occurs in immeasurable units beyond the applicability of the physical laws. Like electric charge, energy and angular momentum, space is quantized in unit of thrice of Planck's space and thus space is discrete rather than continuous in any form. Space is a complex function of basic natural forces and it increases symmetrically with constant rate $9.81972 \times 10^{-61}\ m^3\ s^{-1}$. Space-time plot is a straight line extending infinity indicates irreversible expanding nature of the universe in analogous of the Hubble's law. Reverse extrapolation of space-time line brings the space zero at time $-t_p \cong 5.39106(32) \times 10^{-44}\ s$ if Planck's time t_p is at origin. Thus, the universe may have come into quantum existence with thrice of the quantum size within framework of laws of physics when it already had an age $\approx 10^{-43}\ s$. Present calculation estimates the universe should take $\cong 3.23 \times 10^{130}\ yrs$ to expand in the present size in absence of other interactions. Due to instrumental limitation, this smallest expansion rate is beyond its measurement and comparison.

ACKNOWLEDGEMENTS

The author is very thankful to Profs K. N. Upadhyay, S. N. Thakur, D. N. Tripathi and fellowmen for fruitful discussions. He expresses very deep gratitude to wife Archana Pandey and daughter Rashika Pandey for their encouragement and cooperation during the work.

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