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Origin of Quantum Space-Time and Primordial Black Hole

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Abstract

In the present theoretical work, an attempt has been made to derive an expression for the quantum volume of discrete space and its growth rate using first rank tensorial Einstein-Gauss gravitation law, Einstein's mass energy equivalence and Heisenberg's uncertainty principle. It is found that the universe may have come into quantum existence with volume thrice the Planck's volume within the framework of physical laws when it already had an age ~10^{-43} s provided the Planck's time is at the origin otherwise, both have the same origin. The size and gravitational field of quantum primordial black hole of quantum mass have been estimated and reported.

Keywords

Quantum Space Volume, Space-Time Growth Rate, Quantum Primordial Black Hole

Subject Areas: **Modern Physics, Theoretical Physics**

1. Introduction

The Minkowski metric equation $\mathrm{d}s^2 = c^2t^2 - \mathrm{d}x^2 - \mathrm{d}y^2 - \mathrm{d}z^2$ unifies the space-time geometrically [1]. The universal gravitational constant G is simply the measure of the gravitational field strength in Newtonian gravity, while it takes on a deeper significance in general relativity that it quantifies how much the other fields affect the space-time geometry. Other field such as the gravitational field interacts with space-time curvature metric through Einstein's gravitation equation $G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$ [2] [3]. The Einstein tensor $G_{\mu\nu}$ depends on the metric curvature, $g_{\mu\nu}$ 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 $\Lambda = 3L^{-2}$ estimates the universe size $L \sim 10^{26}$ m [4] [5]. Einstein, in general relativity, has assumed the universe is constant while it is expanding infinitely in accordance with the Hubble's law.

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In 1893, Heaviside has made an analogy of Maxwell's four equations known as gravitoelectromagnetic equations in the gravitation to study energy propagation in gravitational field [6]. He has proposed the gravitational Poynting vector contained the magnetic component of gravitation hidden in tensor equations of Einstein's general relativity theory. Researchers have predicted *gravitoelectric* and *gravitomagnetic* fields, in the same way around a mass that a moving electric charge is the source of electric and magnetic fields using Heaviside's equations [7]-[11]. Although researchers have attempted to establish a unified theory, yet no complete theory is available that could add gravity with electromagnetic fields. Einstein's general relativity estimates 99% of the material in the universe is dark matter [12]. Wesson has computed the quantum mass $m_q \cong 2\times 10^{-68}$ kg using cosmological constant Λ [13].

From the survey of literatures, it is found that no work however, is available on the quantum volume of discrete space and its growth rate, and the size of quantum primordial black holes and its gravitational field. Of course, Pandey has recently derived the similar expression for the quantum volume and its growth rate in a different approach than the present one [14] [15]. In the present theoretical approach, an attempt has been made to find the quantum volume of discrete space using first rank tensorial Einstein-Gauss gravitation law, Einstein's mass energy equivalence and Heisenberg's uncertainty principle. The size of quantum primordial black hole of quantum mass and its gravitational field have been calculated and reported.

2. Einstein-Gauss Gravitation Law

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 and accordingly attracts each other [16] [17]. The first rank tensorial Einstein-Gauss gravitation law is the total gravitational flux Φ_G *i.e.* 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.*

$$\Phi_G = \oiint \boldsymbol{g}\cdot \mathrm{d}\boldsymbol{A} = \boldsymbol{g}\cdot\boldsymbol{A} = -4\pi G m \tag{1}$$

Negative sign indicates the inward nature of gravitational field. Since, radial gravitational field intensity $\boldsymbol{g}$ and surface area vector $\boldsymbol{A}$ are in opposite directions, then

$$\boldsymbol{g}\cdot\boldsymbol{A} = -\frac{\mathrm{d}^2 r}{\mathrm{d}t^2}A = -\frac{\mathrm{d}^2 V}{\mathrm{d}t^2} = -4\pi G m \tag{2}$$

Or,

$$\frac{\mathrm{d}^2 V}{\mathrm{d}t^2} = 4\pi G m \tag{3}$$

where $V = rA$ is the space volume.

3. Space-Time Relation

Integration of both sides of Equation (3) with respect to time yields to

$$\frac{\mathrm{d}V}{\mathrm{d}t} = 4\pi G m t \tag{4}$$

Derived in inertial reference system, which is independent of the gravity, the Einstein's mass energy equivalent $E = mc^2$ 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 the Heisenberg's uncertainty $Et \ge \hbar$ and $E = mc^2$ relations gives

$$mt \ge \frac{\hbar}{c^2} \tag{5}$$

Combination of Equations (4) and (5) results to

$$\frac{\mathrm{d}V}{\mathrm{d}t} = \frac{4\pi G\hbar}{c^2} \approx 9.81972\times 10^{-61}\ \mathrm{m}^3\cdot\mathrm{s}^{-1} \tag{6}$$

Integration of Equation (6) with respect to time gives

$$V = V_0 + S_O t \tag{7}$$

where $S_O = \frac{4\pi G\hbar}{c^2} \approx 9.81972\times10^{-61}\,\mathrm{m}^3\cdot\mathrm{s}^{-1}$ is space expansion constant, which may be the ultimate least rate of volume expansion. Evidently, expansion of universe is symmetric with constant rate. No law of Physics is applicable in the time less than Planck's time [18] $t_P = \sqrt{G\hbar/c^5} = 5.39106(32)\times10^{-44}\ \mathrm{s}$ therefore, the volume of space at Planck's time is

$$V_O = S_O t_P = 4\pi\sqrt{\frac{G^3\hbar^3}{c^9}} = 3V_P \approx 5.03\times10^{-104}\ \mathrm{m}^3 \tag{8}$$

Noticeably, the space volume equal to thrice the Planck's volume $V_P = \frac{4}{3}\pi\ell_P^3$ at Planck's time quantifies the space. This indicates the space is discrete as well as an integral multiple of thrice the Planck's volume. The Planck's length $\ell_P = \sqrt{G\hbar/c^3} = 1.616199(97)\times10^{-35}\ \mathrm{m}$ is the quantum length where ideas about gravity and space-time cease to be valid. Any length less than Planck's length is beyond the applicability of physical laws [18]-[20].

In a different approach, Pandey has recently estimated the smallest radius of quantum space is $\sim\sqrt[3]{3}\ell_P$ and has reported that the space is quantized with the volume of sphere of this least radius [14]. It would be worth mentioning that Einstein has estimated the size of an extremely small point so called as the world point, which is a physical entity in space-time continuum is a metric limit as the notion of distance disappears into world point, is $\sim10^{-20}\ \mathrm{m}$ [21] [22].

Figure 1 is the space-time plots, which are straight lines. The dotted line is the plot when Planck's time is the origin of space. It intercepts on space axis and extends infinity in absence of other interactions. Reverse extrapolation of space-time dotted line brings the space zero at time $-t_P$. Thus, the space creation may have begun $\approx 5.4\times10^{-44}\ \mathrm{s}$ before applicability of physical laws and may have come into quantum existence with volume thrice the Planck's volume within framework of physical laws.

On the other hand, the indefinite integration of Equation (6) yields the following relation:

$$V = S_O t \tag{9}$$

Obviously, without limiting Planck's time consideration, the inclined straight space-time plot passes through origin, solid line in the **Figure 1**, indicates the space and time have the same origin.

4. Size of Quantum Primordial Black Hole

In Einstein's general relativity, a distorted space-time region is a black hole from which gravity prevents anything, including light, from escaping. The black hole has a one-way surface, called an event horizon, into which objects can fall, but out of which nothing can come. It is black as it absorbs all the radiation that hit it, reflecting nothing, just like a perfect blackbody in thermodynamics. The Schwarzschild radius [23] of black hole of mass M in terms of sun mass $\odot$ is

$$R \approx 2.95\frac{M}{\odot}\ \mathrm{km} \tag{10}$$

Equation (10) estimates the size of black hole equivalent to universe mass $M \approx 5\times10^{22}\odot$ nearly equal to universe size $\sim10^{26}\ \mathrm{m}$ which 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 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.

In general, the size of black hole of mass $\mathrm{m\ kg}$ is of radius $r \sim 1.482222\times10^{-27}\ \mathrm{m\ meter}$. The size of black hole equivalent to the quantum mass $m_q \cong 2\times10^{-68}\ \mathrm{kg}$ calculated by Wesson will be $r_b \sim 2.964\times10^{-95}\ \mathrm{metre}$. This may be the ultimate smallest size of the primordial black hole which may have formed early in the history of the Universe creation, during the Big Bang if quantum mass estimated by Wesson exists.

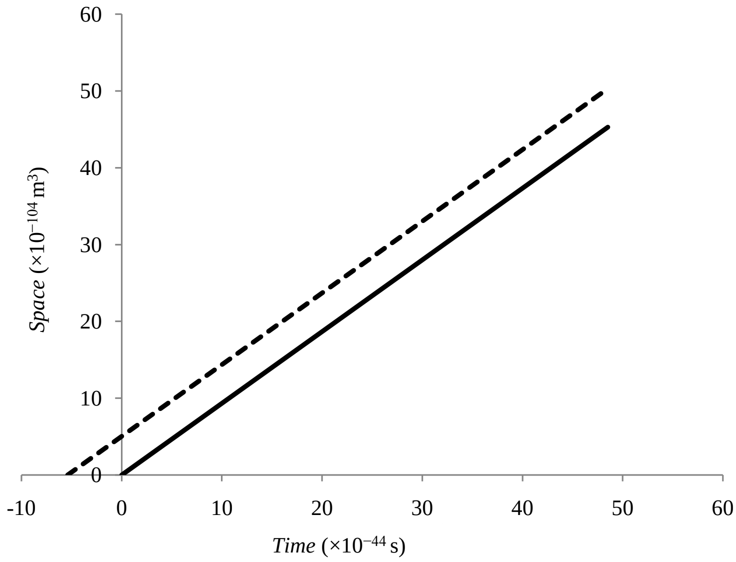

Figure 1. Space-Time plot. Dotted line represent the Planck's quantum time is as the origin and solid line represents without consideration of Planck's quantum time at origin.

5. The Gravitational Field Intensity of Quantum Primordial Black Hole

The gravitational field intensity of the quantum primordial black hole of quantum mass is

$$g = \frac{Gm_q}{r_b^2} \approx 1.518 \times 10^{111} \text{ m} \cdot \text{s}^{-2} \tag{11}$$

Thus, the ultimate smallest theoretical black hole has the maximum gravitational field intensity, which is nearly 10^{60} times the gravitational field associated with the limiting energy over Plank's sphere, to coalesce with other black holes [14]. This value may be the maximum limit of gravitational field intensity of a matter in the framework of physical laws.

6. Conclusion

Present theoretical approach limits to the stationary mass and constancy of limited light speed in the symmetric nature of universe. The universe may have come into quantum existence with volume thrice the Planck's volume within the framework of physical laws when it already had an age $\sim 10^{-43}$ s otherwise, both have the same origin. If quantum mass exists, the quantum primordial black holes may also exist theoretically with enormous gravitational field with which they interact and grow. The gravitational field decreases as the black hole grows due to coalescence. Due to instrumental limitation, this smallest expansion rate and size are beyond their measurement and comparisons. Further, more studies are desirable to replicate in support of the present findings to arrive at a general conclusion.

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References

[1] Minkowski (1908) Space and Time: The Principle of Relativity. Dover, Encyclopedia.

[2] Møller, C. (1952) Theory of Relativity. Oxford University Press, London.

[3] Gupta, S.N. (1957) Einstein's and Other Theories of Gravitation. *Reviews of Modern Physics*, **29**, 334-336.

http://dx.doi.org/10.1103/RevModPhys.29.334

[4] Misner, C.W., Thorne, K.S. and Wheeler, J.A. (1973) Gravitation. In: Freeman, W.H., Ed., San Francisco.

[5] Lineweaver, C.H. (1998) The Cosmic Background and Observational Convergence in the ΩM-ΩΛ Plane. *Astrophysics Journal*, **505**, L69. http://dx.doi.org/10.1086/311613

[6] Heaviside, O. (1893) A Gravitational and Electromagnetic Analogy. *The Electrician*, **31**, 281-282.

[7] Campbell, W.B. and Morgan, T.A. (1976) Maxwell Form of the Linear Theory of Gravitation. *American Journal of Physics*, **44**, 356-365. http://dx.doi.org/10.1119/1.10195

[8] Jefimenko, O.D. (1992) Causality, Electromagnetic Induction and Gravitation. Electret Scientific Company, Star City.

[9] Clark, S.J. and Tucker, R.W. (2000) Gauge Symmetry and Gravito-Electromagnetism. *Classical and Quantum Gravity*, **17**, 4125-4157. http://dx.doi.org/10.1088/0264-9381/17/19/311

[10] Tajmar, M. and de Matos, C.J. (2001) Gravitomagnetic Barnett Effect. *Indian Journal of Physics B*, **75**, 459-461.

[11] Mashhoon, B. (2007) Gravitoelectromagnetism: In Measuring Gravitomagnetism. In: Iorio, L., Ed., *A Challenging Enterprise*, Nova.

[12] Overduin, J.M. and Wesson, P.S. (2003) Dark Sky, Dark Matter. Institute of Physics, London.

[13] Wesson, P.S. (2004) Is Mass Quantized? *Modern Physics Letter*, **19**, 1995-2000. http://dx.doi.org/10.1142/S0217732304015270

[14] Pandey, R.K. (2014) Quantum Volume of Discrete Space and Its Growth Rate. *Journal of Physics & Astronomy*, **3**, FP71-FP76.

[15] Pandey, R.K. (2013) Fundamentals of Gravitoelectromagnetism. Lambert Academic Publishing, Saarbrücken.

[16] Ashtekar, A. and Geroch, R. (1974) Quantum Theory of Gravitation. *Reports on Progress in Physics*, **37**, 1211-1256. http://dx.doi.org/10.1088/0034-4885/37/10/001

[17] Oriti, D., Ed. (2009) Approaches to Quantum Gravity: Toward a New Understanding of Space, Time and Matter. Cambridge University Press, Cambridge. http://dx.doi.org/10.1017/CBO9780511575549

[18] Rickles, D. (2008) Symmetry, Structure and Space-Time. Amsterdam, Elsevier.

[19] Bain, J. (2008) Condensed Matter Physics and the Nature of Space Time. In: Dieks, I.D., Ed., *The Ontology of Spacetime*, Elsevier, Amsterdam. http://dx.doi.org/10.1016/S1871-1774(08)00016-8

[20] Butterfield, J. and Isham, C. (1999) On the Emergence of Time in Quantum Gravity. In: Butterfield, J., Ed., *The Arguments of Time*, Oxford University Press, London.

[21] Einstein, A. (1966) The Meaning of Relativity. Princeton University Press, Princiton.

[22] Pierre, P. (2014) Physics in Discrete Space: On Space-Time Organization. *Journal of Modern Physics*, **5**, 563-575. http://dx.doi.org/10.4236/jmp.2014.58067

[23] Hooft, G. (2009) Introduction to the Theory of Black Holes. Institute for Theoretical physics, Spinoza Institute, 47-48.