On the combined role of Mach's principle and quantum gravity in the evolving cosmology

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Abstract: During evolution, cosmic thermal energy density is always directly proportional to the critical mass-energy density. The product of cosmic 'critical density' and 'critical Hubble volume' can be called as the 'critical mass' of the evolving universe. With reference to Mach's principle, cosmic 'critical density', 'critical volume' and 'critical mass' can be considered as the quantified back ground dynamic properties of the evolving universe. By considering the Planck mass as the critical mass connected with big bang, Planck scale Hubble constant and critical density can be defined. Observed redshift can be reinterpreted as a cosmological light emission phenomenon connected with cosmologically reinforcing or strengthening hydrogen atom. Super novae dimming can also be understood in this way. To understand the ground reality of cosmic rate of expansion, accuracy of the current methods of estimating the magnitudes of current Hubble's constant and current CMBR temperature must be improved.

Key words: Standard cosmology, Quantum cosmology, Mach's principle, Critical volume, Critical mass, Cosmic repulsive force.

1. Introduction

The fundamental question to be answered is: Is the universe a quantum gravitational object or something else? Physicists expressed several opinions with many possible solutions [1,2]. By correlating the basics of Quantum mechanics, Special and General theories of relativity and big bang - in this letter authors explore the possibility of developing a scale independent quantum cosmology.

2. Scale independent quantum cosmology

Some of the other modern cosmologists believe that, during the cosmic evolution, Planck scale quantum gravitational interactions might have an observable effect on the current observable cosmological phenomena. Clearly speaking, with respect to the current concepts of 'Quantum gravity' and Planck scale early universal laboratory, current universe can be considered as a low energy scale laboratory. If one is willing to consider the current observable universe as a low energy scale operating laboratory, currently believed cosmic microwave back ground temperature can be considered as the low energy quantum gravitational effect. At any time in the past, i.e as the operating energy scale was assumed to be increasing; past high cosmic back ground temperature can be considered as the high energy quantum gravitational effect. Thinking in this way, starting from the Planck scale and with reference to the decreasing magnitude of cosmic back ground temperature [3], quantum gravity can be considered as a scale independent model and the universe can be considered as the best quantum gravitational object.

3. The unified Planck scale mass unit connected with big bang

With reference to the famous Planck's constant, the unified quantum mass unit connected with big bang can be expressed as follows. It can be obtained from equations (5,6,7,8 and 9).

$$M_U \cong \left(\frac{\pi}{xy\sqrt{45}}\right)\sqrt{\frac{hc}{G}} \cong 1.82386\times10^{-9}\ \text{kg} \tag{1}$$

Here, from quantum theory of light [4,5],

$x \cong 4.96511423...$ and $y \cong 2.821439372...$

With 98% accuracy, its classical unified expression can be expressed as follows. In this context interested readers may go through the references [5,6].

$$M_U \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 G}} \cong 1.859272\times10^{-9}\ \text{kg} \tag{2}$$

4. The unified quantum scale Hubble constant connected with big bang

With reference to the General theory of light and Friedmann cosmology, current and past critical mass densities can be expressed as follows.

$$\rho_0 \cong \frac{3H_0^2}{8\pi G} \text{ and } \rho_t \cong \frac{3H_t^2}{8\pi G} \tag{3}$$

With reference to the observable volume of the current and past universe, current and past critical volumes can be can be expressed as follows.

$$V_0 \cong \frac{4\pi}{3}\left(\frac{c}{H_0}\right)^3 \text{ and } V_t \cong \frac{4\pi}{3}\left(\frac{c}{H_t}\right)^3 \tag{4}$$

Characteristic critical masses of the current and past universe can be expressed as follows.

$$\left.\begin{array}{l} M_0 \cong \rho_0 V_0 \cong \left(\frac{3H_0^2}{8\pi G}\right)\left[\frac{4\pi}{3}\left(\frac{c}{H_0}\right)^3\right] \cong \frac{c^3}{2GH_0} \\ M_t \cong \rho_t V_t \cong \left(\frac{3H_t^2}{8\pi G}\right)\left[\frac{4\pi}{3}\left(\frac{c}{H_t}\right)^3\right] \cong \frac{c^3}{2GH_t} \\ \to H_0 \cong \frac{c^3}{2GM_0} \text{ and } H_t \cong \frac{c^3}{2GM_t} \end{array}\right\} \tag{5}$$

Scientists proposed several characteristic constants connected with unification and cosmology. Now with reference to the above proposed unified Planck scale quantum mass M_U, unified Hubble's constant (assumed to be connected with big bang) can be defined as follows.

$$\left.\begin{array}{l} H_U \cong \frac{c^3}{2GM_U} \cong \frac{xy\sqrt{45}}{2\pi}\sqrt{\frac{c^5}{Gh}} \\ \cong 1.1067817\times 10^{44}\ \text{sec}^{-1} \end{array}\right\} \tag{6}$$

Using this characteristic big bang Hubble constant, in a cosmological approach, a suitable proportionality coefficient of the following form $\left[1+\ln\left(\frac{H_U}{H_t}\right)\right]$ can be considered for further study as proposed in the following sections.

5. Different relations connected with Quantum cosmology and big bang

Based on the quantum cosmological concepts, the following semi empirical heuristic equations can be given a fundamental significance [5] in cosmology. Using these relations current cosmological parameters can be fitted accurately.

Relation between thermal energy density and critical energy density

Basic concept: During cosmic evolution, at any time, thermal energy density is proportional to the critical mass energy density.

$$aT_t^4 \cong \gamma.\left(\frac{3H_t^2c^2}{8\pi G}\right) \tag{7}$$

where γ is a model dependent proportionality coefficient. With reference to the Planck scale and current key cosmological physical parameters, the proportionality coefficient can possibly be fitted in the following way [5].

$$\gamma \cong \left[1+\ln\left(\frac{H_U}{H_t}\right)\right]^{-2} \tag{8}$$

It is for further study and critical analysis.

$$aT_t^4 \cong \left[1+\ln\left(\frac{H_U}{H_t}\right)\right]^{-2}\left(\frac{3H_t^2c^2}{8\pi G}\right) \tag{9}$$

For the current universe,

$$aT_0^4 \cong \left[1+\ln\left(\frac{H_U}{H_0}\right)\right]^{-2}\left(\frac{3H_0^2c^2}{8\pi G}\right) \tag{10}$$

If $H_0 \cong 71$ km/sec/Mpc, obtained $T_0 \cong 2.723$ K.

Relation between cosmic thermal wave lengths and Hubble lengths

Let λ_f, λ_m represent the thermal wavelengths [4] related with frequency and wavelength domains respectively. From relations and with reference to the two forms of Wien's law, at any time in the past,

$$\left(\lambda_f, \lambda_m\right)_t \cong \left(\frac{x}{y}\right)^{\pm\frac{1}{2}}\sqrt{1+\ln\left(\frac{H_U}{H_t}\right)}\left(\frac{2\pi c}{\sqrt{H_U H_t}}\right) \tag{11}$$

For the current universe [7],

$$\left(\lambda_f, \lambda_m\right)_0 \cong \left(\frac{x}{y}\right)^{\pm\frac{1}{2}}\cdot\sqrt{1+\ln\left(\frac{H_U}{H_0}\right)}\cdot\left(\frac{2\pi c}{\sqrt{H_U H_0}}\right) \tag{12}$$

If $H_0 \cong 71$ km/sec/Mpc, obtained wavelengths are $\left(\lambda_f\right)_0 \cong 1.872655$ mm and $\left(\lambda_m\right)_0 \cong 1.06414$ mm.

Relation between cosmic thermal wave lengths and the Cosmic repulsive force

With usual notation, from General theory of relativity [8,9],

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \quad (13)$$

In this historical relation, the most important point to be noted is that, the expression $\left(8\pi G/c^4\right)$ seems to be a proportionality constant. If one is willing to consider its 'inverse form', it becomes $\left(c^4/8\pi G\right)$ and seems to play a very crucial role in the evolving cosmology. It can be called as the 'repulsive force' of the evolving universe. From above relations it can be expressed as follows. At any time in the past,

$$\sqrt{1+\ln\left(\frac{M_t}{M_U}\right)} \cdot \frac{\sqrt{M_U M_t c^2}}{\sqrt{\left(\lambda_f\right)_t \left(\lambda_m\right)_t}} \cong \frac{c^4}{4\pi G} \quad (14)$$

For the current universe,

$$\sqrt{1+\ln\left(\frac{M_0}{M_U}\right)} \cdot \frac{\sqrt{M_U M_0 c^2}}{\sqrt{\left(\lambda_f\right)_0 \left(\lambda_m\right)_0}} \cong \frac{c^4}{4\pi G} \quad (15)$$

Relation between matter energy density, thermal energy density and critical energy density

Basic concept: During cosmic evolution, at any time, matter energy density is the geometric mean of critical mass energy density and thermal energy density.

$$\left(\rho_m\right)_t \cong \frac{1}{c^2}\sqrt{\left(\frac{3H_t^2c^2}{8\pi G}\right)\left(aT_t^4\right)} \cong \left[1+\ln\left(\frac{H_U}{H_t}\right)\right]\left(\frac{aT_t^4}{c^2}\right)$$

$$\cong \left(\frac{3H_t^2}{8\pi G}\right) \Big/ \left[1+\ln\left(\frac{H_U}{H_t}\right)\right] \quad (16)$$

For the current universe and with reference to elliptical and spiral galaxies [8] whose mass-light ratio is close to 8 to 10,

$$\left(\rho_m\right)_0 \cong \frac{1}{c^2}\sqrt{\left(\frac{3H_0^2c^2}{8\pi G}\right)\left(aT_0^4\right)} \cong \left\{1+\ln\left(\frac{H_U}{H_0}\right)\right\}\left(\frac{aT_0^4}{c^2}\right)$$

$$\cong \left(\frac{3H_0^2}{8\pi G}\right) \Big/ \left\{1+\ln\left(\frac{H_U}{H_0}\right)\right\} \quad (17)$$

If $H_0 \cong 71$ km/sec/Mpc, $\left(\rho_m\right)_0 \cong 6.62\times10^{-32}$ gram.cm^{-3}

Relation between cosmic temperature and temperature fluctuations

Basic concept: During cosmic evolution, at any time, temperature anisotropy is directly proportional to cosmic back ground temperature.

$$\left(\delta T\right)_t \propto T_t \quad (18)$$

$$\left(\delta T\right)_t \cong \left(\frac{3H_t^2c^2}{8\pi G a T_t^4}\right)^{-1} T_t \cong \left[1+\ln\left(\frac{H_U}{H_t}\right)\right]^{-2} T_t \quad (19)$$

For the current universe,

$$\left(\delta T\right)_0 \cong \left(\frac{3H_t^2c^2}{8\pi G a T_0^4}\right)^{-1} T_0 \cong \left[1+\ln\left(\frac{H_U}{H_0}\right)\right]^{-2} T_0 \quad (20)$$

If $H_0 \cong 71$ km/sec/Mpc, $\left(\delta T\right)_0 \cong 135$ μK

6. To fit the magic numbers 5%, 27% and 67% of the modern (accelerating) cosmology

Current critical mass density can be expressed as:

$$\rho_0 \cong M_0 \Big/ \frac{4\pi}{3}\left(\frac{c}{H_0}\right)^3 \cong \frac{3H_0^2}{8\pi G} \quad (21)$$

$$\cong 9.469\times10^{-30}\,\text{gram.cm}^{-3}$$

Current matter density can be expressed as:

$$\left(\rho_{\text{matter}}\right)_0 \cong \left(\frac{3H_0^2}{8\pi G}\right) \Big/ \left[1+\ln\left(\frac{H_U}{H_t}\right)\right] \quad (22)$$

$$\cong 6.62\times10^{-32}\ \text{gram.cm}^{-3}$$

For a while guess that, mass density of the current universe suddenly drops to the magnitude of the current 'matter density'. Then current Hubble length hypothetically increases by a factor

$$\left\{\left[1+\ln\left(\frac{H_U}{H_t}\right)\right]\right\}^{\frac{1}{3}} \cong (143.028)^{\frac{1}{3}} \cong 5.23 \quad (23)$$

This can be compared with the currently believed 'matter density percentage' of the accelerating universe [7-10].
Current critical mass-energy density can be expressed as:

$$\rho_0 c^2 \cong M_0 c^2 \Big/ \frac{4\pi}{3}\left(\frac{c}{H_0}\right)^3 \cong \frac{3H_0^2c^2}{8\pi G} \quad (24)$$

$$\cong 8.51\times10^{-10}\,\text{J.m}^{-3}$$

Current thermal energy-energy density can be expressed as:

$$aT_0^4 \cong \frac{3H_0^2c^2}{8\pi G} \Big/ \left[1+\ln\left(\frac{H_U}{H_0}\right)\right]^2 \quad (25)$$

$$\cong 4.16\times10^{-14}\,\text{J.m}^{-3}$$

For a while guess that, mass-energy density of the current universe suddenly drops to the magnitude of the current thermal energy density. Then current Hubble length hypothetically increases by a factor

$$\left\{\left[1+\ln\left(\frac{H_U}{H_t}\right)\right]\right\}^{\frac{2}{3}} \cong (143.028)^{\frac{2}{3}} \cong 27.35 \quad (26)$$

This can be compared with the currently believed 'dark matter density percentage' of the accelerating universe[7-10].

These two accurate coincidences cast doubt on the validity of the third well believed algebraic 'dark energy density percentage form' of [100-(5.23+27.35)]% =67.42%.

7. Reinterpreting cosmic red shift

During cosmic evolution, right from the beginning of formation of hydrogen atoms, as any baby hydrogen atom starts growing, cosmologically, bonding strength increases in between proton and electron causing increasing electron excitation energy to emit increased quantum of energy. With reference to the current strengthened or reinforced hydrogen atom, difference in 'emitted quantum of energy' may appear to be the observed cosmological redshift associated with galactic hydrogen atom. Observed Super novae dimming can be understood in this way [9]. Based on this new proposal, 'galaxy receding' concept suggested by Hubble [11,12] can be reviewed and possibly can be relinquished. If cosmic time is running fast or if cosmic size/boundary is increasing fast or if cosmic temperature is decreasing fast then redshift seems to increase fast with reference to the current hydrogen atom. For a while guess that cosmological binding strength of proton and electron in the cosmologically evolving hydrogen atom is inversely proportional to the cosmic temperature, then with usual notation, observed cosmic red shift can be expressed as follows.

$$\left(E_{photon}\right)_t \cong \left(\frac{T_0}{T_t}\right)\left\{\left(\frac{e^4 m_e}{32\pi^2\varepsilon_0^2\hbar^2}\right)\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]\right\} \cong \frac{hc}{\lambda_t} \tag{27}$$

where, T_0 represents the current CMBR temperature, represents T_t past cosmic temperature and λ_t is the wavelength of photon received from the galactic photon.

At any time in the past, at any galaxy, emitted photon energy can be expressed as follows.

$$\left.\begin{array}{l} E_t \cong \dfrac{hc}{\lambda_t} \cong \left(\dfrac{T_0}{T_t}\right)\left(\dfrac{hc}{\lambda_0}\right) \cong \left(\dfrac{T_0}{T_t}\right)E_0 \\ \rightarrow z_0 \cong \dfrac{\lambda_t-\lambda_0}{\lambda_0} \cong \dfrac{E_0-E_t}{E_t} \cong \dfrac{T_t-T_0}{T_0} \\ \text{and } \dfrac{E_0}{E_t} \cong \dfrac{\lambda_t}{\lambda_0} \cong \dfrac{T_t}{T_0} \cong (z_0+1) \end{array}\right\} \tag{28}$$

Here, z_0 is the current redshift, E_t is the energy of emitted photon from the galactic hydrogen atom and E_0 is the corresponding energy in the laboratory. λ_t is the wave length of 'emitted as well as received' photon from the galactic hydrogen atom and λ_0 is the corresponding wave length in the laboratory.

At any time in the past - in support of the proposed cosmological red shift interpretation, in hydrogen atom above relations can be expressed in the following form. From Bohr's theory of hydrogen atom, with usual notation, for the revolving electron,

$$\left(E_{\text{potential}}\right)_t \cong -\left(\frac{T_0}{T_t}\right)\frac{e^4 m_e}{16\pi^2\varepsilon_0^2\hbar^2} \tag{29}$$

$$\left(E_{\text{total}}\right)_t \cong -\left(\frac{T_0}{T_t}\right)\frac{e^4 m_e}{32\pi^2\varepsilon_0^2\hbar^2} \tag{30}$$

$$\left(E_{\text{photon}}\right)_0 \cong \left(\frac{T_0}{T_t}\right)\left\{\frac{e^4 m_e}{32\pi^2\varepsilon_0^2\hbar^2}\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]\right\} \tag{31}$$

From laboratory point of view, above concept can be understood in the following way. After some time in future,

$$z_f \cong \frac{E_f-E_0}{E_0} \cong \frac{E_f}{E_0}-1 \tag{32}$$

Here, E_f is the energy of photon emitted from laboratory hydrogen atom after some time in future. E_0 is the energy of current photon emitted from laboratory hydrogen atom. z_f is the redshift of laboratory hydrogen atom after some time in future. From now onwards, as time passes, in future - $\left[d\left(z_f\right)/dt\right]$ can be considered as an index of the absolute rate of cosmic expansion. As cosmic time passes, within the scope of experimental accuracy of laboratory hydrogen atom's redshift,

$$\left.\begin{array}{l}\left[d\left(z_f\right)/dt\right]\rightarrow \text{Increasing}\rightarrow \text{Cosmic Acceleration}\\ \left[d\left(z_f\right)/dt\right]\rightarrow \text{Constant}\rightarrow \text{Cosmic Uniform expansion}\\ \left[d\left(z_f\right)/dt\right]\rightarrow \text{Decreasing}\rightarrow \text{Cosmic Deceleration}\\ \left[d\left(z_f\right)/dt\right]\rightarrow \text{Zero}\rightarrow \text{Cosmic halt}\end{array}\right\}$$

8. Discussion and Conclusion

The authors request the science community to please look into the following points in an unbiased approach.

1) As suggested by S.W. Hawking [13], there is no scientific proof or evidence to Friedmann's second assumption [14].
2) If it is true that galaxy constitutes so many stars, each star constitutes so many hydrogen atoms and light is coming from any excited electron of any galactic star's any hydrogen atom, then considering redshift as an index of 'whole galaxy' receding may not be reasonable.
3) Even though no one could measure the actual galactic receding speed, most of the cosmologists were attracted by the Hubble's redshift interpretation [11,12].
4) Merely by estimating 'galaxy distance' and without measuring any 'galaxy's actual receding speed', one cannot verify the cosmic acceleration.
5) Note that, in 1947 Hubble himself thought for a new mechanism for understanding the observed red shift [12]. In his words: "We may predict with confidence that the 200 inch will tell us whether the red shifts must be accepted as evidence of a rapidly expanding universe, or attributed to some new principle in nature. Whatever may be the answer, the result may be welcomed as another major contribution to the exploration of the universe".
6) Even though it is very attractive, Einstein could not implement the Mach's principle [15,16] in Hubble-Friedmann-cosmology [7-10].
7) Until 1964, cosmologists could not believe in 'cosmic back ground temperature' [3].
8) In the past, 'quantum gravity' was in its beginning stage and now it is in an advanced theoretical phase.

In this context, in this brief report, the authors introduced the words, 'cosmic critical volume' and 'cosmic critical mass'. Sincerely speaking, these two words seem to be connected with "Mach's principle". With reference to Mach's principle, cosmic 'critical density', 'critical volume' and 'critical mass' can be considered as the quantified back ground properties of the evolving universe. Accommodating Mach's principle in modern cosmology is a very challenging but 'inevitable' task. With reference to the proposed semi empirical relations and accurate data fitting, now it seems essential to revise the basics of modern cosmology with respect to Quantum gravity and Mach's principle. Based on the Hubble's law and Super novae dimming, currently it is believed that, universe is accelerating [9,10]. Modern cosmologists believe that rate of the change of the Hubble constant describes how fast/slow the Hubble constant changes over time and this rate does not tell if the Universe is currently expanding. This logic seems to be misleading. In authors' opinion, if magnitude of past Hubble's constant was higher than the current magnitude then magnitude of past $\left(c/H_t\right)$ will be smaller than the current Hubble length $\left(c/H_0\right)$. If so rate of decrease of the Hubble constant can be considered as a true index of rate of increase in Hubble length and thus with reference to Hubble length, rate of decrease of the Hubble constant can be considered as a true index of cosmic rate of expansion. Proceeding further - in future, certainly with reference to current Hubble's constant, $d\left(c/H_0\right)/dt$ gives the true cosmic rate of expansion. Same logic can be applied to cosmic back ground temperature also. Clearly speaking $d\left(T_0\right)/dt$ gives the true cosmic rate of expansion. To understand the ground reality, accuracy of current methods of estimating the magnitudes of $\left(H_0 \text{ and } T_0\right)$ must be improved. Future science, engineering and technology may resolve all the related issues

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References

[1] Hawking, Stephen W. . Quantum cosmology. In Hawking, Stephen W.; Israel, Werner. 300 Years of Gravitation. Cambridge University Press. pp. 631–651.(1987)
[2] Ashtekar, Abhay New variables for classical and quantum gravity. Physical Review Letters 57 (18): 2244–2247(1986)
[3] R.A. Alpher, H.A. Bethe, and G. Gamow. The origin of chemical elements. Phys. rev.73,80,1948.
[4] Lianxi Ma et al. Two forms of Wien's displacement law. Lat. Am. J. Phys. Educ. Vol. 3, No. 3, Sept. 2009
[5] U. V. S. Seshavatharam, and S. Lakshminarayana, On the Evolving Black Holes and Black Hole Cosmology- Scale Independent Quantum Gravity Approach. Frontiers of Astronomy, Astrophysics and Cosmology, vol. 1, no. 1 (2014): 1-15.
[6] G..J. Stoney, On the Physical Units of Nature. Phil. Mag. 11 (1881) 381-91.
[7] David N. Spergel et al. Planck Data Reconsidered. http://arxiv.org/pdf/1312.3313.pdf

[8] J. V. Narlikar. Introduction to cosmology. Cambridge Univ Press, 2002.
[9] Perlmutter, S. et al. Measurements of the Cosmological Parameters Ω and Λ from the First Seven Supernovae at z ≥ 0.35. Astrophysical Journal 483 (2): 565, (1997)
[10] J. A. Frieman et al. Dark energy and the accelerating universe. Ann.Rev.Astron.Astrophys.46, p385.(2008)
[11] Hubble E. P, A relation between distance and radial velocity among extra-galactic nebulae, PNAS, 1929, vol. 15, 1929, pp.168-173.
[12] Hubble, E.P, The 200-inch telescope and some problems it may solve. PASP, 59, pp153-167, (1947).
[13] Hawking S.W. A Brief History of Time. Bantam Dell Publishing Group. 1988
[14] Friedman, A. Über die Möglichkeiteiner Welt mitconstanter negative Krümmung des Raumes. Zeit. Physik. 21: 326-332. (1924).
[15] Sciama, D. W. The Physical Foundations of General Relativity. New York: Doubleday & Co. 1969.
[16] Raine, D. J. Mach's Principle in general relativity. Royal Astronomical Society. Vol171, pages 507, 1975