On the possible role of Mach's principle and quantum gravity in cosmic rotation - A short communication

U. V. S. Seshavatharam[1], **S. Lakshminarayana**[2]

[1] *Honorary faculty, I-SERVE, S. No-42, Hitex road, Hitech city, Hyderabad-84, Telangana, India.*

[2] *Dept. of Nuclear Physics, Andhra University, Visakhapatnam-03, AP, India.*

E-mails: [1] *seshavatharam.uvs@gmail.com*, [2] *lnsrirama@gmail.com*

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Abstract: In this paper, we show one theoretical possibility for cosmic rotation. We would like to appeal that: 1) A globally rotating universe is consistent with general relativity and quantum gravity. 2) As currently believed dark energy is having no observational evidence, it is better to search for cosmic rotational effects. In this context, one can see the main stream journal articles on cosmic axis of rotation and observational effects of cosmic rotation. Based on Mach's principle and quantum gravity, we imagine our universe as the best quantum gravity sphere and assume that, at any stage of cosmic evolution: 1) Planck scale Hubble parameter plays a crucial role. 2) Space-time curvature follows, $GM_t \cong R_t c^2$ where M_t and R_t represent the ordinary cosmic mass and radius respectively. 3) Cosmic thermal wavelength is inversely proportional to the ordinary matter density. 4) Magnitude of angular velocity is equal to the magnitude of Hubble parameter. Based on these assumptions, at $H_0 \cong 70\,\mathrm{km/sec/Mpc}$, estimated current matter density is $0.04341\left(\frac{3H_0^2}{8\pi G}\right)$ and corresponding radius is 29 Gpc. Current cosmic rotational kinetic energy density is $0.667\left(\frac{3H_0^2c^2}{8\pi G}\right)$. We would like to emphasize that: 1) Currently believed mysterious dark energy can be identified with current cosmic rotational kinetic energy. 2) Currently believed 'inflation' concept can be relinquished. With advanced science, engineering and technology and by considering the most recent observations on 'cosmic axis of evil' and 'axial alignment' of distance astronomical bodies, a unified model of quantum cosmology can be developed.

Keywords: Big bang; Quantum gravity; Planck scale Hubble parameter; Mach's principle; Observational cosmology; Cosmic rotational effects; Cosmic axis of evil;

Nomenclature

1. (Ω_{OM}) = Ratio of ordinary matter density to critical density.
2. (Ω_{DM}) = Ratio of dark matter density to critical density.
3. (Ω_{DE}) = Ratio of dark energy density to critical energy density.
4. H = Hubble parameter.
5. ω = Cosmic angular velocity.
6. R = Cosmic radius.
7. M = Cosmic (ordinary) mass.
8. I = Cosmic moment of inertia $= f_i MR^2$ where f_i =Inertial factor associated with cosmic ordinary matter density.
9. K_{rot} = Cosmic rotational kinetic energy.
10. $\frac{3(K_{rot})}{4\pi R^3}$ = Cosmic rotational kinetic energy density.
11. (λ_{max}) = Cosmic thermal wavelength.
12. T = Cosmic temperature $= \frac{2.898\times10^{-3} K.m}{(\lambda_{max})}$.
13. V = Cosmic expansion velocity = Cosmic rotational velocity.
14. (d_g) = Galactic distance from and about the point of big bang.
15. (v_g) = Galactic receding speed from and about the point of big bang.

Note-1: For the above symbols, subscript t denotes time dependent value, 0 denotes current value and pl denotes Planck scale value.
Note-2: $\beta \cong$ A new number related with quantum constants $\cong 4.96511423\left(\frac{45}{128\pi^7}\right)^{\frac{1}{4}} \cong 0.51572$.

1 Introduction

Based on quantum gravity [1,2], we define the Planck scale Hubble parameter, $H_{pl} \cong \sqrt{\frac{c^5}{G\hbar}} \cong 1.855 \times 10^{43}$ $\mathbf{sec}^{-1}$ and apply it to current cosmological data fitting with, $\gamma_t \cong \left[1 + \ln\left(\frac{H_{pl}}{H_t}\right)\right]$ where H_t is the time dependent Hubble parameter. To proceed further, we imagine that, $\sqrt{\left(\frac{3H_t^2c^2}{8\pi G(aT_t^4)}\right)} \cong \gamma_t$.

1.1 To choose the magnitude of H_0

1. As per the 2015 Planck data [3]: $H_0 \cong (67.31 \pm 0.96)$ km/sec/Mpc and $T_0 \cong (2.722 \pm 0.027)$ K.
2. According to the advanced observational data analysis by Adam G. Riess et al [4], current best value of $H_0 \cong (73.24 \pm 1.74)$ km/sec/Mpc.
3. With reference to $T_0 \cong 2.722$ K and our proposed set of assumptions, in this paper, we choose, $H_0 \cong 70\,\text{km/sec/Mpc} \cong 2.26853 \times 10^{-18} sec^{-1}$. This value seems to lie in between (67.31 and 73.24) km/sec/Mpc.

1.2 To understand the role of Mach's principle in cosmic evolution

In a quantitative approach, Mach's principle [2] can be understood with the relation $GM \cong c^2R$. With reference to cosmic evolution and ordinary matter, we make an attempt to modify this relation as $GM_t \cong c^2R_t$.

1.3 Motivating points needing a special focus

1. As there is no physical evidence for dark energy, there is a need for developing alternative models of cosmology.
2. As there is no physical evidence for extra dimensions, cosmological models can be confined to 3+1 dimensions.
3. As current science and technology is lagging in distinguishing 'free space' and 'cosmic space', it is better to have 'common space' paradigm.
4. Quantum gravity point of currently believed standard cosmology is in its budding stage and needs a serious review.
5. With reference to Planck scale and currently observed cosmic boundary of ~ 93 Gly, non-inflationary cosmological models can be developed.
6. Considering a 3+1 dimensional spherical universe with expansion and rotation, it is also possible to have flat model.
7. Rotational models consistent with quantum gravity can be developed.
8. In the current gigantic universe, if current angular velocity is very small and if observer's location/position is unknown, it is impossible to disprove cosmic rotation.
9. To develop a unified model of cosmology, to the possible extent one can try for accommodating Friedmann relations in quantum cosmology models.
10. Alternative cosmological models should be reviewed in an unbiased approach.

1.4 Strange conclusions pertaining to most recent cosmological observations

Subject of cosmology is quite interesting, very complicated and quite controversial. By going through the following points, one can understand the ground reality.

1. According to J.T.Nielsen, Alberto Guffanti and Subir Sarkar[5], evidence for the currently believed cosmic acceleration is only marginal and current universe seems to expand at a constant rate. In their words: 'There exists now a much bigger database of supernovae so we can perform rigorous statistical tests to check whether these 'standardisable candles' indeed indicate cosmic acceleration. Taking account of the empirical procedure by which corrections are made to their absolute magnitudes to allow for the varying shape of the light curve and extinction by dust, we find, rather surprisingly, that the data are still quite consistent with a constant rate of expansion'.
2. According to T. Padmanabhan [6]:"One natural - and in fact, inevitable - contribution to cosmological constant arises from the energy density of quantum vacuum fluctuations. The trouble is, we do not know how to compute the gravitational effects of quantum fluctuations of the vacuum from first principles. Naive estimates suggests that this will give $\Lambda\left(\frac{G\hbar}{c^3}\right) \approx 1$ which misses the correct result by 120 orders of magnitude! It is possible to get around this difficulty and get the correct value but only if we are prepared to make some extra assumptions. The appearance of G and $\hbar$ together strongly suggests that the problem of dark energy needs to be addressed by quantum gravity. None

of the currently popular models of quantum gravity has anything meaningful to say on this issue (let alone predict its correct value). In fact, explaining the observed value of the dark energy is the acid test for any quantum gravity model and all the models currently available flunk this test. There is no doubt that, when we eventually figure this out, it will lead to as drastic a revolution in our conceptual understanding as relativity and quantum theory did".

3. According to Martin Bozowald[1], standard cosmology can be refined with reference to 'quantum gravity'. In his opinion,

   (a) "Quantum cosmology is based on the idea that quantum physics should apply to anything in nature, including the whole universe. Quantum descriptions of all kinds of matter fields and their interactions are well known and can easily be combined into one theory - leaving aside the more complicated question of unification, which asks for a unique combination of all fields based on some fundamental principles or symmetries. Nevertheless, quantizing the whole universe is far from being straightforward because, according to general relativity, not just matter but also space and time are physical objects. They are subject to dynamical laws and have excitations (gravitational waves) that interact with each other and with matter. Quantum cosmology is therefore closely related to quantum gravity, the quantum theory of the gravitational force and space-time. Since quantum gravity remains unfinished, the theoretical basis of quantum cosmology is unclear. And to make things worse, there are several difficult conceptual problems to be overcome".

   (b) "We remain far from a proper understanding of quantum cosmology, especially when physics at the Planck scale is involved. At the same time, research on quantum cosmology has led to progress in our understanding of generally covariant quantum systems and often showed unexpected effects of quantum space-time".

4. According to Anna Ijjas, Abraham Loeb and Steinhardt [7], currently believed inflationary model was much less likely to explain our universe than previously thought. According to their analysis, the chances of obtaining a universe matching the observations after a period of inflation is very poor. In their opinion, currently believed 'inflation' is an 'unlikeliness problem'. They emphasize that, based on the observations - inflationary models require more parameters, more fine-tuning of those parameters, more unlikely initial conditions than the simplest models and 'inflationary theory' is unlikely to be correct. Interesting point to be noted is that, in 2015, the unlikeness problem was reaffirmed and strengthened by a subsequent round of measurements reported by the Planck satellite team.

5. According to Stacy McGaugh and Federico Lelli [8], the rotational velocity of stars in galaxies has a strong correlation between the motion of the stars and the amount of visible mass in the galaxies. This latest study is based on near -infrared data from the Spitzer Space Telescope and casts doubt on the well believed 'dark matter'.

2 Semi empirical relations connected with quantum gravity

With reference to the set of assumptions as proposed in the abstract, at any stage of cosmic evolution, we choose the following set of relations. One can modify them for a better understanding.

1. $\sqrt{\left(\frac{3H_t^2c^2}{8\pi G(aT_t^4)}\right)} \cong \gamma_t \cong \left[1+\ln\left(\frac{H_{pl}}{H_t}\right)\right]$.

2. $(\lambda_{max})_t \cong \left(\frac{1}{(\Omega_{OM})_t}\right)\frac{c}{\sqrt{H_t H_{pl}}}$.

3. $T_t \cong \frac{2.898\times10^{-3}\text{ Km}}{(\lambda_{max})_t} \cong (\Omega_{OM})_t \times \frac{h\sqrt{H_0 H_{pl}}}{4.965114k_B}$.

4. $(\Omega_{OM})_t \cong \left(\frac{3M_t}{4\pi R_t^3}\right) \div \left(\frac{3H_t^2}{8\pi G}\right)$
   $\cong \frac{c}{(\lambda_{max})_t\sqrt{H_t H_{pl}}} \cong \frac{0.51572}{\sqrt{\gamma_t}} \cong \frac{k}{\sqrt{\gamma_t}}$.

5. $R_t \cong \sqrt{\frac{2}{(\Omega_{OM})_t}}\frac{c}{H_t}$

6. $V_t \cong R_t\omega_t \cong R_t H_t \cong \sqrt{\frac{2}{(\Omega_{OM})_t}}\,c$

7. $M_t \cong \sqrt{\frac{2}{(\Omega_{OM})_t}}\frac{c^3}{GH_t} \cong \frac{c^2V_t}{GH_t}$

8. $(K_{rot})_t \cong \frac{1}{2}I_t\omega_t^2 \cong \frac{1}{2}I_tH_t^2 \cong \frac{f_i}{2}M_tR_t^2H_t^2$
   where $f_i \cong$ Inertial factor assocaited with cosmic moment of inertia.

9. $(\Omega_{DM})_t = 1-\left[(\Omega_{OM})_t + \frac{3(K_{rot})_t}{4\pi R_t^3}\right]$

3 To choose various values of γ and H

If defined $H_{pl} \cong 1.854921 \times 10^{43} sec^{-1}$, one can choose different values of γ in between $\gamma_{pl} \cong 1$ and $\gamma_0 \cong 141.2564$. For each value of γ, one can get a corresponding H.

4 Current cosmic physical parameters

If $T_0 \cong 2.722$ K, $(\lambda_{max})_0 \cong 1.06466$ mm and $H_0 \cong 2.26853 \times 10^{-18} sec^{-1} \cong 70\,\text{km/sec/Mpc}$,

1. $\sqrt{\left(\frac{3H_0^2c^2}{8\pi G\left(aT_0^4\right)}\right)} \cong \gamma_0 \cong 141.2564.$
2. $(\Omega_{OM})_0 \cong \frac{c}{(\lambda_{max})_0\sqrt{H_0 H_{pl}}} \cong \frac{0.51572}{\sqrt{\gamma_0}} \cong 0.04341.$
3. $R_0 \cong \sqrt{\frac{2}{(\Omega_{OM})_0}}\frac{c}{H_0} \cong 8.97 \times 10^{26}\,\text{m}$ $\cong 94.8154$ Gly$\cong 29.085$ Gpc.
4. $V_0 \cong R_0\omega_0 \cong R_0 H_0 \cong \sqrt{\frac{2}{(\Omega_{OM})_0}}\,c \cong 6.7878c.$
5. $M_0 \cong \sqrt{\frac{2}{(\Omega_{OM})_0}}\frac{c^3}{GH_0} \cong \frac{c^2V_t}{GH_0}$ $\cong 1.208 \times 10^{54}$ kg.
6. If current cosmic sphere is a thin spherical shell with very low ordinary matter density, $(K_{rot})_0 \cong \frac{1}{3}M_0R_0^2H_0^2 \cong 1.667 \times 10^{72} J$ where $f_i \cong \frac{2}{3}$.
7. Current cosmic rotational kinetic energy density $\cong \frac{3(K_{rot})_0}{4\pi R_0^3} \cong 0.667\left(\frac{3H_0^2c^2}{8\pi G}\right)$
8. $(\Omega_{DM})_0 = 1 - \left[(\Omega_{OM})_0 + \frac{3(K_{rot})_0}{4\pi R_0^3}\right] \cong 0.2899.$

5 Planck scale physical parameters

1. $\sqrt{\left(\frac{3H_{pl}^2c^2}{8\pi G\left(aT_{pl}^4\right)}\right)} \cong \gamma_{pl} \cong 1.$
2. $T_{pl} \cong \left(\frac{3H_{pl}^2c^2}{8\pi Ga}\right)^{\frac{1}{4}} \cong 9.247 \times 10^{31}$ K.
3. $(\lambda_{max})_{pl} \cong \frac{2.898\times10^{-3}\,\text{K.m}}{T_{pl}} \cong 3.134 \times 10^{-35}$m.
4. $(\Omega_{OM})_{pl} \cong \frac{c}{(\lambda_{max})_{pl}H_{pl}} \cong 0.5157.$
5. $R_{pl} \cong \sqrt{\frac{2}{(\Omega_{OM})_{pl}}}\frac{c}{H_{pl}} \cong 3.183 \times 10^{-35}\,\text{m}\,.$
6. $V_{pl} \cong R_{pl}\omega_{pl} \cong R_{pl}H_{pl} \cong \sqrt{\frac{2}{(\Omega_{OM})_{pl}}}\,c$ $\cong 1.97c.$
7. $M_{pl} \cong \sqrt{\frac{2}{(\Omega_{OM})_{pl}}}\frac{c^3}{GH_{pl}} \cong \frac{c^2V_{pl}}{GH_{pl}}$ $\cong 4.286 \times 10^{-8}$ kg.
8. If Planck scale universe is a point sphere of high density, $(K_{rot})_{pl} \cong \frac{1}{5}M_{pl}R_{pl}^2H_{pl}^2 \cong 2.99 \times 10^9 J$ where $f_i \cong \frac{2}{5}$.
9. Planck scale cosmic rotational kinetic energy density $\cong \frac{3(K_{rot})_{pl}}{4\pi R_{pl}^3} \cong 0.40\left(\frac{3H_{pl}^2c^2}{8\pi G}\right)$
10. $(\Omega_{DM})_{pl} \cong 1 - \left[(\Omega_{OM})_{pl} + \frac{3(K_{rot})_{pl}}{4\pi R_{pl}^3}\right] \cong 0.0843.$

6 To understand the cosmic age

With reference to the Planck scale and currently believed cosmic age, at any stage of cosmic evolution, cosmic age can be approximated with:
$(t \times H_t) \approx \left[1 + \ln\left(\frac{H_t}{H_0}\right)\right] \cong (\gamma_0 - \gamma_t) + 1$. Based on this relation, cosmic age corresponding to a temperature of ≈ 3000 K and Hubble parameter of $\approx 2.5 \times 10^{-12} sec^{-1}$ could be around 189,022 years. This is roughly about half of the current estimations of 380,000 years.

7 To interpret the observed cosmic redshift and velocity-distance relation

1. $(z+1) \cong \frac{T_t}{T_0} \cong \frac{(\lambda_{max})_0}{(\lambda_{max})_t}$ $\cong \left(\frac{(\Omega_{OM})_t}{(\Omega_{OM})_0}\right)\sqrt{\frac{H_t}{H_0}} \cong \sqrt{\frac{\gamma_0}{\gamma_t}}\exp\left(\frac{\gamma_0-\gamma_t}{2}\right).$
2. Time dependent Hubble parameter can be expressed with: $H_t \cong \left(\frac{(\Omega_{OM})_0}{(\Omega_{OM})_t}\right)^2(z+1)^2H_0$ $\cong \left(\frac{\gamma_t}{\gamma_0}\right)(z+1)^2H_0 \cong e^{(\gamma_0-\gamma_t)}H_0$
3. At present, from and about the point of big bang, galactic receding speeds can be approximated with $(v_g)_0 \cong \left(\frac{(d_g)_0}{R_0}\right)V_0 \cong \left(\frac{V_0}{R_0}\right)(d_g)_0 \cong H_0\,(d_g)_0.$

8 Possible implications of our proposed set of assumptions

1. <u>**Cosmological constant problem**</u>: With reference to assumption-1,ratio of Planck scale critical density to current critical density is, $\left(\frac{3H_{pl}^2c^2}{8\pi G}\right) \div \left(\frac{3H_0^2c^2}{8\pi G}\right) \cong \left(\frac{H_{pl}}{H_0}\right)^2 \cong 6.685 \times 10^{121}.$ We wish to appeal that, our assumption-1 can be considered as a characteristic tool for constructing a model of 'quantum gravity'.

2. **Horizon problem**: The 'horizon problem' is a problem with the standard cosmological model of the Big Bang. It points out that different regions of the universe have not 'contacted' each other because of the great distances between them, but nevertheless they have the same temperature and other physical properties. If one is willing to consider the concept of 'matter causes the space-time to curve', 'horizon problem' can be understood. According to hot big bang model, during its evolution, as universe is expanding, thermal radiation temperature decreases and matter content increases. As matter content increases, based on Mach's principle [2], at any stage of evolution, it is possible to have an increasing radius of curvature, $R_t \cong \frac{GM_t}{c^2}$. Clearly speaking, for the current case, as there exists no matter outside of $R_0 \cong \frac{GM_0}{c^2}$, there is no scope for 'causal disconnection'.

3. **Cosmic inflation**: Mainstream cosmologists believe that the superluminal expansion period of the universe (called "cosmic inflation") ended by 10^{-32} seconds (a tiny fraction of a second) after the hot big bang [9]. Since that time, they believe, expansion initially decelerated (from gravity) and then, after about 6 billion years, began very slowly to accelerate (from dark energy). Many cosmologists proposed different starting mechanisms for initiating and fine tuning the believed 'inflation'. In this context, we would like to stress the fact that, with $R_0 \cong \sqrt{\frac{2}{(\Omega_{OM})_0}}\left(\frac{c}{H_0}\right)$, estimated current cosmic radius is 94.815 Gly
=29.08 Gpc and is just twice of the modern estimate [10]! Clearly speaking, considering our proposed assumptions, currently believed cosmic inflation can be reviewed [11].

4. **CMBR anisotropy**: Temperature fluctuations are directly proportional to actual galactic ordinary matter density.

5. **Cosmic rotation**: As there exits no well established relation in between Hubble parameter and angular velocity, many of the modern cosmologists are not believing in cosmic rotation. We would like to stress the fact that, with reference to the well established "magnitude" of the currently believed dark energy, it is possible to have a concrete theory of cosmic rotation. We would like to appeal that, rotation is a natural phenomena for most of the sub-universal objects like galaxies, stars and planets and current gigantic universe can also be imagined to be an evolving and rotating sphere. Over the last sixty plus years, numerous rotating and expanding general relativity-compatible cosmological models have been developed[12-28]. L.M. Chechin is seriously working on various issues connected with cosmic rotation[21,22]. In this paper, we show one theoretical possibility. Important point to be noted is that, a globally rotating universe is consistent with general relativity [15,16] and quantum gravity. As currently believed dark energy is having no observational evidence, it is better to search for cosmic rotational effects.

6. **Cosmic axis of rotation**: In the current gigantic universe, tracing the 'point of big bang' and tracing the 'rotational axis' are most challenging tasks. First of all, one must believe in their existence. It needs reliable observational support. It may be noted that, many of the cosmological observations are complicated to interpret. Recent observations seems to shed light on the 'cosmic axis of evil' and 'axial alignment' of distant galaxies and quasars. In this context, one can see the main stream journal articles on cosmic axis of rotation and observational effects of cosmic rotation [29-41].

7. **Λ term Vs. cosmic deceleration**: Centrifugal deceleration can be expressed with: $\frac{V_t^2}{R_t} \cong V_t H_t \cong GM_t\left(\frac{H_t^2}{c^2}\right)$. By neglecting factor 3, qualitatively, if one is willing to identify $\left(\frac{H_t^2}{c^2}\right)$ with Λ_t, it is possible to show that, $\Lambda_t \approx \frac{V_t H_t}{GM_t}$. Based on this kind of interpretation,
$\frac{\Lambda_{pl}}{\Lambda_0} \approx \left(\frac{V_{pl} H_{pl}}{V_0 H_0}\right) \div \left(\frac{M_{pl}}{M_0}\right) \approx \left(\frac{H_{pl}}{H_0}\right)^2$.

8. **To estimate dark matter and dark energy**: At present one cannot prove cosmic rotation. If indeed there exists cosmic rotation, cosmic rotational kinetic energy depends on the cosmic inertial factor. For a high dense sphere, cosmic moment of inertia is $\frac{2}{5}M_t R_t^2$ and for a low dense sphere, cosmic moment of inertia is $\frac{2}{3}M_t R_t^2$. Corresponding rotational kinetic energy density seems to be $0.4\left(\frac{3H_{pl}^2 c^2}{8\pi G}\right)$ and $0.67\left(\frac{3H_0^2 c^2}{8\pi G}\right)$. Ignoring 'rotation' concept and if one is willing to interrelate $(\Omega_{OM})_t$ and $(\Omega_{DM})_t$, with a semi empirical relation of the kind, $(\Omega_{DM})_t \approx \frac{\beta^2}{\exp(\Omega_{OM})_t}$, it is possible to estimate $(\Omega_{DE})_t$. Based on this kind of relation and with reference to currently believed 'cosmic density sum rule',
for the Planck scale, $(\Omega_{OM})_{pl} \approx 0.5157$,
$(\Omega_{DM})_{pl} \approx 0.159$ and $(\Omega_{DE})_{pl} \approx 0.325 \sim 0.40$.
For the current scale, $(\Omega_{OM})_0 \approx 0.04341$,
$(\Omega_{DM})_0 \approx 0.255$ and $(\Omega_{DE})_0 \approx 0.702 \sim 0.667$.

9 Conclusion

It may be noted that, currently believed 'modern cosmology' is not so standardised. Readers are strongly encouraged to see an excellent and very recent review on 'problems in modern cosmology' [42] in which practically all points of views are presented including mutually exclusive ones. In any model of cosmology [43], fundamental questions to be solved are: 1) Why do 'dark matter' and 'visible matter' have their measured values of $\approx 33\%$ of critical energy? 2) Why do 'dark energy' has its measured values of $\approx 68\%$ of critical energy? 3) How to estimate their past and future magnitudes? In this context, we appeal that, our set of assumptions and relations can be given some consideration and with advanced science, engineering and technology, their scope and workability can be scrutinized and validated.

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