International Journal of Astronomy, Astrophysics and Space Science
2018; 5(1): 1-13
http://www.openscienceonline.com/journal/aass

Toy Model of Evolving and Spinning Quantum Cosmology – A Review

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To cite this article

Satya Seshavatharam U. V., S. Lakshminarayana. Toy Model of Evolving and Spinning Quantum Cosmology – A Review. *International Journal of Astronomy, Astrophysics and Space Science.* Vol. 5, No. 1, 2018, pp. 1-13.

Received: March 7, 2018; **Accepted**: March 22, 2018; **Published**: April 27, 2018

Abstract

Quantum gravity (QG) is a wide range physical model intended for understanding the in-built cosmological quantum phenomena on small scale as well as large scale distances. So far, progress in this direction is very nominal and general theory of relativity (GTR) needs a serious review with reference to 'quantum cosmology'. In this context, assuming that, Planck scale Hubble parameter and Mach's principle play a crucial role in entire cosmic evolution, we propose a toy model of evolving flat space rotating quantum cosmology. We would like to suggest that, 1) Cosmic temperature is directly proportional to the cosmic ordinary matter density and current ordinary matter density is about 0.0434 times the current critical density. 2) Current cosmic radius is about 10.45 Gpc and seems to constitute around 14 Hubble spheres. 3) Dark energy density ratio seems to be equal to the cubic root of dark matter density ratio and by following Friedmann's cosmic density ratio sum rule, dark matter density and dark energy density, both, can be estimated with respect to ordinary matter density. 4) Current dark energy can be identified with current cosmic rotational kinetic energy associated with current ordinary matter and dark matter. 5) Planck scale expansion velocity is 1.85*c* and current expansion velocity is 2.44*c* and there is no need to invoke inflation like concepts.

Keywords

Quantum Cosmology, Dark Energy, Dark Matter, Expansion Velocity, Inflation Free, Rotational Kinetic Energy, Galactic Rotation Curves

1. Introduction

By considering 'Planck scale' as a characteristic limit of the evolving universe and considering 'Mach's principle' as a deep cosmic probe, in a quantum gravity approach [1-4] evolving spinning quantum cosmology can be developed. In this toy model, by fitting the current ordinary matter density with current cosmic temperature and current Hubble parameter, we try to estimate the current cosmic radius and cosmic matter content. We sincerely put forward that, without inflation [5], [6] our toy model is coherent in fitting most of the observable current cosmic physical parameters and extrapolation to past and future is easy. Proceeding further, we proposed a simple relation for understanding past, present and future cosmic density ratio break up with reference to cosmic moment of inertia and needs further investigation.

1.1. About Inflation

Weighing the big crunch, estimating the energy content of big crunch, understanding the materialistic nature of big crunch, span/duration of formation of big crunch, estimating the intensity/power of big bang, span/duration of big bang and correlations between big crunch, big bang and Planck scale- seem to be very important in understanding 'conservation of energy' and 'inflation' on cosmic scales. To understand these points, further study is required at very fundamental level and is beyond the scope of current science. Even though majority of modern scientists are believing in 'inflation' [7], [8] based on Planck 2013 data, a serious debate is going on among the founders of inflation. In their published paper [Inflationary schism. Physics Letters B 736 (2014) 142-146], Anna Ijjas, Paul J. Steinhardt and Abraham

Loeb raise the following question- *If classic inflation is outdated and a failure, are we willing to accept postmodern inflation, a construct that lies outside of normal science? Or is it time to seek an alternative cosmological paradigm?* It is quite surprising. Future science, engineering and technology may resolve the issue. Anyhow, to understand the ground reality, we are working on understanding the concepts of 'inflation' in a quantum gravitational approach.

1.2. About Quantum Cosmology

According to M. Bojowald [1]: 1) "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". 2) "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"

According to T. Padmanabhan [3]: "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 suggest 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".

According to C. Sivaram [4]: "Although there has been a considerable spurt of recent interest in research in several formal aspects of quantum gravity including considerable mathematical progress, the subject still remains enigmatic and remote from other areas of physics. Despite several suggestions and complex models, no clear cut consistent consensus on uniting quantum theory and gravity has emerged. It would appear as if quantum gravity has no implications or impact on the rest of everyday mundane physics which depends on measurement or observation of well-defined physical quantities or properties that characterize a system or a substance. We shall see that this is not strictly true. It is possible to carry out calculations of the effects of quantum gravity on certain systems and come out with numbers! This has been known for some time especially in the case of a weak field in a linearized theory".

2. Concepts and Relations Pertaining to Quantum Cosmology

2.1. Nomenclatures

1) $\left(\Omega_{OM}\right)=$ Ratio of ordinary matter density to critical density.
2) $\left(\Omega_{DM}\right)=$ Ratio of dark matter density to critical density.
3) $\left(\Omega_{DE}\right)=$ Ratio of dark energy density to critical energy density.
4) $H=$ Hubble parameter and ω =Angular velocity.
5) $V_{\exp}=$ Cosmic expansion velocity and $V_{rot}=$ Rotational velocity.
6) $M_{OM}=$ Cosmic ordinary mass content.
7) $M_{DM}=$ Cosmic dark matter content.
8) $R=$ Cosmic radius associated with M_{OM} and M_{DM}
9) $\left(\lambda_{max}\right)=$ Cosmic thermal wavelength and $T=$ Cosmic temperature $=\frac{2.898\times10^{-3}\,^{\circ}\text{K.m}}{\left(\lambda_{max}\right)}$.
10) $\sqrt{\left(\frac{3H^2c^2}{8\pi G\left(aT^4\right)}\right)}\cong\gamma=$ Square root of Ratio of critical energy density to thermal energy density.
11) $\left(d_g\right)=$ Galactic distance from and about the point of big bang or Planck scale.
12) $\left(v_g\right)=$ Galactic receding speed from and about the point of big bang or Planck scale.

Note-1: For the above symbols, subscript t denotes time dependent value, subscript 0 denotes current value and subscript pl denotes Planck scale value.

Note-2: $\beta\cong$ A new number related with quantum constants $\cong 4.96511423\left(\frac{45}{128\pi^7}\right)^{\frac{1}{4}} \cong 0.51572$.

2.2. Proposed New Concepts

Based on Mach's principle and quantum gravity, we imagine our universe as a quantum gravity sphere and consider the following *concepts*. With further study, they can be grouped into *two or three assumptions*.

At any stage of cosmic evolution:

1) $\sqrt{\left(\frac{3H_t^2c^2}{8\pi G\left(aT_t^4\right)}\right)} \cong \left[1+\ln\left(\frac{H_{pl}}{H_t}\right)\right]$ plays a crucial role in entire cosmic evolution.
2) Cosmic thermal wavelength, $\left(\lambda_{max}\right)_t$ is inversely proportional to, $\left(\Omega_{OM}\right)_t$.
3) Space-time curvature follows, $G\left(M_{OM}+M_{DM}\right)_t \cong R_t c^2$.
4) Ordinary matter density ratio, $\left(\Omega_{OM}\right)_t$ plays a crucial role in cosmic density ratio break up.
5) Magnitude of angular velocity, ω_t is equal to the magnitude of Hubble parameter, H_t.
6) Magnitude of expansion velocity $\left(V_{\exp}\right)_t$, is equal to magnitude of rotational velocity, $\left(V_{rot}\right)_t$.

2.3. Choosing the Magnitude of H_0

1) As per the 2015 Planck data [9]: $H_0 \cong (67.31 \pm 0.96)$ km/sec/Mpc and the present temperature of the CMB radiation is, $T_0 \cong (2.722 \pm 0.027)$ K.
2) According to the advanced observational data analysis by A. G. Riess et al [10], 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 concepts, in this paper, we choose, $H_0 \cong 70\text{km/sec/Mpc} \cong 2.26853\times10^{-18}\,sec^{-1}$. This value seems to lie in between (67.31 and 73.24) km/sec/Mpc.

2.4. The Planck Scale in Entire Cosmic Evolution

So far no mainstream cosmological model implemented Planck scale in current cosmic evolution. In this complicated situation, in a positive approach, we make an attempt to implement the 'Planck scale' in the entire cosmic evolution. With further study, our approach can be developed for a better understanding. Based on quantum gravity, we define the Planck scale Hubble parameter, $H_{pl} \cong \sqrt{\frac{c^5}{G\hbar}} \cong 1.855\times10^{43}$ $\sec^{-1}$. To proceed further, we define that,

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

where H_t is the time dependent Hubble parameter.

Note-3: If defined $H_{pl} \cong 1.854921\times10^{43}\ sec^{-1}$, 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 and all other physical parameters can be estimated.

2.5. Semi Empirical Relations Connected with Quantum Gravity

With reference to the set of concepts, at any stage of cosmic evolution, we choose the following set of 'semi empirical model relations'. One can modify them for a better understanding. At any arbitrary point of time,

1) The temperature of the CMB radiation,

$$\left.\begin{aligned}
&\left(\lambda_{max}\right)_t \cong \frac{1}{\left(\Omega_{OM}\right)_t}\left(\frac{c}{\sqrt{H_{pl}H_t}}\right) \text{ and} \\
&T_t \cong \frac{2.898\times10^{-3}\,^{\circ}\text{Km}}{\left(\lambda_{max}\right)_t} \cong \left(\Omega_{OM}\right)_t \times \frac{h\sqrt{H_{pl}H_t}}{4.965114k_B} \\
&\cong \left[1+\ln\left(\frac{H_{pl}}{H_t}\right)\right]^{-\frac{1}{2}}\left(\frac{3H_t^2c^2}{8\pi Ga}\right)^{\frac{1}{4}} \cong \left[\gamma_t\right]^{-\frac{1}{2}}\left(\frac{3H_t^2c^2}{8\pi Ga}\right)^{\frac{1}{4}}
\end{aligned}\right\} \quad (2)$$

Where $\left(\frac{c}{\sqrt{H_{pl}H_t}}\right)$ can be called as the Planck-Hubble mean length.

2) Ordinary matter density ratio,

$$\left(\Omega_{OM}\right)_t \cong \left(\frac{\left(M_{OM}\right)_t}{\frac{4\pi}{3}R_t^3}\right) \div \left(\frac{3H_t^2}{8\pi G}\right) \cong \frac{0.51572}{\sqrt{\gamma_t}} \cong \frac{\beta}{\sqrt{\gamma_t}} \quad (3)$$

3) Cosmic radius,

$$R_t \cong \sqrt{\frac{2}{\left[\left(\Omega_{OM}\right)_t+\left(\Omega_{DM}\right)_t\right]}}\left(\frac{c}{H_t}\right) \quad (4)$$

3. Relations Between Ordinary Matter Density, Dark Matter Density and Dark Energy Density

In a heuristic approach, if one is willing to consider the relations proposed in section-2.5, magnitude of the current and the Planck scale cosmological physical parameters can be fitted/predicted. It needs further study.

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

According to most advanced research [11], dark energy and dark matter can be considered as characteristic manifestations of quantum gravity at a fundamental level. With reference to the observed values of current dark matter density and dark energy density, in a quantitative approach, we noticed that,

$$(\Omega_{DM})_0 \approx (\Omega_{DE})_0^3 \tag{5}$$

Based on this observation, by considering Friedmann's cosmic density ratio sum rule, we developed the following relations. They need for further study. Starting from the Planck scale to the current scale,

$$\left.\begin{array}{l} (\Omega_{OM})_t \cong \dfrac{0.51572}{\sqrt{\gamma_t}} \text{ and} \\ \left\{(\Omega_{OM})_t + (\Omega_{DM})_t + (\Omega_{DE})_t\right\} \cong 1 \\ \cong \left\{(\Omega_{OM})_t + (\Omega_{DM})_t + (\Omega_{DM})_t^{1/3}\right\} \\ \cong \left\{(\Omega_{OM})_t + (\Omega_{DE})_t^3 + (\Omega_{DE})_t\right\} \end{array}\right\} \tag{6}$$

$(\Omega_{DM})_t$ and $(\Omega_{DE})_t$ can be estimated with Cardan's method of solving cubic equations. Relations can be expressed in the following way.

$$(u_t, v_t) = \left[\frac{\left[1-(\Omega_{OM})_t\right] \pm \sqrt{\left[1-(\Omega_{OM})_t\right]^2 + \frac{4}{27}}}{2}\right]^{\frac{1}{3}} \text{ and } \left\{\begin{array}{l} (\Omega_{DE})_t \cong (u_t + v_t) \\ (\Omega_{DM})_t \cong (u_t + v_t)^3 \end{array}\right. \tag{7}$$

It may be noted that, $(\Omega_{DM})_{pl}$ starts at around 0.07 at $\gamma_{pl} \cong 1$ and slowly reaches to a current value of 0.293. Similarly, $(\Omega_{DE})_{pl}$ starts at around 0.4135at $\gamma_{pl} \cong 1$ and slowly reaches to a current value of 0.664. See the following figure 1. Top green curve represents $(\Omega_{DE})_t$, middle red curve represents $(\Omega_{DM})_t$ and bottom blue curve represents $(\Omega_{OM})_t$.

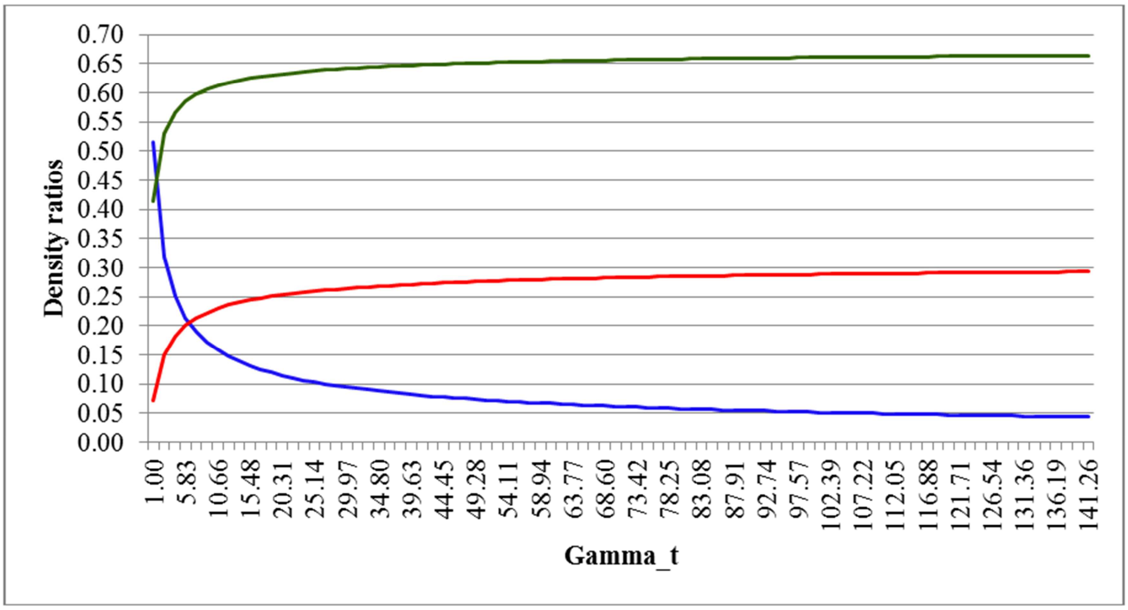

Figure 1. *Cosmic density ratio break up.*

Note-4: Keeping cosmic moment of inertia in view, we have developed relations (5), (6) and (7). With respect to other physical concepts like ratio of critical energy density and thermal energy density, one can develop different relations for understanding the past, current and future cosmic density ratio breakup.

4. Current and Planck Scale Cosmic Physical Parameters

Based on the above relations (1) to (7), for the current case,

$$\left(M_{OM}\right)_0 \cong \left(\Omega_{OM}\right)_0 \left(\frac{3H_0^2}{8\pi G}\right) \cong 5.6154\times 10^{52}\ \text{kg} \quad (8) \qquad \left(M_{DM}\right)_0 \cong \left(\Omega_{DM}\right)_0 \left(\frac{3H_0^2}{8\pi G}\right) \cong 3.786\times 10^{53}\ \text{kg} \quad (9)$$

$$\left[\left(M_{OM}\right)_0 + \left(M_{DM}\right)_0\right] \cong \left[\left(\Omega_{OM}\right)_0 + \left(\Omega_{DM}\right)_0\right]\left(\frac{3H_0^2}{8\pi G}\right) \cong 4.3474\times 10^{53}\ \text{kg} \quad (10)$$

See table 1 for various cosmic physical parameters associated with current and Planck scales.

Table 1. *Current and Planck scale cosmic physical parameters.*

Current scale	**Planck scale**
$H_0 \cong 70\text{km/sec/Mpc} \cong 2.26853\times 10^{-18} sec^{-1}$	$H_{pl} \cong \sqrt{\frac{c^5}{G\hbar}} \cong 1.855\times 10^{43}\ \sec^{-1}$
$\gamma_0 \cong \left[1+\ln\left(\frac{H_{pl}}{H_0}\right)\right] \cong 141.2564$	$\gamma_{pl} \cong \left[1+\ln\left(\frac{H_{pl}}{H_{pl}}\right)\right] \cong 1$
$\left(\Omega_{OM}\right)_0 \cong \left(\beta/\sqrt{\gamma_0}\right) \cong 0.04341$	$\left(\Omega_{OM}\right)_{pl} \cong \left(\beta/\sqrt{\gamma_{pl}}\right) \cong 0.5157$
$\left(\Omega_{DM}\right)_0 \cong 0.29267$	$\left(\Omega_{DM}\right)_{pl} \cong 0.0707$
$\left(\Omega_{DE}\right)_0 \cong 0.67$	$\left(\Omega_{DE}\right)_{pl} \cong 0.4136$
$T_0 \cong \left(\Omega_{OM}\right)_0 \times \frac{h\sqrt{H_{pl}H_0}}{4.965114k_B} \cong 2.722\ \text{K}$	$T_{pl} \cong \left(\Omega_{OM}\right)_{pl} \times \frac{hH_{pl}}{4.965114k_B}$ $\cong 9.247\times 10^{31}\ \text{K}$
$R_0 \cong \sqrt{\frac{2}{\left[\left(\Omega_{OM}\right)_t + \left(\Omega_{DM}\right)_t\right]}}\frac{c}{H_0} \cong 10.453\ \text{Gpc}$	$R_{pl} \cong \sqrt{\frac{2}{\left[\left(\Omega_{OM}\right)_{pl} + \left(\Omega_{DM}\right)_{pl}\right]}}\left(\frac{c}{H_{pl}}\right)$ $\cong 2.9845\times 10^{-35}\text{m}$
$\left(V_{rot}\right)_0 \cong R_0\omega_0 \cong 2.44c$	$\left(V_{rot}\right)_{pl} \cong R_{pl}\omega_{pl} \cong 1.85c$
$\left(M_{OM}\right)_0 \cong \left(\Omega_{OM}\right)_0\left(\frac{3H_0^2}{8\pi G}\right)\left(\frac{4\pi}{3}R_0^3\right)$ $\cong 5.6154\times 10^{52}\ \text{kg}$	$\left(M_{OM}\right)_{pl} \cong \left(\Omega_{OM}\right)_{pl}\left(\frac{3H_{pl}^2}{8\pi G}\right)\left(\frac{4\pi}{3}R_{pl}^3\right)$ $\cong 3.54\times 10^{-8}\ \text{kg}$
$\left(M_{DM}\right)_0 \cong \left(\Omega_{DM}\right)_0\left(\frac{3H_0^2}{8\pi G}\right)\left(\frac{4\pi}{3}R_0^3\right)$ $\cong 3.786\times 10^{53}\ \text{kg}$	$\left(M_{DM}\right)_{pl} \cong \left(\Omega_{DM}\right)_{pl}\left(\frac{3H_{pl}^2}{8\pi G}\right)\left(\frac{4\pi}{3}R_{pl}^3\right)$ $\cong 4.85\times 10^{-9}\ \text{kg}$
$\left[\left(M_{OM}\right)_0 + \left(M_{DM}\right)_0\right] \cong 4.3474\times 10^{53}\ \text{kg}$	$\left[\left(M_{OM}\right)_{pl} + \left(M_{DM}\right)_{pl}\right] \cong 4.0\times 10^{-8}\ \text{kg}$

5. To Interpret the Current Cosmic Dark Energy Density

Let, for a moment,

I_0 = Current cosmic moment of inertia = $\frac{2}{3}\left[\left(M_{OM}\right)_0 + \left(M_{DM}\right)_0\right]R_0^2$

ω_0 = Current cosmic angular velocity = Numerically equal to H_0

$\left(K_{rot}\right)_0$ = Current cosmic rotational kinetic energy = $\frac{1}{2}I_0\omega_0^2 \cong \frac{1}{2}I_0H_0^2$

Based on the above estimated current values and considering current evolving universe as a quantum gravitational sphere rotating with $\omega_0 \cong H_0$ having a very small density of $\frac{3\left[\left(M_{OM}\right)_0 + \left(M_{DM}\right)_0\right]R_0^3}{4\pi} \cong 3.1\times 10^{-27}\ \text{kg/m}^3$, it is noticed that,

$$\begin{aligned}(K_{rot})_0 &\cong \frac{1}{2}I_0\omega_0^2 \cong \frac{1}{3}\left[(M_{OM})_0+(M_{DM})_0\right]R_0^2\omega_0^2 \\ &\cong \frac{1}{3}\left[(M_{OM})_0+(M_{DM})_0\right]R_0^2H_0^2 \cong 7.751\times10^{70}\ \text{Joule}\end{aligned} \tag{11}$$

$$\left\{(K_{rot})_0 \Big/ \frac{4\pi}{3}R_0^3\right\} \cong 5.522\times10^{-10}\ \text{J.m}^{-3} \cong \frac{2}{3}\left(\frac{3H_0^2c^2}{8\pi G}\right) \tag{12}$$

To a great surprise, it is numerically matching with the currently believed dark energy density and needs further study [12] to [61] at a fundamental level. This may be a coincidence also. Even though, cosmic matter density is varying in between very small and very big values, proposed relations (5) to (7) seem to apply for the whole range of cosmic moment of inertia associated with factors $\left(\frac{2}{3}\right)$ and $\left(\frac{2}{5}\right)$. As per modern concepts, dark energy is the driving force of cosmic expansion and acceleration. If one is willing to consider dark energy as cosmic rotational kinetic energy, some of the basic concepts of modern cosmology seem to be reviewed at fundamental level. In this context, readers are strongly encouraged to see references [12] to [61] for understanding cosmic rotation on practical or observational approach. We are working in this direction.

6. The Cosmic Age

With reference to the Planck scale cosmic age of $\approx \frac{1}{H_{pl}} \cong \sqrt{\frac{G\hbar}{c^5}}$, current cosmic age of $\approx \frac{1}{H_0}$ and standard cosmology based cosmic age of 380,000 years pertaining to 3000 K, with trial-error we developed the following semi empirical relation. We are working on understanding its physical back ground and needs further study.

$$(t\times H_t) \approx \left[1+\ln\left(\frac{H_t}{H_0}\right)\right] \cong (\gamma_0-\gamma_t)+1 \tag{13}$$

Based on this relation, cosmic age corresponding to a temperature of ≈ 3000 K, Hubble parameter of $\approx 2.5\times10^{-12}\,sec^{-1}$ and $\gamma_t \approx 127.344$ could be around 189,022 years. This is roughly about half of the current estimations of 380,000 years.

7. The Observed Cosmic Redshift and Velocity-Distance Relation

Redshift associated with cosmic scale factor and cosmic temperature ratio, past Hubble parameter and Hubble's law can be expressed in the following way.

1) Inverse of the cosmic scale factor can be expressed with,

$$\left.\begin{aligned}&(z+1) \cong \frac{T_t}{T_0} \cong \frac{(\lambda_{max})_0}{(\lambda_{max})_t} \cong \left(\frac{(\Omega_{OM})_t}{(\Omega_{OM})_0}\right)\sqrt{\frac{H_t}{H_0}} \cong \sqrt{\frac{\gamma_0}{\gamma_t}}\exp\left(\frac{\gamma_0-\gamma_t}{2}\right) \\ &\rightarrow z \cong \left(\frac{T_t}{T_0}\right)-1 \cong \left(\frac{(\lambda_{max})_0}{(\lambda_{max})_t}\right)-1 \\ &\cong \left\{\left(\frac{(\Omega_{OM})_t}{(\Omega_{OM})_0}\right)\sqrt{\frac{H_t}{H_0}}\right\}-1 \cong \left\{\sqrt{\frac{\gamma_0}{\gamma_t}}\exp\left(\frac{\gamma_0-\gamma_t}{2}\right)\right\}-1\end{aligned}\right\} \tag{14}$$

2) Time dependent Hubble parameter can be expressed with,

$$H_t \cong \left(\frac{(\Omega_{OM})_0}{(\Omega_{OM})_t}\right)^2 (z+1)^2 H_0 \cong \left(\frac{\gamma_t}{\gamma_0}\right)(z+1)^2 H_0 \cong e^{(\gamma_0-\gamma_t)}H_0 \tag{15}$$

3) At present, from and about the hypothetical point of Planck scale or big bang, galactic receding speeds can be approximated with,

$$(v_g)_0 \cong \left(\frac{(d_g)_0}{R_0}\right)(V_{\exp})_0 \cong \left(\frac{(V_{\exp})_0}{R_0}\right)(d_g)_0 \cong H_0(d_g)_0 \tag{16}$$

When $(d_g)_0 \rightarrow R_0$, $(v_g)_0 \cong H_0R_0$. This can be compared with currently believed Hubble's law for the current expanding universe.

8. The Galactic Rotational Curves at Core radius

With reference to the currently believed role of dark matter in galaxies [62], [63], [64], [65] in a quantitative approach, we noticed that,

$$v_{gr} \approx \left[\frac{(\Omega_{OM})_0}{(\Omega_{DM})_0}\right]^{\frac{1}{2}}\sqrt{\frac{GM_g}{R_g}} \approx 0.385\sqrt{\frac{GM_g}{R_g}} \tag{17}$$

where, M_g = Mass of galaxy, R_g = Core radius of galaxy, and v_{gr} = Galactic rotation speed.

Relation (17) needs further study with respect to frame dragging effects, galactic own-rotation speed, distribution of stars in the galaxy and distribution of dark matter in the galaxy. See the following picture 2. We arranged the galactic rotation speeds in ascending order. Red curve represents our approximation and blue curve represents MSTG fit. Interesting observation is that, starting from a galactic mass of $0.13\times10^{10}M_{\odot}$ to a galactic mass of $33\times10^{10}M_{\odot}$, our approximation seems to be in line with MSTG fit. See table 2 for data.

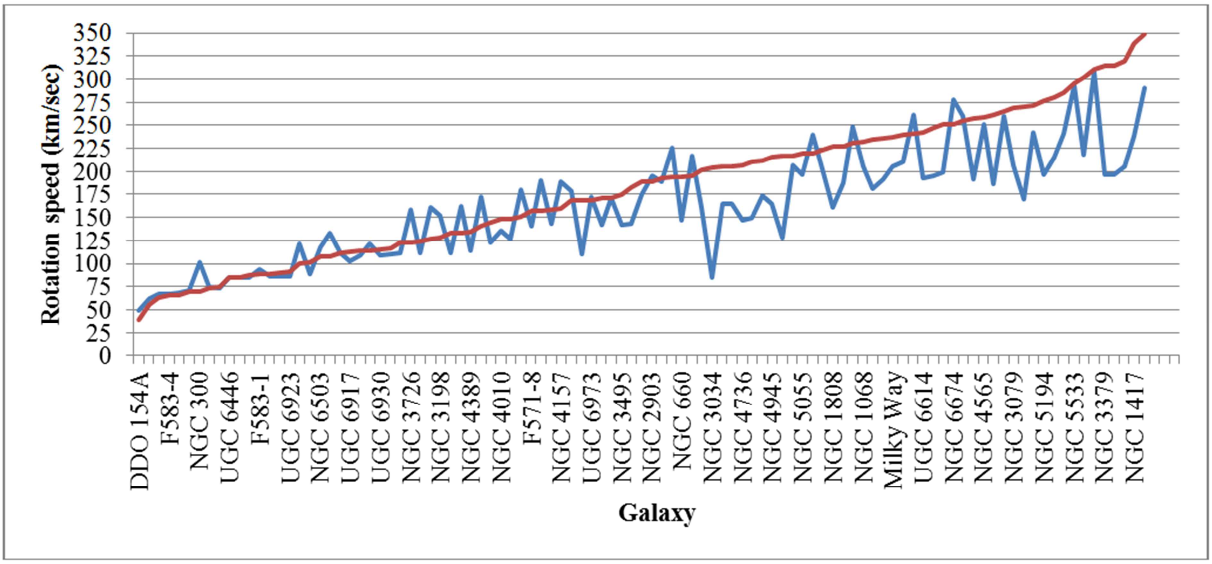

Figure 2. *Galactic rotation speeds in ascending order.*

In table 2,

1) Column-1 represents the galaxy name.
2) Column-2 represents the galactic mass estimation from MSTG data
3) Column-3 represents the estimated tolerance of galactic mass estimation from MSTG data
4) Column-4 represents the galactic core radius estimation from MSTG data
5) Column-5 represents the estimated tolerance of galactic core radius from MSTG data
6) Column-6 represents the estimated MSTG model of revolving speeds of orbiting stars.
7) Column-7 represents the tolerance in estimated MSTG model of revolving speeds of orbiting stars.
8) Column-8 represents our approximation for galactic rotation speed at core radius.

Table 2. *To approximate the galactic rotation speeds at core radius of galaxy.*

Galaxy Name	Galaxy Mass ($10^{10}M_{\odot}$)	Tolerance in Galaxy Mass ($10^{10}M_{\odot}$)	Galaxy core radius (kpc)	Tolerance in galaxy core radius (kpc)	Rotation speed from MSTG estimations (km/sec)	Tolerance in rotation speed from MSTG estimations (km/sec)	Our approximation for rotation speed at core radius (km/sec)
Dwarf (LSB & HSB) Galaxies							
DDO 154	0.13	0.02	0.53	0.07	48.9	2.4	39.6
DDO 168	0.42	0.09	0.66	0.08	67.1	4.7	63.7
DDO 170	0.4	0.04	0.82	0.07	61.9	2.3	55.8
F583-4	0.38	0.04	0.57	0.05	67.2	2.4	65.2
NGC 55	1.17	0.07	0.99	0.05	84.4	2	86.8
NGC 1560	0.79	0.05	0.93	0.04	74.9	1.7	73.6
NGC 2708	9.43	1.1	0.66	0.05	218.7	10.8	301.9
NGC 3109	0.78	0.04	1.15	0.04	68.6	1.3	65.8
NGC 3877	8.65	0.53	1.31	0.06	164.8	4.3	205.2
NGC 3949	6.51	0.3	0.99	0.03	164.5	3.2	204.8
NGC 3972	4.09	0.23	1.18	0.05	126.8	2.9	148.7
NGC 4062	2.98	0.17	0.43	0.02	149.4	3.4	210.3
NGC 4085	5.11	0.54	1.12	0.07	142	6.1	170.6
NGC 4096	1.07	0.07	0.24	0.01	110.1	2.8	168.7
NGC 4389	4.4	1.02	1.56	0.18	113.9	10.6	134.1
NGC 4569	6.23	0.51	0.39	0.03	205	7	319.2
NGC 5585	1.17	0.07	0.94	0.04	85.7	1.8	89.1
UGC 2259	0.77	0.02	0.48	0.01	88.8	1	101.2
UGC 3691	2.83	0.14	0.86	0.03	123.5	2.3	144.9
UGC 6399	1.34	0.08	1.05	0.04	86.7	2	90.2
UGC 6446	0.83	0.04	0.73	0.04	85.1	1.4	85.2
UGC 6818	1.31	0.53	1.5	0.32	73.1	10.8	74.6
UGC 6917	2.06	0.11	1.04	0.05	102.1	2.2	112.4

Galaxy Name	**Galaxy Mass** ($10^{10} M_{\odot}$)	**Tolerance in Galaxy Mass** ($10^{10} M_{\odot}$)	**Galaxy core radius (kpc)**	**Tolerance in galaxy core radius (kpc)**	**Rotation speed from MSTG estimations (km/sec)**	**Tolerance in rotation speed from MSTG estimations (km/sec)**	**Our approximation for rotation speed at core radius (km/sec)**
UGC 6923	0.96	0.17	0.74	0.1	86.5	5.6	91.0
UGC 7089	0.86	0.08	1.15	0.07	71.1	2.3	69.1
LSB GALAXIES							
F563-1	2.26	0.16	1.06	0.07	110.4	2.7	116.6
F568-3	3.08	0.41	1.58	0.13	110.9	5.2	111.5
F571-8	5.46	0.84	1.4	0.14	141.2	8	157.7
F583-1	1.56	0.12	1.28	0.06	93.2	2.3	88.2
NGC 247	2.27	0.17	1.11	0.06	109.4	2.8	114.2
NGC 598	1.78	0.04	0.64	0.01	110.9	0.8	133.2
NGC 1003	1.64	0.03	0.8	0	121.5	0.8	114.4
NGC 1417	16.6	0.49	0.92	0.02	238.2	2.8	339.3
NGC 3495	4.16	0.27	0.87	0.04	142.1	3.3	174.7
NGC 3672	14.86	0.2	1.21	0.01	215.2	1.2	279.9
NGC 3917	6.25	0.45	1.6	0.09	142.8	3.8	157.9
NGC 4010	5.56	0.88	1.62	0.17	136.2	7.9	148.0
NGC 4183	2.04	0.11	0.85	0.05	111.3	2	123.7
UGC 6446	0.83	0.04	0.73	0.04	85.1	1.4	85.2
UGC 6614	11.36	1.79	1.24	0.22	192.3	11.9	241.8
UGC 6930	2.17	0.13	1.03	0.06	109.5	2.2	115.9
UGC 6983	2.12	0.16	0.9	0.07	111.5	2.8	122.6
HSB GALAXIES							
IC 342	7.95	0.14	1.36	0.03	188.3	1.2	193.1
Milky Way	9.12	0.28	1.04	0.05	204.8	2.4	236.5
NGC 224	20.19	0.3	1.84	0.04	259.6	1.6	264.6
NGC 253	6.94	0.25	0.86	0.04	188	2.5	226.9
NGC 300	2.03	0.17	2.7	0.19	101.7	2.9	69.3
NGC 660	3.2	0.06	0.54	0.02	146.6	0.9	194.4
NGC 801	20.07	2.09	2.65	0.24	240.3	10.2	219.8
NGC 891	7.47	0.17	0.78	0.03	194.9	1.7	247.2
NGC 1068	9.42	0.54	1.11	0.07	205.9	4.5	232.7
NGC 1097	22.68	0.31	1.19	0.03	290.1	1.6	348.7
NGC 1365	14.96	0.25	1.29	0.03	242.6	1.6	272.0
NGC 1808	4.1	0.1	0.51	0.02	160.6	1.4	226.5
NGC 2403	3.8	0.13	2.09	0.07	133.7	1.6	107.7
NGC 2590	14.05	0.48	1.1	0.05	241	3.3	285.5
NGC 2841	33.04	1.31	2.19	0.14	308.3	5.2	310.2
NGC 2903	9.66	0.61	1.72	0.11	195.9	4.8	189.3
NGC 2998	15.13	1.2	2.52	0.19	216.7	6.8	195.7
NGC 3031	6.95	0.12	0.67	0.02	191.8	1.3	257.2
NGC 3034	0.52	0.03	0.08	0.01	85	1.6	203.6
NGC 3079	8.73	0.23	0.77	0.03	207.1	2.1	268.9
NGC 3198	5.55	0.28	2.18	0.12	152.1	2.8	127.4
NGC 3379	6.99	0.06	0.45	0.01	196.7	0.6	314.8
NGC 3379	6.99	0.06	0.45	0.01	196.7	0.6	314.8
NGC 3521	7.89	0.1	0.8	0.02	198.7	1	250.8
NGC 3628	9.13	0.31	1.17	0.05	202.3	2.6	223.1
NGC 3726	9.6	1.37	4.07	0.58	158.4	8.8	122.7
NGC 3769	2.59	0.24	1.66	0.2	121.7	3.8	99.8
NGC 3893	7.7	1	1.74	0.29	179.3	8.9	168.0
NGC 3953	20.47	1.65	3.46	0.28	225.5	7.4	194.3
NGC 3992	25.16	2.32	2.77	0.44	260.9	10	240.7
NGC 4013	6.01	0.35	0.7	0.19	181.1	3.9	234.0
NGC 4051	7.21	1.31	2.58	0.43	161.7	11.1	133.5
NGC 4088	9.74	1.52	3.15	0.51	172.4	10.4	140.5
NGC 4100	10.3	1.59	2.89	0.49	180.2	10.8	150.8
NGC 4138	4.31	0.9	0.68	0.39	160.7	12.1	201.1
NGC 4157	11.64	1.21	2.92	0.36	188.5	7.7	159.5
NGC 4217	12.92	1.54	3.31	0.36	189.7	8.9	157.8
NGC 4258	7.29	0.14	0.84	0.03	191.9	1.4	235.3
NGC 4303	3.08	0.08	0.59	0.02	143.8	1.4	182.5
NGC 4321	21.67	0.45	2.12	0.06	260.2	2.2	255.4
NGC 4448	1.98	0.08	0.27	0.01	127.8	1.7	216.3
NGC 4527	5.55	0.23	0.79	0.05	174.3	2.7	211.7
NGC 4565	18.11	0.21	1.72	0.03	251.2	1.2	259.2

Galaxy Name	Galaxy Mass ($10^{10} M_{\odot}$)	Tolerance in Galaxy Mass ($10^{10} M_{\odot}$)	Galaxy core radius (kpc)	Tolerance in galaxy core radius (kpc)	Rotation speed from MSTG estimations (km/sec)	Tolerance in rotation speed from MSTG estimations (km/sec)	Our approximation for rotation speed at core radius (km/sec)
NGC 4631	6.15	0.1	1.34	0.03	171.4	1	171.1
NGC 4736	3.15	0.08	0.47	0.02	146.8	1.3	206.8
NGC 4945	4.58	0.12	0.63	0.03	165.1	1.6	215.4
NGC 5033	9.9	0.51	1.1	0.08	210.2	4.2	239.6
NGC 5055	8.38	0.06	1.11	0.01	196.9	0.5	219.5
NGC 5194	7.29	0.23	0.61	0.03	196.6	2.3	276.1
NGC 5236	6.16	0.12	1.1	0.04	175.5	1.3	189.0
NGC 5457	10.2	0.27	1.39	0.04	206.5	2.1	216.4
NGC 5533	28.81	1.92	2.11	0.23	293.2	8.2	295.1
NGC 5907	4.59	0.26	0.4	0.05	169.3	3.5	270.6
NGC 6503	1.98	0.06	1.1	0.05	117.4	1.3	107.2
NGC 6674	32.48	2.38	3.27	0.33	277.7	8.6	251.7
NGC 6946	8.95	0.65	3.54	0.27	161.2	4.5	127.0
NGC 6951	6.22	0.22	0.58	0.03	185.8	2.5	261.6
NGC 7331	21.47	0.76	2.56	0.1	248.9	3.6	231.3
UGC 6973	6.41	0.45	1.43	0.12	172.5	4.5	169.1

9. Discussions and Conclusions

9.1. Cosmological Constant Problem

With reference to proposed concepts, the ratio of the Planck scale critical density to the current critical density is,

$$\left(\frac{3H_{pl}^2 c^2}{8\pi G}\right) \div \left(\frac{3H_0^2 c^2}{8\pi G}\right) \cong \left(\frac{H_{pl}}{H_0}\right)^2 \cong 6.685\times 10^{121} \quad (18)$$

We wish to appeal that, this idea can be considered as a characteristic tool for constructing a model of 'quantum gravity' with cosmic evolution.

9.2. 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 large 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 the universe is expanding, thermal radiation temperature decreases and matter content increases. As matter content increases, based on Mach's principle, at any stage of evolution, it is possible to have an increasing radius of curvature, $R_t \cong \frac{G}{c^2}\left[\left(M_{OM}\right)_t + \left(M_{DM}\right)_t\right]$. For the current case, $R_0 \cong \frac{G}{c^2}\left[\left(M_{OM}\right)_0 + \left(M_{DM}\right)_0\right] \cong 10.45 \text{ Gpc}$ and there is no scope for 'causal disconnection' of distant visible matter.

9.3. Cosmic Inflation with Respect to Current Cosmic Radius

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. 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 $R_0 \cong \sqrt{\frac{2}{\left[\left(\Omega_{OM}\right)_0 + \left(\Omega_{DM}\right)_0\right]}}\left(\frac{c}{H_0}\right)$, estimated current cosmic radius is 10.45 Gpc. With respect to the proposed estimation/fit of current cosmic radius, currently believed cosmic inflation can be reviewed and possibly, can be relinquished.

9.4. CMBR Fluctuations

Temperature fluctuations are directly proportional to actual galactic ordinary matter density fluctuations. Clearly speaking, observed hot spots and cold spots can be interpreted with higher and lower (ordinary) matter densities pertaining to galactic surroundings.

9.5. Cosmic Expansion Velocity

Now a days, main stream cosmologists are seriously working on 'eternal light speed expansion' [66-71]. In this context, in our earlier published papers, based on ordinary matter density and Hubble's law, we come across different magnitudes of cosmic expansion velocities ranging from $2c$ to $12c$. We would like to appeal that, by considering the decreasing density of ordinary matter and dark matter, starting from the Planck scale, it is possible to get an expression for cosmic expansion velocity or rotational velocity comparable to speed of light. It can be expressed as follows. At the cosmic equator,

$$\left.\left(V_{\exp}\right)_t \cong R_t H_t \cong \sqrt{\frac{2}{\left[\left(\Omega_{OM}\right)_t + \left(\Omega_{DM}\right)_t\right]}}\left(c\right)\right\} \quad (19)$$

$$\frac{(V_{\exp})_t}{c} \cong \sqrt{\frac{2}{\left[(\Omega_{OM})_t + (\Omega_{DM})_t\right]}} \tag{20}$$

Based on this expression, for the Planck scale, $(V_{\exp})_{pl} \cong 1.85c$ and for the current scale, $(V_{\exp})_0 \cong 2.44c$. Interesting point to be noted is that, after 14 billion years of cosmic expansion, increment in expansion velocity or rotational velocity seems to be only $(V_0 - V_{pl}) \cong 0.59c$. We are working on accommodating this kind of approach in our future toy models.

9.6. Various Cosmological Physical Parameters

See the following figure 3 for various cosmological physical parameters.

In this figure 3, X-axis represents $\gamma_t \cong (1 \text{ to } 141.256)$,

On the Y- axis:

1) Ln(Ht) represents the natural log of decreasing cosmic Hubble parameter.
2) Ln(Tt) represents the natural log of decreasing cosmic temperature.
3) Ln(Mt) represents the natural log of increasing cosmic ordinary matter and dark matter.
4) Ln(Rt) represents the natural log of increasing cosmic radius.
5) Ln(Tt) represents the natural log of increasing cosmic time.

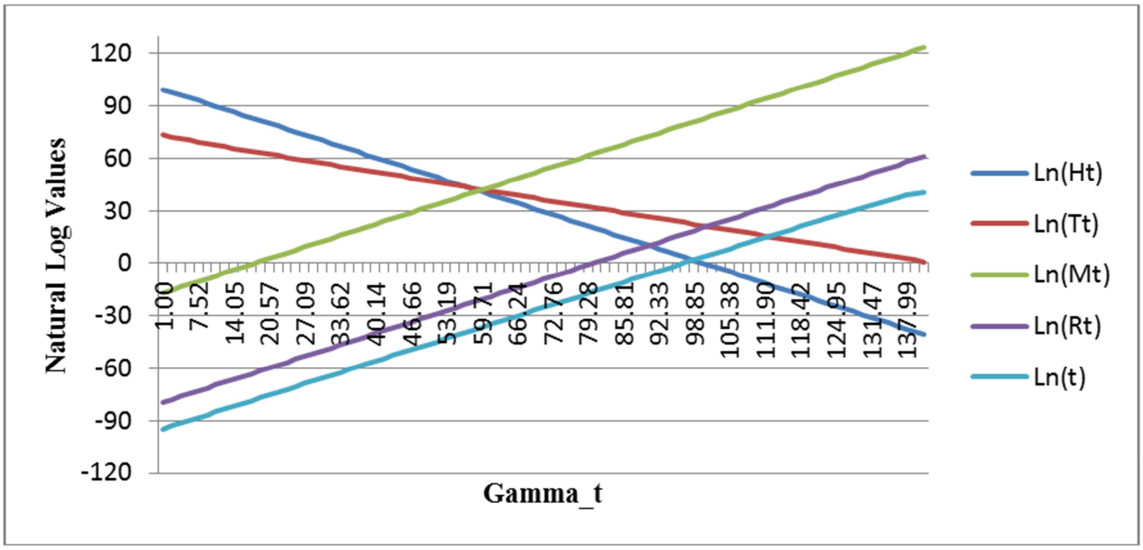

Figure 3. *Natural log of various cosmic physical parameters.*

9.7. Model Derivation for Cosmic Angular Velocity

With a simple derivation it is possible to show that, Hubble's constant H_t is a representation of cosmic angular velocity. We presented this derivation in many of our published papers [14, 15]. Basic idea of this derivation is to express the angular velocity of any rotating celestial body in terms of its mass, radius, density and surface escape velocity. Assume that, a planet of mass M and radius R rotates with angular velocity ω_e and linear velocity v_e in such a way that, free or loosely bound particle of mass m lying on its equator gains a kinetic energy equal to potential energy. Then,

$$\frac{1}{2} m v_e^2 = \frac{GMm}{R} \tag{21}$$

$$R\omega_e = v_e = \sqrt{\frac{2GM}{R}} \text{ and } \omega_e = \frac{v_e}{R} = \sqrt{\frac{2GM}{R^3}} \tag{22}$$

i. e Linear velocity of planet's rotation is equal to free particle's escape velocity. Without any external power or energy, test particle gains escape velocity by virtue of planet's rotation. Now writing, $M = \frac{4\pi}{3} R^3 \rho_e$,

$$\omega_e = \frac{v_e}{R} = \sqrt{\frac{8\pi G \rho_e}{3}} \text{ Or } \omega_e^2 = \frac{8\pi G \rho_e}{3} \tag{23}$$

$$\rho_e = \frac{3\omega_e^2}{8\pi G} \tag{24}$$

Proportionality constant being $\left(\frac{3}{8\pi G}\right)$, from equation (24), it seems that,

$$\text{density} \propto (\text{angular velocity})^2 \tag{25}$$

Equation (24) is similar to the famous 'flat model concept' of cosmic 'critical density',

$$\rho_c = \frac{3H_t^2}{8\pi G} \tag{26}$$

Comparing equations (24) and (26), dimensionally and conceptually,

$$\left\{\rho_e = \frac{3\omega_e^2}{8\pi G}\right\} \Leftrightarrow \left\{\rho_c = \frac{3H_t^2}{8\pi G}\right\} \tag{27}$$

$$H_t^2 \to \omega_e^2 \text{ and } H_t \to \omega_e \tag{28}$$

Thus, dimensions of 'Hubble's constant' can possibly be considered as 'radian/second'. In any physical system under study, when situation is similar, for any one 'simple' physical parameter, there cannot be two different physical meanings and there cannot be two different units. This is a simple clue and based on this, one can make an attempt to introduce 'cosmic rotation' in modern cosmology.

9.8. To Conclude

We would like to suggest that:

1) Cosmic expansion, Lambda term, dark matter, cosmic temperature, inflation, cosmic acceleration and dark energy and vacuum energy are different concepts, using by which alternative models of GTR are emerging and are being extended in many ways.
2) Quantum gravity is a wide range physical model intended for understanding the in-built cosmological quantum phenomena on small scale as well as large scale distances. So far, progress in this direction is very nominal and 'GTR' needs a serious review with reference to 'quantum cosmology'.
3) Current cosmic radius is about 10.45 Gpc and current cosmic sphere seems to constitute around 15 Hubble spheres and needs further study with respect to the Bayesian model average estimate of >251 Hubble spheres proposed by M. Vardanyan et al [72].
4) Quantum mechanics point of view, 'spin' is a basic and characteristic property and quantum gravity point of view, it is a must to review the currently believed 'standard cosmology' with reference to cosmic rotation. We are working on analyzing the reasons for the coincidence of the 'magnitude equality' of current Hubble parameter and current angular velocity. In literature one can find support for this [19, 20, 31, 47, 48].
5) In standard cosmology, there exists no procedure in understanding the dark energy, dark matter and ordinary matter in a unified approach. Our proposed concepts and relations can be recommended for further research.
6) Even though subject of 'inflation' is very interesting, root causes of inflation are still very unclear. To understand the ground reality, we are working on understanding the concepts of 'inflation' in a quantum gravitational approach to enable it to be incorporated in our toy model.
7) With reference to relations (1) to (12), we are working on understanding the physical significance of dark matter and dark energy in a quantum gravitational rotating frame [12-13]. With reference to particle physics, current technological limits on particle colliding energy, unidentified/unseen particles, unknown particle interactions and incomplete final unification scheme - to some extent, one can hopefully believe in the existence of dark matter. Even though its believed proportion is around 70% and a number of surveys are going on to detect dark energy, so far, no one could find a single clue for tracing its physical identity or physical existence. In this identity crisis, it is reasonable to note that cosmic rotational kinetic energy seems to have more physical meaning and physical identity than the mysterious dark energy. To support this, we put forward interested cosmologists to take initiative in understanding and studying the observational effects of cosmic rotation [19, 20, 47, 48, 50, 51].
8) Without knowing the actual galactic distances and actual galactic receding speeds, with 100% confidence level, it may not be possible to decide the absolute nature of cosmic expansion rate. With reference to our proposed concepts, we are working on understanding the need of considering the observed galactic redshifts and their estimated distances in inferring the actual cosmic expansion rate.
9) Independent of galactic redshift data, we are working on finding alternative tools for understanding the cosmic expansion rate. In future, with advanced science, engineering and technology, by considering $\frac{d(\lambda_{\max})_0}{dt}$ or $\frac{d(T_0)}{dt}$ or $\frac{d(H_0)}{dt}$ or $\frac{d(\Omega_{OM})_0}{dt}$ or $\frac{d(\Omega_{DM})_0}{dt}$, absolute cosmic rate of expansion can be estimated.

Acknowledgements

It is great pleasure to express our deep gratitude to Dr. E. Terry Tatum for his valuable technical discussions and kind encouragement. Author Seshavatharam is indebted to professors brahmashri M. NagaphaniSarma, Chairman, shri K. V. Krishna Murthy, founder Chairman, Institute of Scientific Research in Vedas (I-SERVE), Hyderabad, India and Shri K. V. R. S. Murthy, former scientist IICT (CSIR), Govt. of India, Director, Research and Development, I-SERVE, for their valuable guidance and great support in developing this subject. Both authors are very much thankful to the anonymous reviewers for their kind and valuable suggestions.

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