A comparative study on cosmic dark energy and rotational kinetic energy

U. V. S. Seshavatharam[1] and S. Lakshminarayana[2]

[1]Honorary faculty, I-SERVE, Alakapuri, Hyderabad-35, Telangana, India.
Email: seshavatharam.uvs@gmail.com
[2]Dept. of Nuclear Physics, Andhra University, Visakhapatnam-03, AP, India.
Email: lnsrirama@gmail.com

Abstract: Qualitatively and quantitatively, we review the basics of standard cosmology with respect to Planck scale, Mach's principle, superluminal expansion speeds and superluminal rotation speeds. Important results to be noted are: 1) At H_0=70 km/sec/Mpc, fitted current cosmic temperature is 2.721 K; 2) Estimated current cosmic radius is 90 billion light years and is 2 times the current observable cosmic radius; 3) Estimated current cosmic mass is $1.146\text{x}10^{54}$ kg and is 8 times the current estimate; 4) Magnitude of the currently believed visible mass density is equal to the estimated current cosmic mass density; 5) Magnitude of the currently believed dark energy is equal to the magnitude of the estimated current cosmic rotational kinetic energy;

Key words: Planck scale, Mach's principle**,** Super luminal expansion speeds and rotation speeds, Rotational kinetic energy, Dark energy.

1. Introduction

We suppose that, the observable universe is an evolving and rotating sphere about the point of big bang and Planck scale is the characteristic energy scale associated with big bang and quantum gravity [1]. We define the Planck scale Hubble parameter as $H_{pl} \cong \sqrt{c^5/G\hbar}$ and apply it to cosmological data fitting in the form of $\left[1+\ln\left(H_{pl}/H_t\right)\right]^n$ where H_t is the running Hubble parameter and n is a suitable power index.

To have a closed and massive universe, we choose 'Mach's principle'. In this context, one of our assumption, $\left(GM_0/R_0c^2\right)\cong 1$ can be given some consideration at fundamantal level. One can find interesting technical discussion on this assumption by D.W.Sciama, R.H. Dicke, C. Brans and G. J. Whitrow [2-4].

We re-view the assumed effects of 'inflation' [5,6] 'acceleration' and 'dark energy' [7,8,9] with increasing super luminal expansion speeds and increasing super luminal rotational speeds.

2. Workable assumptions connected with Planck scale

With the following simple and logical assumptions, most of the currently believed cosmological observations can be reviewed and refined at fundamental level.

1) With reference to big bang and Planck scale, Hubble parameter associated with Planck scale can be defined as $H_{pl} \cong \sqrt{c^5/G\hbar} \cong 1.8549215\times10^{43}$ sec^{-1}

2) Speed of light can be considered as the initial cosmic expansion speed.

3) At any stage of cosmic evolution, from and about the point of big bang,

- **a)** H_t^{-1} can be considered as the cosmic age.
- **b)** $\frac{GM_t}{R_tc^2}\cong 1$ where M_t is the cosmic mass and R_t is the cosmic radius or distance travelled.
- **c)** Magnitude of cosmic angular velocity is equal to H_t.
- **d)** $V_t \cong \sqrt{1+\ln\left(H_{pl}/H_t\right)}\times c$ can be considered as the cosmic expansion speed.
- **e)** Ratio of critical energy density and thermal energy density is equal to $\left[1+\ln\left(H_{pl}/H_t\right)\right]^2$.

3. Discussion on the proposed assumptions and their consequences or results

We would like to highlight the following points.

1) Modern cosmologists strongly believe that current universe is acceelrating. But they are silent in quantifying the past and current cosmic expansion speeds. In general, 'cosmic acceleration' means, 'rate of increase' in cosmic expansion speed. Based on assumptuion 3d, we treied our level best in quantifying the past and current cosmic expansion speeds.

2) Even though, modern cosmology is strongly believing in current cosmic acceelration, it is silent in quantifying the current cosmic acceleraton. Along with the assumed cosmic age, we assume the current and initial cosmic expansion speeds and thereby estimating the current cosmic acceleration by implementing the utmost basic kinematic relation! In addition, based on the estimated current cosmic acceleration, we estiamted the current cosmic radius.

3) With reference to the proposed assumptions, current universe seems to constitute 267 Hubble spheres. According to Mihran Vardanyan et al [10], the curvature scale of the Universe is conservatively constrained to be $R_c > 42$ Gpc (99%), corresponding to a lower limit to the number of Hubble spheres in the Universe NU > 251 (99%). This coincidence clearly indicates the workability of our proposed assumptions.

4) We consider continuous super luminal expansions and hence it is possible to understand the currently observed large scale cosmic homogeniety or isotropy. Thus the 'inflation' concept can be relinqushed [5,6]. In addition, concepts associated with 'fine tuning' of 'beginning of inflation' can also be ignored. Important point to be noted is that, modern estimate of cosmic radius is strictly assumed to obey 'inflation' whereas our estimate of cosmic radius (that is twice of modern estiamte) is independent of 'inflation'.

5) As the observed universe is very large and observers cannot reach all parts of the univese, one may be forced to believe in 'temperature isotropy'. In reality, as universe is continuously assumed to be expanding at increasing super luminal speeds, expecting 'temperature isotropy' may not be reasonable.

6) Since it is assumed that, universe is always expanding with increasing super luminal speeds, generally believed 'Lambda term ' can be ignored in our proposed model.

7) Without a radial in-flow of matter in all directions towards one specific point, one cannot expect a big crunch and without a big crunch, one cannot expect a big bang. Really if there was a 'big bang' in the past, with reference to formation of big bang as predicted by GTR and with reference to the cosmic rate of expansion that might had been taken place simultaneously in all directions at a 'naturally selected rate' about the point of big bang - 'point' of big bang can be considered as the characteristic reference point of cosmic expansion in all directions. Thinking in this way, to some extent, point of big bang can be considered as a possible center of cosmic expansion.

8) It may be noted that, many cosmologists are working on 'cosmic rotation' [11-20]. According to Fani Dosopoulou et al [14]: "Current observations are consistent with small amounts of universal rotation, which means that, if the universe rotates, it does so very slowly. This is also in agreement with the inflationary scenario, where the exponential expansion is expected to essentially eliminate any traces of primordial vorticity. Nevertheless, most (if not all) astrophysical structures rotate, which raises the question whether their rotation is of cosmological origin, or a relatively recent addition due to local physical processes. Magnetic fields have long been known to act as sources of rotational distortions and the agent responsible for their generation is the field's tension. Consequently, one could argue that the origin of cosmic magnetism and that of universal rotation are closely (if not directly) related. Put another way, magnetized universes should also rotate".

9) From modern estimates, cosmic radius about earth is 46.5 billion light years and from our estimate, cosmic radius about the point of big bang is 90 billion light years and ratio of these two radii is very close to ½. Estimated radii point of view, factor ½ is not a big issue. As earth is far away from the cosmic boundary, even though, if universe is really rotating, one may not be able to observe the effects of cosmic rotation from and about earth.

10) Considering all the proposed assumptions collectively, it is certainly possible to show that, ratio of currently believed 'dark enery density' and proposed 'rotational kinetic energy density' is equal to unity. This coincidence casts doubt on the existence of 'dark energy' at fundamanetal level and needs further study.

11) Even though our proposed model is independent of galactic redshifts, galactic distances and galactic receding speeds, with proposed assumptions, outline of the currently believed evolving cosmic structure can be understood very easily. By measuring the actual galactic receding speeds, assumption 3d can be investigated further.

12) In any model of cosmology, fundamental questions to be solved are: 1) Why do 'dark matter' and 'visible matter' have their measured values of ~33% of critical energy? 2) Why do 'dark energy' has its measured values of ~68% of critical energy? 3) How to estimate their past and future magnitudes? These are the puzzling questions raised by the Royal Swedish Academy of Sciences [7] in 2011. In the conclusion part, Royal Swedish Academy of Sciences say: "The study of distant supernovae constitutes a crucial contribution to cosmology. Together with galaxy clustering and the CMB anisotropy measurements, it allows precise determination of cosmological parameters. The observations present us with a challenge, however: What is the source of the dark energy that drives the accelerating expansion of the Universe? Or is our understanding of gravity as described by general relativity insufficient? Or was Einstein's "mistake" of introducing the cosmological constant one more stroke of his genius? Many new experimental efforts are underway to help shed light on these questions". In this context, in section-4, we tried our level best in answering these basic questions with assumption 3b which is having a long history in General relativity and Cosmology .

4. Various applications of $\left[1+\ln\left(H_{pl}/H_0\right)\right]$ in cosmology

Cosmic temperature: For the current case,

$$aT_0^4 \cong \left[1+\ln\left(\frac{H_{pl}}{H_0}\right)\right]^{-2}\left(\frac{3H_0^2c^2}{8\pi G}\right) \cong \left(\frac{c}{V_0}\right)^4\left(\frac{3H_0^2c^2}{8\pi G}\right) \quad (1)$$

where V_0 is the current cosmic expansion speed.

$$\sqrt{\frac{3H_0^2c^2}{8\pi GaT_0^4}} \cong \left[1+\ln\left(\frac{H_{pl}}{H_0}\right)\right] \cong \left(\frac{V_0}{c}\right)^2 \quad (2)$$

With trial-error, if it is assumed that, $H_0 \cong 70.0$ km/sec/Mpc, obtained $T_0 \cong 2.7208$ K and $\sqrt{1+\ln\left(\frac{H_{pl}}{H_0}\right)} \cong \left(\frac{V_0}{c}\right) \cong 11.8851.$

This fitted value of H_0 seems to lie in between $\left[(67.7\pm0.66)\text{ to }(73.24\pm1.74)\right]$km/sec/Mpc of references [8] and [9] respectively.

Cosmic acceleration: For the current case, if

$V_0 \cong 11.8851\times c$ and $t_0 \cong H_0^{-1}$,

$$a_0 \cong \frac{V_0-c}{t_0} \cong (V_0-c)H_0 \cong 7.403\times10^{-9}\ \text{m.sec}^{-2} \quad (3)$$

Cosmic radius: For the current case, cosmic radius or distance travelled,

$$S_0 \cong R_0 \cong \frac{V_0^2-c^2}{2a_0} \cong \frac{V_0^2-c^2}{2(V_0-c)H_0} \cong \frac{V_0+c}{2H_0} \cong \left(\frac{c}{2H_0}\right)\left[1+\sqrt{1+\ln\left(\frac{H_{pl}}{H_0}\right)}\right] \cong 6.4425\left(\frac{c}{H_0}\right) \cong 8.514\times10^{26}\ \text{m} \quad (4)$$

From our estimate, current distance (observable and non-observable) about the point of big bang is 90 Gly= 27.6 Gpc. Our estimate seems to be approximately 1.935 times higher than modern estimation. Clearly speaking, current universe seems to constitute 267 Hubble spheres [10].

Galactic receding speeds: Based on relation (4), within the current radius of 90 Gly=27.6 Gpc, from and about the point of big bang, galactic receding speeds can be approximated with the following relation.

$$v_g \cong \left(\frac{d_g}{S_0}\right)V_0 \cong \left(\frac{d_g}{S_0}\right)11.8851c \cong \left\{\frac{2\sqrt{1+\ln\left(H_{pl}/H_0\right)}}{\left[1+\sqrt{1+\ln\left(H_{pl}/H_0\right)}\right]}\right\}\left(d_gH_0\right) \quad (5)$$

where d_g is the (assumed current) galactic distance from the point of big bang and v_g is the (current) galactic receding speed. Based on this relation (5), within the current boundary of 90 Gly=27.6 Gpc, galactic distances corresponding to assumed galactic receding speeds can be expressed in the following way.

$$d_g \cong \left(\frac{v_g}{V_0}\right)S_0 \cong \left(\frac{v_g}{11.8851c}\right)8.514\times10^{26}\ \text{m} \quad (6)$$

By co-relating the estimated galactic distances and actual receding speeds with observed galactic red shifts, further research can be carried out.

Cosmic mass and mass density: From applications 2 and 3, current visual and non-visual cosmic radius is around 90 Gly= 27.6 Gpc. With reference to assumption 3b, current mass of our (visible and invisible parts) universe can be estimated with the

following relation.

$$M_0 \cong \frac{c^2 R_0}{G} \cong 1.14654 \times 10^{54} \text{ kg} \quad (7)$$

where, $R_0 \cong \frac{V_0 + c}{2H_0} \cong \left(\frac{c}{2H_0}\right)\left[1 + \sqrt{1 + \ln\left(\frac{H_{pl}}{H_0}\right)}\right]$.

With this mass, current cosmic mass density can be expressed with the following relation.

$$\left(\rho_{mass}\right)_0 \cong \frac{3c^2}{4\pi G R_0^2} \cong \left[1 + \sqrt{1 + \ln\left(\frac{H_{pl}}{H_0}\right)}\right]^{-2} \frac{3H_0^2}{\pi G}$$

$$\cong 4.43505 \times 10^{-28} \text{ kg.m}^{-3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Now ratio of mass energy density and critical energy density [5] can be expressed with the following relation.

$$\left(\frac{\rho_{mass} c^2}{\rho_{critical} c^2}\right)_0 \cong 8\left[1 + \sqrt{1 + \ln\left(\frac{H_{pl}}{H_0}\right)}\right]^{-2} \cong 0.048185 \quad (9)$$

Cosmic rotational kinetic energy: From assumptions 3a, 3b and 3c, current cosmic rotational kinetic energy can be estimated in the following way.

$$\left(K_{rot}\right)_0 \cong \frac{1}{2} I_0 \omega_0^2 \cong \frac{1}{2} I_0 H_0^2 \quad (10)$$

As current 'mass density' is very small in magnitude, current observable universe can be considered as a thin spherical shell and hence its corresponding current moment of inertia can be expressed with the following relation .

$$I_0 \cong \frac{2}{3} M_0 R_0^2 \quad (11)$$

From the above two relations, current cosmic rotational kinetic energy can be expressed with the following simple relation.

$$\left(K_{rot}\right)_0 \cong \frac{1}{3} M_0 R_0^2 \omega_0^2 \cong \frac{1}{3} M_0 R_0^2 H_0^2 \quad (12)$$
$$\cong 1.4257 \times 10^{72} \text{ J}$$

Surprisingly it is noticed that, ratio of proposed current cosmic rotational energy density and currently believed dark energy density is very close to unity. It can be expressed in the following way.

$$\left[\frac{\left(K_{rot}\right)_0}{\left(4\pi/3\right) R_0^3}\right] \Big/ \left[0.68 \times \left(\frac{3H_0^2 c^2}{8\pi G}\right)\right] \cong 0.98 \quad (13)$$

where $0.68 \times \left(\frac{3H_0^2 c^2}{8\pi G}\right)$ is the currently believed dark energy density [8]. With reference to critical energy density, current rotational kinetic energy density can be expressed with the following relation.

$$\frac{\left(K_{rot}\right)_0}{\left(4\pi/3\right) R_0^3} \cong \frac{M_0 \omega_0^2}{4\pi R_0} \cong \frac{M_0 H_0^2}{4\pi R_0} \cong \frac{H_0^2 c^2}{4\pi G} \quad (14)$$

Surprisingly it is noticed that, ratio of current cosmic rotational kinetic energy density and critical energy density is equal to $\frac{2}{3} \cong 0.666667$. It can be expressed in the following way.

$$\left[\frac{\left(K_{rot}\right)_0}{\left(4\pi/3\right) R_0^3}\right] \Big/ \left[\frac{3H_0^2 c^2}{8\pi G}\right] \cong \frac{2}{3} \quad (15)$$

If one is willing to consider this coincidence as a 'heuristic coincidence', it is possible to say that, currently believed 'dark energy' is nothing but the current cosmic rotational kinetic energy. It is for further study .

Dark matter density: Based on the currently believed 'flat' model concept and current observations, 'dark matter' energy density can be fitted in the following way.

$$\left(\rho_{d.mat} c^2\right)_0 \cong 1 - \left[\frac{\left(K_{rot}\right)_0}{\left(4\pi/3\right) R_0^3} + \frac{M_0 c^2}{\left(4\pi/3\right) R_0^3}\right]$$
$$\cong 1 - \left[\frac{2}{3} + 0.048185\right] \cong 0.28515 \quad (16)$$

Qualitatively this can be compared with the currently believed 'dark matter' energy density [8] and needs further study.

Cosmic scale factor: It may be noted that,

1) Based on the modern concepts of cosmic scale factor ,
2) With reference to CMBR redshift of ~1100 and temperature ~3000 K and
3) With reference to the data prepared as per the proposed relations,

it is possible to show that,

$$\left((z+1) \cong \frac{T_t}{T_0}\right) \approx \sqrt{\left(\frac{V_0}{V_t}\right)\left(\frac{R_0}{R_t}\right)} \quad (17)$$

Important point to be noted here is that, the expression

$\sqrt{\left(\frac{V_0}{V_t}\right)\left(\frac{R_0}{R_t}\right)}$ seems to play an interesting role in understanding the cosmic scale factor and needs further study. For example, for $H_t \cong 2.4569\times10^{-12}$ sec^{-1} and $T_t \cong 2981.91$ K,

$$(z+1) \cong \sqrt{\frac{V_0 R_0}{V_t R_t}} \cong \sqrt{\frac{3.5631\times10^{9} * 8.514\times10^{26}}{3.3833\times10^{9} * 7.4955\times10^{20}}} \cong 1093.73$$

We are working in this new direction.

5. Conclusions

By following the proposed assumptions, in this paper we tried our level best in estimating and co-relating the Hubble parameter, temperature, age, expansion speed, accelertion, radius, mass, mass-energy density, rotational kinetic energy, dark matter energy density and galactic receding speeds of the current accelerating universe. Advantages of the proposed assumptions are:

1) Inherently connected with the Planck scale
2) Successful inplementaion of Mach's principle.
3) Logically very simple to implement and understand.
4) Resolves the key issues connected with currently believed 'inflation','cosmic horizon' and 'dark energy'.
5) Perfectly connects the current hubble parameter and current cosmic temperature.
6) In all the cases, exptrapolation to past and future is very easy.
7) With further research, a unified model of quantum cosmology can be developed.

Acknowledgements

Authors are very much thankful to Dr. E. Terry Tatum and Dr. L.M.Chechin. One of the authors, Seshavatharam U.V.S, is indebted to professors K.V. Krishna Murthy, 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 .

References

[1] Martin Bozowald. Quantum cosmology: a review. Rep. Prog. Phys. 78 (2015) 023901

[2] G. J. Whitrow. The Mass of the Universe. Nature 158, 165-166 (1946)

[3] D.W.Sciama. On the Origin of Inertia. MNRAS 113, 34, (1953)

[4] C. Brans and R. H. Dicke. Mach's principle and a relativistic principle of gravitation. Phys. Rev. 124, 925 (1961)

[5] Guth AH. Inflationary universe: A possible solution to the horizon and flatness problems. Phys. Rev.;D23:347.(1981).

[6] Steinhardt PJ. The inflation debate: Is the theory at heart of modern cosmology deeply flawed? Scientific American.;304(4):18-25. (2011)

[7] The accelerating universe. Compiled by the Class for Physics of the Royal Swedish Academy of Sciences (2011) . www.nobelprize.org/nobel_prizes/physics/laureates/2011/advanced-physicsprize2011.pdf

[8] Planck Collaboration: Planck 2015 Results. XIII. Cosmological Parameters.

[9] Adam G. Riess et al. A 2.4% Determination of the Local Value of the Hubble Constant. Astrophys.J. 826 no.1. (2016)

[10] Mihran Vardanyan et al. Applications of Bayesian model averaging to the curvature and size of the Universe. MNRAS Lett 413, 1, L91-L95 (2011).

[11] L.M. Chechin. Rotation of the Universe at different cosmological epochs. Astron.Rep. 60 no.6, 535-541. (2016)

[12] Demidchenko V. V. and Demidchenko V. I. The rotating universe. Liberal Arts in Russia.. Vol. 5. No. 2. Pp. 131-160. (2016)

[13] Tatum, E.T., Seshavatharam, U.V.S. and Lakshminarayana, S. The Basics of Flat Space Cosmology. International Journal of Astronomy and Astrophysics, 5, 116-124 (2015)

[14] Fani Dosopoulou and Christos G. Tsagas. Vorticity survival in magnetized Friedmann universes. Phys.Rev.D89:103519,(2014)

[15] Michael J. Longo, Detection of a Dipole in the Handedness of Spiral Galaxies with Redshifts z 0.04, Phys. Lett. B.699:224-229 (2011)

[16] Wlodzimierz Godlowski. Global and local effects of rotation: Observational aspects. International Journal of Modern Physics D 20 1643 (2011)

[17] Yuri N. Obukhov et al. Rotation in string cosmology. Class.Quant.Grav.20:1103-1114, (2003)

[18] Wlodzimierz Godlowski and Marek Szyd lowsk . Dark energy and global rotation of the Universe. Gen.Rel.Grav. 35 2171-2187(2003)

[19] Li-Xin Li. Effect of the Global Rotation of the Universe on the Formation of Galaxies. Gen.Rel.Grav. 30, 497(1998)

[20] Rainer W. Kuhne. On the Cosmic Rotation Axis. Mod.Phys.Lett.A12:2473-2474 (1997)