Cosmological Constant

Bhatt, Ankur S. [*]   Becker, F.M.

July 13, 2019

Abstract

The exact cosmological constant is theoretically derived and described as the ratio of Planck length and the particle horizon radius. Additionally, equations relating the sterile neutrino mass, planck mass and mass of the universe are all created. Furthermore, the mass of the universe can be derived as encoded information located on the cosmic horizon.

Keywords: cosmological constant, dark energy

1 Introduction

A new model is introduced which satisfies the Friedmann equations for a flat universe without the contribution of dark matter. Recent researches such as MOND and quantized inertia suggest dark matter is an effect and not an actual substance (material, real particle). Therefore, the contribution of the dark matter particle as part of the deSitter models for the universe curvature might be relevant. The standard approach considers dark energy as compensating for a matter dominated deSitter dictated curvature. This results in a flat cosmos. In recent years, it has been found that the cosmological constant has an actual value and is not a theoretical artifact. The present value of the cosmological constant is significantly small and only slightly contributes to the addition of the Hubble parameter. In this paper the cosmological constant is correlated to the smallest energy oscillation (wavelength) that spans the particle horizon. The model(s) under discussion include the consideration that the particle horizon is an information boundary (which was determined by Hawking and Unruh) which influences the conditions of virtual particles at the horizon. This could be seen as an equivalence of event horizon but without the particle horizon and is actually the cosmic event horizon in Minkowski space. With the properties of an information boundary, the particle horizon is suggested to be a carrier of mass energy (as similar to a black hole entropy is available at that coordinate). Here, the mass equivalence allocation by energy is influenced by the energy associated to the cosmological constant. The coordinate of the information horizon energy confinement equivalence is computed by the superposition probability in position (significantly high harmonic spectrum) localized at the horizon. This could be interpreted as a dark energy contribution since the direction of the gravitational effect is outwards (considering an observer particle is in the middle of the particle horizon span). This also suggests that

[*]ankurb@g.ucla.edu

the interpreted curvature of space by a matter equivalence at the information horizon is an inverse slope. By Gauss's law of gravity, matter is allocated to the center. This results in two mass coordinates one at the observer particle and the other at the information horizon with two opposing force vectors. This simplified scenario might be seen as an anti DeSitter (AdS) curvature which would be by Gauss's law located at the horizon and a DeSitter matter curvature which are in superposition and overlay onto each other.

2 Method

2.1 Computation of Informational Mass & Cosmological Constant

The mass of the Universe can be thought of as encoded in the horizon as conjectured by holographic principle. First consider the energy of the fundamental wavelength in terms of compton energy.

$$E_{\Theta} = \frac{\hbar c}{\Theta/2} \tag{1}$$

Next, Consider the ratio of the surface area of the observable universe divided by the minimum area that can contain a qbit of information using the Schwarzschild radius, $2l_p$.

$$R_{SA} = \frac{4\pi\left(\frac{\Theta}{2}\right)^2}{4\pi l_p^2} \tag{2}$$

Now surmise that each qbit is associated to the minimum fundamental energy. Multiply the fundamental energy by the ratio factor to compute the total energy located on the horizon.

$$E_{\mathrm{H}} = \frac{2\hbar c}{\Theta} \cdot \frac{4\pi\left(\frac{\Theta}{2}\right)^2}{4\pi l_p^2} \tag{3}$$

Finally use $E = mc^2$ to convert into mass.

$$m_{\mathrm{H}} = \frac{2\hbar c}{\Theta} \cdot \frac{4\pi\left(\frac{\Theta}{2}\right)^2}{4\pi l_p^2} \cdot \frac{1}{c^2} \tag{4}$$

Further reduce (4) and cancel like terms to find the following.

$$m_{\mathrm{H}} = \frac{\hbar}{l_p c} \cdot \frac{\Theta}{2l_p} \tag{5}$$

Finally use the definition of Planck mass $m_p = \frac{\hbar}{l_p c}$ and to obtain the following cosmological constant relation. The left hand side is what Sheppeard predicted [4] and right side similar to McCulloch [3].

$$\sqrt{\Lambda} = \frac{m_p}{M_H} = \frac{2l_p}{\Theta} \tag{6}$$

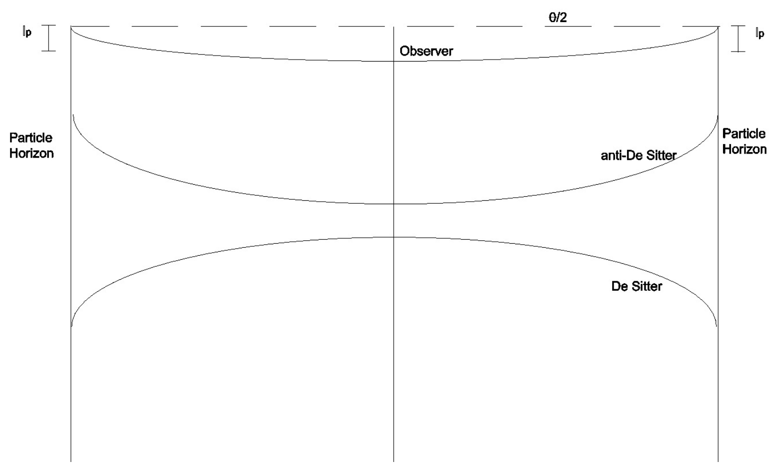

Figure 1: CC

2.2 Cosmological Constant using Mass-Energy & Compton energy

Consider the energy for two different masses, m_p and M_H.

$$E_{m_p} = m_p c^2 \tag{7}$$

$$E_{M_H} = M_H c^2 \tag{8}$$

Take the ratio of the two equations to yield the following.

$$\frac{E_{m_p}}{E_{M_H}} = \frac{m_p}{M_H} \tag{9}$$

Similarily find the maximum and minimum compton energy wave values from the center of the universe to its edge namely, l_p and $\Theta/2$.

$$\frac{E_\Theta}{E_{l_p}} = \frac{\frac{2\hbar c}{\Theta}}{\frac{\hbar c}{l_p}} \tag{10}$$

Reduce this equation to yield the following.

$$\frac{E_\Theta}{E_{l_p}} = \frac{2l_p}{\Theta} \tag{11}$$

Equate (10) and (12) and notice they are equivalent. This is the mass equivalence formula and it is equal to the cosmological constant.

$$\sqrt{\Lambda} = \frac{m_p}{M_H} = \frac{2l_p}{\Theta} \tag{12}$$

The equation can also be squared to obtain a form more equivalent to an energy density ratio.

$$\boldsymbol{\Lambda = \frac{m_p^2}{M_H^2} = \frac{(2l_p)^2}{\Theta^2}} \tag{13}$$

Planck time and the adjusted age of the universe can also indicate the cosmological constant where p_t is Planck time and $t_{0,\mathrm{adj}}$ is age of universe adjusted for inflation.

$$\sqrt{\Lambda} = \frac{m_p}{M_H} = \frac{2l_p}{\Theta} = \frac{p_t}{t_{0,\mathrm{adj}}} \tag{14}$$

2.3 Cosmological Constant using Newton's Gravity Law

Consider Newton's Gravity Force Law

$$F = \frac{GMm}{r^2} \tag{15}$$

Now consider the following thought experiment where two Planck masses, m_p, are at a minimum distance from each other namely the Planck length, l_p.

$$F_{m_p} = \frac{Gm_p^2}{l_p^2} \tag{16}$$

Now consider another thought experiment where two total Universe masses, M_H, are at a distance, $\Theta/2$ from each other. Note: This is the maximum distance two mass objects can be apart due to the information boundary of the horizon.

$$F_{M_H} = \frac{GM_H^2}{(\Theta/2)^2} \tag{17}$$

Consider the concept that these minimum and maximum conditions could be equivalent due to symmetry.

$$F_{m_p} = F_{M_H} \tag{18}$$

Subsitute in for both force equations.

$$\frac{Gm_p^2}{l_p^2} = \frac{GM_H^2}{(\Theta/2)^2} \tag{19}$$

Rewrite and simplify.

$$\frac{m_p^2}{M_H^2} = \frac{(2l_p)^2}{\Theta^2} \tag{20}$$

2.4 Neutrino mass equivalence principle

The neutrino/CMB coupling factor was found to be the following [4] [5] [1].

$$\frac{2m_{\nu,\text{sterile}}}{m_p} = \sqrt{\frac{2l_p}{\Theta}} \tag{21}$$

Replace m_p in (21) using (12).

$$\boldsymbol{\frac{2m_{\nu,\text{sterile}}}{M_H} = \left(\frac{2l_p}{\Theta}\right)^{3/2}} \tag{22}$$

2.5 Equivalence Principle to solve for Planck's constant

Consider Newton's Gravity Force Law

$$F = \frac{GMm}{r^2} \tag{23}$$

Now consider the following thought experiment where one mass, m, is located at the center of the observable universe and the other is the full mass at the horizon , M_H located at the edge of the universe at location $\Theta/2$ away.

$$F_G = \frac{GmM_H}{(\Theta/2)^2} \tag{24}$$

Next use Newton's force law, $F = ma$ and equate to see the acceleration on the test mass, m.

$$ma = \frac{4GmM_H}{\Theta^2} \tag{25}$$

Substitute in the minimum acceleration, $a = 2c^2/\Theta$ using quantized inertia since the test mass is at its maximum distance away from M_H. Cancel out the test mass, m.

$$\frac{2c^2}{\Theta} = \frac{4GM_H}{\Theta^2} \tag{26}$$

Simplify and notice that this has full convergence.

$$\boldsymbol{\frac{c^2}{G} = \frac{M_H}{\Theta/2}} \tag{27}$$

Next substitute in for $G = \frac{c^3 l_p^2}{\hbar}$.

$$\frac{c^2\hbar}{c^3 l_p^2} = \frac{M_H}{\Theta/2} \tag{28}$$

Finally solve for $\hbar$ which results in the following.

$$\hbar = \boldsymbol{\frac{2 l_p^2 M_H c}{\Theta}} \tag{29}$$

2.6 Hawking Radiation energy connection to Cosmological constant

Consider the radiation energy for a Planck sized black hole.

$$E_{H,l_p} = \frac{\hbar c^3}{8\pi G m_p} \tag{30}$$

Replace both $G = \frac{c^3 l_p^2}{\hbar}$ and $m_p = \frac{\hbar}{l_p c}$ using composite gravitational constant and Planck mass defintion formula. Consider the radiation energy for a Planck sized black hole.

$$E_{H,l_p} = \frac{\hbar c^3}{8\pi} \cdot \frac{\hbar}{c^3 l_p^2} \cdot \frac{l_p c}{\hbar} \tag{31}$$

Simplify to obtain the following.

$$E_{H,l_p} = \frac{c^2}{8\pi} \cdot \frac{\hbar}{l_p c} \tag{32}$$

Identify the Planck mass term to obtain the following.

$$E_{H,l_p} = \frac{1}{8\pi} \cdot m_p c^2 \tag{33}$$

This can also be written as the Compton energy of the shortest wavelength l_p.

$$E_{H,l_p} = \frac{1}{8\pi} \cdot \frac{\hbar c}{l_p} \tag{34}$$

Therefore define $E_{l_p} = \frac{\hbar c}{l_p}$ which results in the following relation.

$$E_{H,l_p} = \frac{1}{8\pi} E_{l_p} \tag{35}$$

This relation could is linked to the Compton energy of the wavelength l_p by a factor of 8π. This could come from the fact that the energy is measured from the observer so it is halved and the total volume intergral of 4π is divided to normalize the radiation to one dimension. It could also come from the fact that Hawking Radiation uses traditional Newton's Gravity law to compute gravity $g = \frac{GM}{r_s^2}$ where r_s is the Schwarzschild radius. It is was discovered that a factor of 4 appears at the limit of Newton's adjusted gravity formula. Also Hawking uses $\hbar$ instead of h which is traditionally used for radiation energy when mass is converted to energy. This could account for the 8π factor. In general it seems the 8π is a quantum correlation factor from relativity to the quantum realm.

This methodology can be furth extended to discover the relationship to the mass at the horizon and Planck mass. Replace $G = \frac{c^3 l_p^2}{\hbar}$ into (36) and m_p with M_H. Consider the radiation energy for a Planck sized black hole.

$$E_{H,M_H} = \frac{\hbar c^3}{8\pi M_H} \cdot \frac{\hbar}{c^3 l_p^2} \tag{36}$$

Simplify to obtain the following.

$$E_{H,M_H} = \frac{1}{8\pi M_H} \cdot \frac{\hbar^2}{l_p^2} \tag{37}$$

Next look at the Compton energy of the longest wavelength that fits between the observer and horizon namely $\Theta/2$.

$$E_{\Theta/2} = \frac{2\hbar c}{\Theta} \tag{38}$$

Using the concepts above it can be suggested that the following could hold true.

$$E_{H,M_H} = \frac{1}{8\pi} \cdot E_{\Theta/2} \tag{39}$$

Plug into both energy values to obtain the following.

$$\frac{1}{8\pi M_H} \cdot \frac{\hbar^2}{l_p^2} = \frac{1}{8\pi} \cdot \frac{2\hbar c}{\Theta} \tag{40}$$

This equation reduces down to the familiar Cosmological Constant relation after subsituting in for $m_p = \frac{\hbar}{l_p c}$

$$\sqrt{\Lambda} = \frac{m_p}{M_H} = \frac{2l_p}{\Theta} \tag{41}$$

2.7 Freidman Equation Convergence

Here is a compilation of various Hubble constant values. A logarthimic fit was used. The average value will be $H_{0,\text{avg}} = 70.87$. The best fit of 70.95 was used for calculations.

	LY	H0	
Planck (CMB)	1.38E+10	67.8	
Hubble #1 (NGC4258) 2011	2.37E+08	72.25	(+/-) 2.51
Hubble #2 (LMC) 2011	163000	71.02	(+/-) 2.67
Hubble #3 (M31) 2011	2.50E+07	74.5	(+/-) 3.27
Spitzer (LMC)	163000	74.1	
Hubble 2019 (LMC)	1.63E+05	74.03	
Hubble & Gaia (MW)	100000	73.52	(+/-) 1.62
Cosmic Flow (normalized VIRGO)	5.40E+07	75	(+/-) 2
HE0435-1223 (z=1.689)	2.3E+10	71.9	
Holicow Quasar SDSS1206+4332 (B)	1.03E+10	68.8	(+/-) 5
Hubble 2018 (MW cepheids)	9.00E+03	73.25	(+/-) 2.3

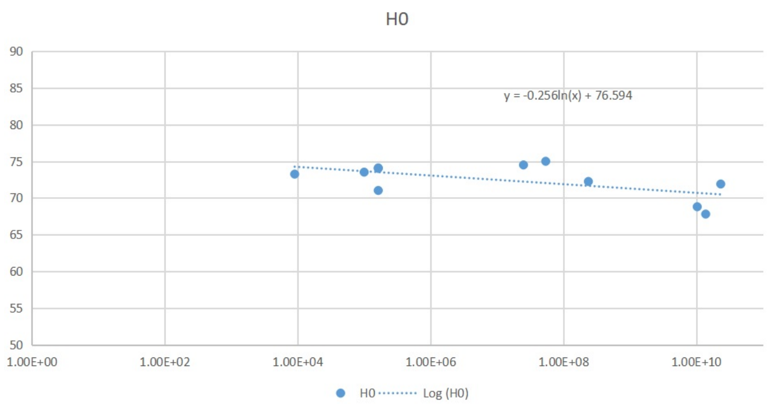

Figure 2: Logarithmic fit of Hubble Constant

$H_0 = 70.95 \quad [\text{km/(s mpc)}]$
$\rho_c = 9.4557 \cdot 10^{-27} \quad [\text{kg/m}^3]$
$\Theta = 8.8 \cdot 10^{26} \quad [\text{m}]$
$\Omega_{vac} = 0.7355$
$\Omega_M = 0.2634$
$\Omega_r = 0.000231$
$M_{tot} = \rho_c \Omega_M = 8.8870 \cdot 10^{53} \quad [\text{kg}]$

Below is the Freidman equation for a flat universe where $k = 0$ and ρ is the total density.

$$H^2 = \frac{8\pi G\rho}{3} + \frac{\Lambda_{DE} c^2}{3} \tag{42}$$

Next compute for conformal time. Notice the conformal time have a special form that might have some special geometrical significance.

$$\eta = \frac{1}{H_0}\int_0^\infty \frac{dz}{\Omega_\Lambda + \Omega_M(1+z)^3 + \Omega_r(1+z)^4} = 3.375 = \left(\frac{3}{2}\right)^3 \tag{43}$$

$$\eta_0 = \frac{\eta}{H_0} = 8.80 \cdot 10^{26} \quad [\mathrm{m}] \tag{44}$$

The value of Θ seems the most logical fits as previous data fits.

Additionally, using H_0 as indicated above correlates the age of the universe to 13.781 billion years within the accepted range.

$$t_0 = \frac{1}{H_0} = 13.781 \cdot 10^{10} \quad \text{light years} \tag{45}$$

The cosmic diameter looks to be $8.80 \cdot 10^{26}$ [m]. Some additional errors could come from the measurement of the critical energy density.

The computed Cosmological Constant value is. Additionally, a flat universe is used assumed to be consistent with recent findings.

$$\Lambda_{\mathrm{meas}} = \frac{3H_0^2 p_T^2}{8\pi}\Omega_{vac} = 1.3491 \cdot 10^{-123} \tag{46}$$

The cosmological constant using the mass from the Freidman Equations are the following.

$$\Lambda = \frac{m_p}{M_H} = 1.3495 \cdot 10^{-123} \quad [\mathrm{m}] \tag{47}$$

Interesting to note that the following holds true. It could be that the AdS and DS universes overlayed creates this relationship.

$$M_{tot} = 3/2 M_H \tag{48}$$

Finally is interesting to note that the relationship between the hubble radius and comoving radius is the following.

$$R_\Theta = (3/2)^3 R_H \tag{49}$$

3 Discussion

Below are the explicit values used to compute the cosmological constant. Following is a summary of the important equations that link mass from the neutrino scale to mass of the universe.

Table 1: Cosmological Constant & Neutrino, Planck and Universe Masses

Equation	**LHS Value**	**RHS Value**	**Error %**
$\frac{m_p^2}{(M_H)^2} = \frac{(2l_p)^2}{\Theta^2}$	$1.3475 \cdot 10^{-123}$	$1.3493 \cdot 10^{-123}$	0.131
$\frac{2m_{\nu,\text{sterile}}}{M_H} = \left(\frac{2l_p}{\Theta}\right)^{3/2}$	$7.0356 \cdot 10^{-93}$	$7.0400 \cdot 10^{-93}$	0.064
$\frac{2m_{\nu,\text{sterile}}}{m_p} = \sqrt{\frac{2l_p}{\Theta}}$	$1.9166 \cdot 10^{-31}$	$1.9166 \cdot 10^{-31}$	0.0016
$\hbar = \frac{2l_p^2 M_H c}{\Theta}$	$1.0546 \cdot 10^{-34}$[J s]	$1.0553 \cdot 10^{-34}$[J s]	0.066
$E_{H,M_H} = \frac{1}{8\pi} \cdot E_{\Theta/2}$	$2.8571 \cdot 10^{-34}$ [J]	$2.8589 \cdot 10^{-34}$ [J]	0.066
Λ_{meas}	$1.3477 \cdot 10^{-123}$	—	—

The models discussed include the consideration that the longest wave, which can span the observable universe, is disallowed for natural oscillations by the observer particle in the center. From conservation of energy, momentum appears to be established with a random propagation direction of the observer particle towards the cosmic horizon. Considering two particles sit next each other with both having the same conditions on their own, this would lead to a distance separation. This effect could be understood as being correlated to the cosmological constant. The cosmological constant is of low numerical value and additionally the associated fundamental wave from the universe span is also of lowest energy level with regards to an allowed discrete energy and momentum spectrum in the zero point field (ZPF). Considering the vacuum is filled with vacuum fluctuations, this could be described by the method of virtual particles as a cancellation of allowed energy that might shift to provide momentum. The observer particle is inherently pushed around by the cancellation of the longest wavelength allowed in the span of observation. According to the theory of quantized inertia this leads to the minimum discrete acceleration. The natural maximum allowed saturated energy states (discrete modes) inside the observable universe are reduced by the observer particle. Hence a situation is established where, between two particles, the space increases (see the Hubble effect). A minimum acceleration adds to the effect to the Hubble parameter and as result, a minimized cosmological constant is established. The results of this paper may support the view that in a balance perspective the lowest possible energy in the observable cosmos (similar to the minimum quantized acceleration) contributes a mass equivalent at the information horizon and is therefore adds a small element to the effect which is perceived as dark energy.

4 Appendix

Consider the energy outside of electron an electron.

$$E_{\mathrm{out},e} = \frac{\ln\left(\frac{R_H}{r_e}\right)}{\ln\left(\frac{R_H}{2l_p}\right)} = \frac{2}{3} \tag{50}$$

Consider the energy outside of proton.

$$E_{\mathrm{out},p} = \frac{\ln\left(\frac{R_H}{r_p}\right)}{\ln\left(\frac{R_H}{2l_p}\right)} \approx \frac{2}{3} \tag{51}$$

It seems there is a special relationship in quantum mechanics with the number 2/3 as also discovered by Koide [2]. It is seen in the conformal time factor.

References

[1] A. S. Bhatt and F. M. Becker. Neutrino mass replaces planck mass as fundamental particle. *vixra.org*, page 7, 2019.

[2] Y. Koide. New view of quark and lepton mass hierarchy. *Phys. Rev. D*, 28:252–254, Jul 1983.

[3] M. E. McCulloch and J. Giné. Modified inertial mass from information loss. *Modern Physics Letters A*, 32(28):1750148, 2017.

[4] M. Sheppeard. The algebra of non local neutrino gravity. 01 2018.

[5] M. D. Sheppeard. Constraining the standard model in motivic quantum gravity. *Journal of Physics: Conference Series*, 1194:012097, apr 2019.