The Observed Magnitude of Cosmological Constant directly derived from the Quantization Theory of Gravity

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Starting from the theoretical background developed for obtaining the Quantization of Gravity, in the paper *Mathematical Foundations of the Relativistic Theory of Quantum Gravity*, I show here that, it is possible to derive a *theoretical* value of the Cosmological Constant, extremely close to the *observed* value.

Key words: Cosmological constant, Cosmological constant problem, Quantization of Gravity, Quantization of Mass, Cosmology.

INTRODUCTION

The foremost challenge of Quantum Gravity Theory is to find the *theoretical* background, which would allow determining the observed *positive* value of Cosmological Constant Λ *,

$$\left(\Lambda l_{planck}^2\right)_{observed} = 1.38\times10^{-123} \qquad (1)$$

related to the accelerating expansion of our Universe [1, 2]. The finding that the Universe is in accelerating expansion was first announced in 1998, and it results from astronomical observations of type IA supernovae carried out by Supernovae Cosmology Project and High-z Supernova Search Teams. The unexpected large discrepancy between theoretical results and observed result for Λ still exists [3, 4, 5, 6].

In this article I show that, starting from the theoretical background developed for the Quantization of Gravity, in the paper *Mathematical Foundations of the Relativistic Theory of Quantum Gravity* [7] it is possible to derive a theoretical value of the Cosmological Constant, extremely close to the observed value (Eq. 1).

* The Cosmological Constant is defined as $\Lambda = 8\pi(G/c^2)\rho_{vac} = \kappa\rho_{vac}$, where κ is *Einstein's constant*. The true dimension of Λ is a length^{-2}. Thus, Λl_{planck}^2 is a dimensionless number.

THEORY

The *Quantization of Gravity* [7] shown in the *Mathematical Foundations of the Relativistic Theory of Quantum Gravity* (See **page 6**) predicts the existence of an elementary *quantum* of matter (smallest indivisible particle of matter) with *inertial* mass, $m_{i0(\min)}$, given by

$$m_{i0(\min)} = \pm h\sqrt{3/8}\big/cd_{\max} = \pm3.9\times10^{-73}\,kg \qquad (2)$$

where $d_{\max} = 3.4\times10^{30}\,m$ is defined as the *maximum* "diameter" that the Universe can reach [7] (See **page 34**).

It also predicts that the *space* in the Universe is *totally* filled with particle of this type, forming a *Continuous Universal Quantum Fluid* (CUF), containing n_U particles, with density ρ_{CUF}, respectively given by (See [7] **page 34**)

$$n_U = \frac{M_U}{m_{i0\min}} \qquad (3)$$

and

$$\rho_{CUF} = \frac{n_U m_{i0(\min)}}{V_U} \qquad (4)$$

where M_U is the total mass of particles (elementary *quantum* of matter) in the Universe, and V_U is the volume of the Universe.

Since the *space*, in the Universe, is *expanding*, then the space traversed by a photon expands behind it during the voyage since the Big-Bang. Thus, considering this fact, it is possible to show that the current distance to the most distant object we can see is evaluated in 46 billion light-years $(4.4\times10^{26}m)$ [8], and not $R_H \cong c/H$, which is the radius of the *not expanding* Universe, where the density of matter is approximately equal to the *critical density*, $\rho_{crit} = 3H^2/8\pi G$ (recent measurements point to $H = 2.1\times10^{-18}s^{-1}$ $(67.36 km.s^{-1}/MPc)$[9]). Thus, $V_U = \frac{4}{3}\pi R_U^3$ is the volume of the expanding Universe ($R_U = 4.4\times10^{26}m$), while $V_H = \frac{4}{3}\pi R_H^3$ is the volume of the not expanding Universe. Consequently, we can write that

$$\rho_U = \frac{M_U}{V_U} \qquad (5)$$

and

$$\rho_{crit} = \frac{M_U}{V_H} = \frac{3H^2}{8\pi G} \qquad (6)$$

From Eq. (5) and (6), we get

$$\rho_U = \frac{M_U}{V_U} = \frac{3H^2}{8\pi G}\left(\frac{R_H}{R_U}\right)^3 \qquad (7)$$

Now, starting from Eq. (3) and (2), we can write that

$$n_U = \frac{M_U}{m_{i0\min}} = \frac{M_U}{2\pi\hbar\sqrt{3/8}/cd_{\max}} \qquad (8)$$

By substitution of n_U given by Eq.(4) into Eq. (8), we obtain

$$\frac{\rho_{CUF}V_U}{m_{i0(\min)}} = \frac{M_U}{2\pi\hbar\sqrt{3/8}/cd_{\max}} \qquad (9)$$

whence

$$\rho_{CUF} = \frac{(M_U/V_U)m_{i0(\min)}}{2\pi\hbar\sqrt{3/8}/cd_{\max}} \qquad (10)$$

Substituting the values in Eq. (10), we obtain the density of *Cosmological Quantum Vacuum,* i.e.,

$$\rho_{CUF} = 0.058\rho_{crit} = 4.6\times10^{-28}\,kg.m^{-3}$$

Cosmological observations point to $\sim 2.2\times10^{-28}kg.m^{-3}$ $(\sim 2\times10^{-10}erg.cm^{-3} \sim 2\times10^{-11}J.m^{-3})$ [10].

Multiplying both sides of the Eq. (10) by Einstein's constant $(8\pi G/c^2)$, the result is

$$\left(\frac{8\pi G\rho_{CUF}}{c^2}\right) = \frac{4Gd_{\max}m_{i0(\min)}}{c\hbar\sqrt{3/8}}(M_U/V_U) \qquad (11)$$

whence, we obtain

$$\underbrace{\left(\frac{8\pi G\rho_{CUF}}{c^2}\right)}_{\Lambda}\underbrace{\left(\frac{G\hbar}{c^3}\right)}_{l_{planck}^2} = \frac{4G^2d_{\max}m_{i0(\min)}}{c^4\sqrt{3/8}}\left(\frac{M_U}{V_U}\right) \qquad (12)$$

Therefore, Eq. (12) can be rewritten in the following form

$$\Lambda l_{planck}^2 = \frac{4G^2d_{\max}m_{i0(\min)}}{c^4\sqrt{3/8}}\left(\frac{M_U}{V_U}\right) \qquad (13)$$

Substitution of M_U/V_U given by Eq. (7) into Eq. (13), yields

$$\Lambda l_{planck}^2 = \frac{4G^2d_{\max}m_{i0(\min)}}{c^4\sqrt{3/8}}\frac{3H^2}{8\pi G}\left(\frac{R_H}{R_U}\right)^3 = \frac{4G^2d_{\max}m_{i0(\min)}}{c^4\sqrt{3/8}}\frac{3H^2}{8\pi G}\left(\frac{c}{R_U H}\right)^3 = \frac{Gd_{\max}m_{i0(\min)}}{c\sqrt{3/8}}\frac{3}{2\pi R_U^3 H} \qquad (14)$$

Substituting the values in Eq. (14), we obtain

$$\Lambda l_{planck}^2 = 1.3\times10^{-123} \qquad (15)$$

Comparing this result with the observed value, given by Eq.(1)

$$\left(\Lambda l_{planck}^2\right)_{observed} = 1.38\times10^{-123}$$

we can conclude that *theoretical* value of the Cosmological Constant here obtained is extremely close to the *observed* value.

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