Holographic Origin of High Cosmological Constant Related to Large Mass Defect in Semiclosed Friedman Universe

By Noboru Hokkyo
Senjikan Institute, Japan

Abstract- An extremely high value of Einstein's cosmological constant $\Lambda \sim 10^{122}$ in quantum cosmology compared to astronomical observations, $0 \leq \Lambda \leq 1$, is related to the extremely large general relativistic mass defect of massive semiclosed universe.

Keywords: cosmology; general relativity, quantum theory; holography; black hole; semiclosed universe.

GJSFR-A Classification : FOR Code: 020199p
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I. INTRODUCTION

Inflationary cosmology succeeded in explaining the origin of the large-scale structure of observed universe evolving from a singular Big Bang or large quantum fluctuations of pre-existing spacetime metric in causally related small region, answering why the present universe appears flat, homogeneous and isotropic. Yet, apart from problems of the fine tuning of initial universe appeares flat, homogeneous and isotropic. Yet, causally related small region, answering why the present universe appears flat, homogeneous and isotropic. Yet, causally related small region, answering why the present universe appears flat, homogeneous and isotropic.

In the Friedman-Lemaître cosmology the expansion history is determined by a set of dimensionless parameters at present epoch whose sum is normalized to unity. As the observed energy density in the cosmic background radiation shows a minor contribution $\Omega_{\gamma} \sim 1.10^4$ to $H_0^2$ the following numerical relations between dimensionless density parameters $\Omega_{\Lambda,m}$ and the critical densities $\rho_{c,\Lambda,m}$ are considered significant:

$$\Omega_{\Lambda} = 8\pi\rho_{c}\Lambda/3H_0^2 = \rho_{c}/\rho_{\Lambda} = 0.72,$$  \hspace{1cm} (2)

$$\Omega_{m} = 8\pi\rho_{c}\Lambda/3H_0^2 = \rho_{c}/\rho_{m} = 0.28.$$  \hspace{1cm} (3)

Only from dimensional cosideration, we put $\Lambda = c^2/\hbar G = c^2/l_p^2 \sim 10^{88}$ sec$^{-2}$, where $l_p = c^2/\hbar G = 10^{-33}$ cm is the Planck length, $m_p = h/c\gamma \sim 10^{-4}$ g the planck mass. Using the Planck constant $\hbar = 1.026 \times 10^{-27}$ erg $\cdot$ sec and the cosmological unit $h$ defined in $H_0 = 100$ hkm/sec Mpc, we get $\Lambda \sim 10^{122}$ h$^{-2}$.

III. HOLOGRAPHIC COSMOLOGICAL CONSTANT

Holographic principle in string theory states that the description of events in a volume of spacetime can be encoded on the boundary to the region like a gravitational horizon. The principle suggests that the entire universe can be seen as a two-dimensional information structure on the cosmological horizon with possible quantum fluctuations. From the observed cosmic background microwave temperature $T = 3$ K the entropy density $s$ of the universe at $t = t_0 \sim 14$Gyr is normalized to uinity. As the observed energy density to support inflation. We here show that about 120 order of magnitude supression of calculated quantum vacuum density to observed values can be understood as a general relativistic mass defect of an expanding and supermassive semiclosed universe.

II. DIMENSIONAL COSMOLOGICAL CONSTANT

Hubble parameter $H$ was originally used to represent Hubble law, $v = H_d$, relating the relative velocity $v$ of the extragalactic objects at a distance $d$ receding away from the Earth. In the Friedman universe $H$ is defined as $H(t) = (da(t)/dt)/a(t)$, where $a(t)$ is a scale factor normalized to $a = 1$ at the present epoch $t = t_0 \sim 14$Gyr, and obeys the equation:

$$H(t)^2 = 8\pi G/3[\rho_{m0}/a(t)^4 + \rho_{\Lambda0}/a(t)^4 + \rho_{c0}/a(t)^4 + \rho_s/a(t)^2(1 + \Omega_{\Lambda} + \Omega_{m})].$$  \hspace{1cm} (1)

Here $\rho_{m0}$ is the nonrelativistic matter (dark and luminous) density, $\rho_c$ the relativistic radiation density, and $\rho_{\Lambda0}$ the dark energy density at $t = t_0$ where $\omega = \rho_{\Lambda0}/\rho_c c^2 < - 1$ is the equation of state relating $\rho_\Lambda$ and pressure $P_\Lambda$ in inflationary cosmology. The most direct evidence of dark energy comes from observations of supernovae with uniform energy density.

Author: Senjikan Institute, Niigata, Japan.

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IV. Semiclosed Universe and Mass Defect

The possibility of joining-on of the dust-filled semi-closed Friedman universe to an asymptotically flat space through Schwarzschild throat was first pointed out by Tolman\(^4\) and used by Oppenheimer and Snyder\(^5\) in their study of the dust motion in massive stellar objects, followed by Milne,\(^6\) Zel’dovich\(^7\) and Novikov\(^8\) independently in the form extendible to the electrically charged universe joined onto asymptotically flat outer space through double-valued Reissner-Nordström (RN) bottle-neck prevented from gravitational pinch-off by the gauge field lines of force extending to infinity or to an oppositely charged anti-universe.\(^9\)

We here consider the embedding of the Planck length in the line element \(ds\) of de-Sitter universe:

\[
ds^2 = g_{tt}c^2dt^2 - g_{rr}dr^2,
\]

\[
g_{tt} = g_{rr}^{-1} = \left(1 - \Lambda c^2 r^2 + l_p^2/r^2\right).
\]

We find that the light velocity \(dr/dt = c\sqrt{g_{tt}/g_{rr}} = c\) determined from \(ds^2 = 0\) is superluminal at \(r = l_p \sim 10^{-33}\) cm and decreases with the increase of \(r\) until \(dr/dt = c\) is reached at \(r = (l_p/c)^2 \sim 10^{-32}\)\(\Lambda^{-1/2}\) cm. From there the light velocity decreases to \(dr/dt = c = 0\) at \(r = (c\Lambda^{1/2})^{-1} \sim 10^{-11}\Lambda^{-1/2}\) cm. In the inflationary universe the radius of the causally related small region expands from \(r = l_p \sim 10^{-33}\) cm to \(r = l_{inf} \sim 10^{-35}\) cm followed by a brief interlude of heating.

The semiclosed Friedman universe is a spherical but unisotropic universe joined onto an asymptotically flat space, and expands with increasing proper time \(\tau = \int g_{tt}^{-1}d\tau\) and radius \(R = \int g_{rr}^{-1}dr\) until the maximum radius \(R_{max}\) is reached with the proper volume \(V_p = 2\pi r_l g_{rr}dr\) and mass \(M_p = \rho V_p\) filling the lower hemisphere of the closed universe with \(\Omega_\Lambda = 0.5\). With further increase of \(r\) from \(r = R_{max}\), \(R_p\) begins to decrease towards \(R_p \sim l_p\), forming a Planck scale gravitational semiclosure with \(\Omega_\Lambda = 1\). In quantum cosmology it is likely that the gravitational semiclosure develop black holes at \(r = R_p = 0\) evaporating a dark energy\(^1\) until the semiclosed universe reaches \(\Omega_\Lambda = 0.5\), liberating the half of the total mass energy \(M_p c^2\) with holographic information content \((R_{max}/l_p)^2\).

V. Conclusion

We have seen that the extremely high value of the cosmological constant \(\Lambda \sim 10^{122}\) in quantum cosmology compared to astronomical observations, \(0 \leq \Lambda \leq 1\), can be related to the extremely large general relativistic mass defect of the semiclosed universe with \(0.5 \leq \Omega_\Lambda \leq 1\).