Is Initial Data for Cosmological Arrow of Time emerging due to Inflation start?

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Abstract

We ask if setting the vanishing chemical potential limit $\mu \to 0$ with entropy $S \propto T^3$ [1] for a number of degrees of freedom significantly greater than the standard electroweak value of $g_\star \sim 100 - 120$, do we have a new foundation for the arrow of time in quantum cosmology with inflation?

1 Introduction

Recently, the author [1] has been considered the problem if the entropy $S = \dfrac{E - \mu N}{T} \to S \propto T^3$ by setting the limit of vanishing chemical potential $\mu \to 0$ with the initial entropy value $S \sim 10^5$ at the beginning of inflation. Specifically resetting the degrees of freedom of about $g_\star \sim 100 - 120$ of the electroweak era value, to $g_\star \sim 1000$ at the onset of inflation, may permit $S_{initial} \propto T^3$. If the initial temperature of an emerging universe were very low, scaling may be a way to generate the arrow of time, with respect to thermal temperatures, alone, with the graviton count a later, emergent particle production phenomenon. Actually this problem is mostly related to the recent results of L. Glinka [8, 9].

1.1 Estimating the size of contribution to energy in $S = E/T$, assuming a frequency $\nu \sim 10^{10}$ Hz for relic gravitons, if the standard chemical potential is effectively $\mu = 0$ at the onset of creation

As suggested earlier by Beckwith [2], gravitons may have contributed to the re-acceleration of the universe one billion years ago. Here, we are making use of refining the following estimates. In what follows, we will have even stricter bounds upon the energy value (as well as the mass) of the graviton based upon the geometry of the quantum bounce, with a radii of the quantum bounce on the order of the Planck length, i.e. $\ell_{Planck} \sim 10^{-35}$ meters [1, 3].

$$m_{graviton}|_{RELATIVISTIC} < 4.4 \times 10^{-22} h^{-1} eV/c^2$$
$$\Leftrightarrow \lambda_{graviton} \equiv \frac{\hbar}{m_{graviton} c} < 2.8 \times 10^{-8} meters \tag{1}$$

For looking at the onset of creation, with a bounce; if we look at the density $\rho_{max} \propto 2.07 \cdot \rho_{Planck}$ for the quantum bounce with a value put in for when $\rho_{Planck} \approx 5.1 \times 10^{99}$ grams/meter^3, where [1]

$$E_{eff} \propto 2.07 \cdot \ell^3_{Planck} \cdot \rho_{Planck} \approx 5 \times 10^{24} GeV \tag{2}$$

Then, taking note of this, one is obtaining having a scaled entropy value of $S = E/T \sim 10^5$ when one has an initial temperature value as Planck temperature $T \approx T_{Planck} \sim 10^{19}$ GeV. One needs, then to consider, if the energy per given graviton is, if a graviton frequency $\nu \propto 10^{10}$ Hz and effective energy $E_{graviton-effective} \propto 2 \cdot h\nu \approx 5 \times 10^{-5}$ eV, then [1]

$$S = E_{eff}/T \sim \frac{10^{38} \times E_{graviton-effective}(\nu \approx 10^{10} Hz)}{T \sim 10^{19} GeV} \approx 10^5. \tag{3}$$

Having said that, the $E_{graviton-effective}$ value is 10^{22} greater than the rest mass energy of a graviton if $E \sim m_{graviton}[red - shift \sim .55] \sim 10^{-27}$ grams is taken when applied to Eq. (2) above.

1.2 The electroweak generation regime of space time for entropy and early universe graviton production before electroweak transitions

A typical value and relationship between an inflaton potential $V[\phi]$, and a Hubble parameter value, H is [1]

$$H^2 \sim \frac{V[\phi]}{m^2_{Planck}}. \tag{4}$$

Also, if we look at the temperature $T^\star$ occurring about the time of the Electroweak transition, if $T \leq T^\star$ when $T^\star = T_c$ was a critical value, (of which we can write $\frac{v(T_c)}{T_c} > 1$, where $v(T_c)$ denotes the Higgs vacuum expectation value at the critical temperature T_c., i.e. $\frac{v(T_c)}{T_c} > 1$ according to C. Balazs et al (2005) [4] and denotes that the electroweak transition was a *strongly first order phase transition*) then one can write, by conventional theory that

$$H \sim 1.66 \cdot [\sqrt{\widetilde{g}_\phi}] \cdot \left[\frac{T^2}{m^2_{Planck}}\right]. \tag{5}$$

Here, the factor put in, of is the number of degrees of freedom. Kolb and Turner [5] put a ceiling of about $\widetilde{g}_\phi \approx 100 - 120$ in the early universe as of about the electro weak transition. If, however, $\widetilde{g}_\phi \sim 1000$ or higher for earlier than that, i.e up to the onset of inflation for temperatures up to $T \approx T_{Planck} \sim 10^{19}$ GeV, it may be a way to write, if we also state that $V[\phi] \approx E_{net}$ that if

$$S \sim 3\frac{m^2_{Planck}}{T}\left[H = 1.66 \cdot \sqrt{\widetilde{g}_\phi} \cdot \frac{T^2}{m_{Planck}}\right]^2 \sim 3 \cdot [1.66 \cdot \sqrt{\widetilde{g}_\phi}]^2 T^3. \tag{6}$$

Should the degrees of freedom hold, for temperatures much greater than $T^\star$, and with $\widetilde{g}_\phi \approx 1000$ at the onset of inflation, for temperatures, rising up to, say $T \sim 10^{19}$ GeV, from initially a very low level, pre inflation, then this may be enough to explain how and why certain particle may arise in a nucleated state, without necessarily being transferred from a prior to a present universe.

Furthermore, if one assumes that $S \propto T^3$ [5] when $\widetilde{g}_\phi \approx 1000$ or even higher even if $T \sim 10^{19} GeV \gg T^\star$, then there is the possibility that when could also hold, if there was in pre inflationary states very LOW initial temperatures, which rapidly built up in an interval of time, as could be given by $0 < t < t_{Planck} \sim 10^{-44}$ seconds [1]

2 Conclusion: the Glinka approach

A way to obtain traces of information exchange , from prior to present universe cycles is finding a linkage between information and entropy. If such a parameterization can be found and analyzed, then S. Lloyd's [6] shorthand for entropy,

$$I = \frac{S_{total}}{k_B \ln 2} = [\sharp operations]^{3/4} = [\rho \cdot c^5 \cdot t^4/\hbar]^{3/4}, \tag{7}$$

could be utilized as a way to represent information which can be transferred from a prior to the present universe. The question to ask, if does Eq. (7) permit a linkage of gravitons as information carriers, and can there be a linkage of information, in terms of the appearance of gravitons in the time interval of, say $0 < t < t_{Planck}$ either by vacuum nucleation of gravitons / information packets. Appropriate values / inputs into ρ are being considered along the lines of graviton mass/ contributions along the lines brought up in this paper already.

An alternative to Eq. (7) if one sees no way of implementing what Ng suggested via his infinite quantum statistics [7] would be to look at thermal inputs from a prior to the present universe, as suggested by L. Glinka [8, 9]

$$n_f = [1/4] \cdot \left[\sqrt{\frac{\nu(a_{initial})}{\nu(a)}} - \sqrt{\frac{\nu(a)}{\nu(a_{final})}} \right] \tag{8}$$

As well as, if $h_0 \sim .75$

$$\Omega_{gw}(\nu) \simeq \frac{3.6}{h_0^2} \left[\frac{n_f}{10^{37}} \right] \left(\frac{\nu(a)}{1kHz} \right)^4 . \tag{9}$$

If we take into consideration having $a \sim a_{final}$, then Eq. (8) above will, in most cases be approximately

$$n_f = [1/4] \cdot \left[\sqrt{\frac{\nu(a_{initial})}{\nu(a)}} - 1 \right] \sim [1/4] \cdot \left[\sqrt{\frac{\nu(a_{initial})}{\nu(a)}} \right] . \tag{10}$$

For looking at $\Omega_g \approx 10^{-5} - 10^{-14}$, with $\Omega_g \approx 10^{-5}$ in pre big bang scenarios, with initial values of frequency set for $\nu(a_{initial}) \approx 10^8 - 10^{10}$ Hz, as specified by L. Grishchuk [10] $\nu(a_{final}) \approx 10^0 - 10^2$ Hz near the present era, and $a \sim [a_{final} \equiv 1] - \delta^+$, i.e. close to the final value of today's scale value, Filling in/ choosing between either implementation of Eq. (7), or Eq. (10) will be what the author is attempting to do in the foreseeable future. I.e. if one can use [7]

$$S \approx n \tag{11}$$

Using Eq. (10) directly, or if $S \neq n$, using Eq. (10) , but instead uses $S \propto T^3$, with temperature rapidly increasing from a low value to $T_{Planck} \approx 10^{19}$ GeV in about a time interval during the onset of inflation, for the beginning of the arrow of time, in Cosmology. Beckwith views determining if the degrees of freedom initially could go as high as $\widetilde{g}_\star \approx 1000$ or even higher even if $T \sim 10^{19}$ GeV as essential in determining the role of $S \propto T^3$ as temperatures go from an initial low point, to $T \sim 10^{19}$ GeV for understanding the role of thermal heat transfer in the arrow of time issue.

Note finally, very importantly, that the concluded way probably require that there be no initially low temperature behavior, pre inflation, prior to the rise of temperature the that of the quantum Planck temperature of $\sim 10^{19}$ GeV.

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