

How a setting of the Vacuum energy density, to today's value in the early universe, leads to an initial Hubble radius for the early universe. i.e. how the early universe partly mimics a black hole.

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Abstract

First we review what was done by Klauber, in his quantum field theory calculation of the Vacuum energy density, and in doing so, use, instead of Planck Mass, which has 10^{19} GeV, which leads to an answer 10^{122} times too large, a cut off value of instead, a number, N , of gravitons, times graviton mass (assumed to be about 10^{-43} GeV) to get a number, N , count of about 10^{31} if the vacuum energy is to avoid an overshoot of 10^{122} , and instead have a vacuum energy 10^{-47}GeV^4 . Afterwards, we use the results of Mueller and Lousto, to compare the number N , of 10^{31} , assumed to be entropy using Ng' infinite quantum statistics, to the ratio of the square of (the Hubble (observational) radius over a calculated grid size which we call a). Here, $a \sim$ a minimum time step we call Δt , times the speed of light. Now in doing so we use a root finder procedure to obtain Δt where we use an inflaton value due to use of a scale factor $a \sim a_{\min} t^\gamma$ if we furthermore use $\delta g_{tt} \sim a_{\min}^2 \cdot \phi_{\text{initial}}$ as the variation of the time component of the metric tensor g_{tt} in Pre-Planckian Space-time up to the Planckian space-time initial values.

Key words Inflaton physics, causal structure, non Linear Electrodynamics.

I. Framing the initial inquiry

We will reference what was doing by Klauber[1] as far as a vacuum energy density, in his textbook, while replacing the cut off value he used, that of the Planck Mass, he assumed, with that of the entropy of initial concentration of gravitons, with the presumed mass of a graviton, 10^{-43} GeV, in order to come up with a count value of 10^{31} for gravitons. Furthermore if we then next go to Muller and Lousto's entangled entropy [2], we get the .31 times the square of (Event horizon radius/ grid size) whereas what we will do is to equate the number, N, of about 10^{31} with the Muller and Lousto's entropy result, in order to calculate the initial event horizon radius, which we find has a value of about 10^{-20} meters. Small enough, according to the comparative calculations, and this depends upon the presumed grid size having a value of a $\sim c$ times Δt . Here we will reference [3] for how Δt is calculated, whereas we will also state that the value of Δt is less than or equal to Planck time, [4], which is of the order of 5.39 times 10^{44} seconds.

The summary result is that we get a set of conditions for a cosmological version of the event horizon, which is equivalent to stating that the early universe, has some qualitative similarities to a black hole, initially.

In doing this, we are assuming that the entropy as calculated by [2] is in correspondence to the Ng count of entropy given in [5] which has $S(\text{initial}) \sim N$, so in this case we have the number of gravitons, as so calculated being the same as

Finally, after establishing that, we reference a modified version of Hawking's power spectrum for black holes given in Calmert, Car and Winstanley, [6] which is the mechanism of how there is initially a start of leakage through what we claim is a causal barrier, which is a way of having information preservation of Planck's constant, from a prior universe, to today's universe. This means crossing the causal barrier given in [3] so as to preserve information so as to have the same physical law, from cycle to cycle.

In applying [6] we should be alert as to that the expression for dE/dt as given, will be having a black body behavior for what is called the absorption cross section, so this absorption cross section is equal to the area of the initial sphere of space-time. In this case we will be looking at the surface area of a bubble of space-time. So this will be markedly different than the black hole case. Otherwise though, much of the construction will be similar.

So, then we will start our inquiry, and to do so, we have the formation of Δt so as to create the grid value, a, which is in the Muller and Lousto definition of entropy. But notice that we will start the idea of entropy, via an arrow of time argument, [7], i.e. that [2], [5], and [7] will be starting points with equivalent definitions of entropy.

II. Examination of the minimum time step, in Pre-Planckian Space-time as a Root of a Polynomial Equation.

We initiate our work, citing [3] to the effect that we have a polynomial equation for the formation of a root finding procedure for Δt , we can, as we did in [3] do the following. Here this straight from [3]. Copied verbatim, and it will be linked to the Muller and Lousto result [2], in the next section afterwards, and then we will right afterwards use [1] for calculating the vacuum energy, with the results of [2] and [3] used so as to explain the significance of what we come up with in our redo of the calculation in [1] with the difference that instead of using the Planck mass in the Vacuum energy calculation, we use N times the mass of a graviton. In doing so we obtain $N \sim 10^{31}$, and if this is a measure of entropy, as by [5] we will then have a way to link the N of our redo [1] calculation with

the Muller and Lousto entangled entropy of [2]. Note that we are below coming up with a precursor of grid size, as in the Muller and Lousto result, [2] which is then compared to how we look at our redo of Eq. (1). I.e. through the device of determining a specific grid size, a.

So let us now begin to look at the step size for time step, as to get the grid size for [2] first.

$$\Delta t \cdot \left(\sqrt{\frac{8\pi G V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right) - \frac{\left(\sqrt{\frac{8\pi G V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right)^2}{2} + \frac{\left(\sqrt{\frac{8\pi G V_0}{\gamma \cdot (3\gamma - 1)}} \cdot \Delta t - 1 \right)^3}{3} - \dots \quad (1)$$

$$\approx \left(\sqrt{\frac{\gamma}{\pi G}} \right)^{-1} \frac{48\pi \hbar}{a_{\min}^2 \cdot \Lambda}$$

From here, we then cited, in [5], using [2] a criteria as to formation of entropy, i.e. If Λ is an invariant cosmological ‘constant’ and if Eq. (1) holds, we can use the existence of nonzero initial entropy as the formation point of an arrow of time [7]

$$S_\Lambda|_{\text{Arrow-of-time}} = \pi \cdot \left(\frac{R_c|_{\text{initial}} \sim c \cdot \Delta t}{l_{\text{Planck}}} \right)^2 \neq 0 \quad (2)$$

This leads to the following, namely in [5] we make our treatment of the existence of causal structure, as given by writing its emergence as contingent upon having

$$\left(\frac{R_c|_{\text{initial}} \sim c \cdot \Delta t}{l_{\text{Planck}}} \right) \sim \mathcal{G}(1) \quad (3)$$

The rest of this article will be contingent upon making the following assumptions. FTR

In short, our view, is that the formation of a minimum time step, if it satisfies Eq. (1) is a necessary and sufficient condition for the formation of an arrow of time, at the start of cosmological evolution we have a necessary and sufficient condition for the initiation of an arrow of time. With causal structure, along the lines of Dowker, as in [8] and given more detail by Eq. (3) above as inputs into Eq. (1) and Eq. (2) i.e. Planck length is set equal to 1 and by [3]

$$\frac{\Delta E \Delta t}{\text{Volume}} \sim \left[\hbar / \text{Volume} \cdot (\delta g_{tt} \sim a_{\min}^2 \cdot \phi_{\text{initial}}) \right] \Big|_{\text{Pre-Planckian}} \quad (4)$$

$$\xrightarrow{(\text{Pre-Planckian}) \rightarrow (\text{Planckian})} \Delta E \Delta t \sim \hbar \Big|_{\text{Planckian}}$$

I.e. the regime of where we have the initiation of causal structure, if allowed would be contingent upon the behavior of [2]

$$g_{tt} \sim \delta g_{tt} \approx a_{\min}^2 \phi_{\text{initial}} \ll 1 \quad (5)$$

$$\xrightarrow{\text{Pre-Planck} \rightarrow \text{Planck}} \delta g_{tt} \approx a_{\min}^2 \phi_{\text{Planck}} \sim 1$$

$$\Leftrightarrow \left(\frac{R_c|_{\text{initial}} \sim c \cdot \Delta t}{l_{\text{Planck}}} \right) \sim \mathcal{G}(1) \Big|_{\text{Planck}}$$

These conditions are enough to have our creating of Δt , which is part of how we will come up, with the grid, for the Muller and Lousto calculation of entanglement entropy [2] i.e. we set the grid size, here, to

$$a \sim c \cdot \Delta t \quad (6)$$

The equivalence of Eq.(5) and Eq. (6) should be obvious, and we will be using Eq. (6) to use [2]'s result next.

III. Examining of the Muller and Lousto Entanglement entropy result, for early universe cosmology.

In short, after a very long set of calculations, their model of entropy comes up with [2], with r_H a cosmological event horizon

$$\begin{aligned} S(Lousto) &\sim .31 \cdot (r_H/a)^2 \\ &\sim .31 \cdot (r_H/c \cdot \Delta t)^2 \\ &\sim .31 \cdot (r_H/l_p)^2 \end{aligned} \quad (7)$$

We argue that this entropy, is equivalent to the count, N, of gravitons, in accordance to Ng's infinite quantum statistics, which will then lead to us adapting the next sections results, as to obtain the number of gravitons, initially.

IV. Calculating the number of gravitons, N, due to a re set of the Vacuum energy calculation given by Klaubert

In [1] Klaubert re does the Vacuum energy calculation, using Planck Mass, in order to obtain the following:

$$\begin{aligned} &\rho(\text{vacuum} - \text{energy} - \text{density}) \\ &= \frac{1}{2\pi} \int_0^\Delta k^3 dk = \frac{\Delta^4}{8\pi} \\ &\xrightarrow{\Delta = \text{planck-mass}} 2.80 \times 10^{74} \text{ GeV}^4 \end{aligned} \quad (8)$$

Our supposition is to make the following change in the above calculation, namely

$$\begin{aligned} &\Delta \xrightarrow{\text{early-universe}} N \cdot m_g \\ &\Rightarrow \rho(\text{vacuum} - \text{energy} - \text{density}) \\ &= \frac{1}{2\pi} \int_0^\Delta k^3 dk = \frac{(N \cdot m_g)^4}{8\pi} \\ &\xrightarrow{\Delta = \text{planck-mass}} 10^{-47} \text{ GeV}^4 \\ &\Leftrightarrow N = 10^{31} \\ &\& m_g = 10^{-43} \text{ GeV} \end{aligned} \quad (9)$$

If, the above N, in Eq. (9) is the same as entropy, then we can state the following, namely

$$\begin{aligned} N &= 10^{31} \sim .31 \cdot (r_H/l_p)^2 \\ \Rightarrow r_H &\sim 10^{15} \times l_p \sim 10^{-20} \text{ meters} \end{aligned} \quad (10)$$

V. Consequences of Eq. (10)

Here for the satisfying of Eq. (10) is contingent upon $R_c|_{initial} \sim c \cdot \Delta t$ as of being about Planck Length. Then, we have to deal with inflation. If there are roughly 65 e folds, according to Freeze [9] we have then

$$R_{initial} \cdot 10^{27} = R_{final} \quad (11)$$

If so, using by [10] the frequency of a wavelength, smaller than $r_H \sim 10^{15} \times l_p \sim 10^{-20} meters$ will then be on the order of 10^{20} Hertz, or about 10^{11} GHz, which is then divided by 10^{27} , which would then indicate a Frequency of about 10^{-7} Hertz today, which sounds horrendous. But is it clear that the frequency, initially would be of the order of 10^{20} Hertz, initially?

Conceivably, depending upon the production scheme, our estimate of $r_H \sim 10^{15} \times l_p \sim 10^{-20} meters$ depends upon a very specific treatment of an obtained $R_c|_{initial} \sim c \cdot \Delta t$ being of the same value as Planck length, and also of $r_H \sim 10^{15} \times l_p \sim 10^{-20} meters$ being of the order of 10^{-20} . Also, it depends upon the magnitude of the presumed inflationary expansion. I.e. a value of instead of 65 e folds for expansion may instead be 50 e folds of expansion, which would correspondingly dramatically shrink the expansion of the wavefunction form for gravitational waves.

The only way such questions can be answered, is by experimental inquiry. The above are rough estimates only

Also the introduction of more analysis from Cosmological Non Linear dynamics, as given in [11,12,13,14] may significantly alter the assumed parameters of our assumptions. Christian Corda, and others have done solid work which may alter what has been presented

In addition, fidelity, or facts in dispute of the Penrose reference, [15] could change the parameter of our assumed problem, greatly again, as well.

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