NLED Gedankenexperiment for modified ZPE and Planck's 'constant', h, in the beginning of cosmological expansion, partly due to NLED

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Abstract. **We initially look at a non singular universe representation of entropy, based in part on what was brought up by Muller and Lousto This is a gateway to bringing up information and computational steps (as defined by Seth Lloyd) as to what would be available initially due to a modified ZPE formalism. The ZPE formalism is modified as due to Matt Visser's alternation of k (maximum) ~ 1/(Planck length), with a specific initial density giving rise to initial information content which may permit fixing the initial Planck's constant, h, which is pivotal to the setting of physical law. The settings of these parameters depend upon NLED.**

1. Introduction

First of all we wish to ascertain if there is a way to treat entropy in the universe , initially, by the usual black hole formulas. Our derivation takes advantage of work done by Muller, and Lousto [1] which have a different formulation of entropy cosmology , based upon a modified event horizon, which they call the Cosmological Event Horizon. i.e. it represents the distance a photon emitted at time t can travel. Afterwards, we give an argument, as an extension of what is presented by Muller and Lousto [1], which we claim ties in with Cai [2], as to a bound to entropy, which is stated to be S (entropy) less than or equal to N, with N, in this case, a micro state numerical factor. Then, a connection as to Ng's infinite quantum statistics[3] is raised. I.e. afterwards, we are then referencing C.S. Camara a way to ascertain a non zero finite, but extremely small bounce and then we use the scaling, as given by Camara [4], that a resulting density, is scaled as by $\rho \sim a^{-4}$. In addition we will set this scaling as a way to set minimum magnetic field values, commensurate to the modified ZPE density value, as given by Visser [5] , with $\rho \sim a^{-4}$ paired off with [5]'s $\rho \sim mass(planck)/(length[Planck])^{3}$, so then the magnetic fields as given by [4] can in certain cases be estimate. In addition, comparing the results of [4] and [5] permit us to use Waleka's [6] result of a time step ~ 1/ square root of $\rho \sim mass(planck)/(length[Planck])^{3}$ versus a time step ~ 1/ square root of $\rho \sim a^{-4}$, with equality giving further constraints upon magnetic fields and a cosmological "constant" Λ. Doing so, will then permit us to make further use of [7] and its relationship between and a cosmological "constant" Λ and an upper bound to the number of produced gravitons. Isolating N (the number of gravitons) and if this is commensurate with entropy due to [2] amd [3] will allow us to use Seth Lloyd supposition of [8] as to the number of permitted operations in quantum physics may be permitted. This final step will allow us to go to the final supposition, as to what number of operations / information may be needed to set a value of h (Planck's constant) in the beginning of the universe, ordi given in [9] with value, $\hbar$ invariant over time.

$$\hbar(initial) = E(initial)\cdot t\left(initial\right) = \rho(initial)\cdot V\left(initial\right)\cdot t\left(initial\right) \tag{1}$$

1. Calculations as to Entropy, and what it says about bouncing, versus non singular universes, and a build up as to fill in entries into Eq. (1) above.

We begin first by putting the results of [1] here and subsequently modifying them. To begin with, we look at what was given as to entropy, and this was actually asked me as to a review of a similar article several weeks ago. By [1], $a(grid)$ ~ Planck's length

$$S(universe) \sim .3 r_H^2 / a(grid)^2 \tag{1a}$$

The specifics of what were done with r_H , is what will be discussed in this section, and Eq.(1a) has its counter part in [10] as given by, if R is the radius of a sphere inside of which harmonic oscillation occurs, and $a(grid)_{H.O.}$ is in this case is of a different value, i.e. generalized Harmonic Oscillator based lattice spacing. By [10] we have

$$S(Harmonic.oscillators) \sim \frac{.3}{4\pi} \cdot \left(\frac{4\pi R^2}{a(grid)_{H.O.}{}^2} \right) \tag{2}$$

The main import of Eq. (1) is that it defacto leads to a ' non dimensional' representation of entropy, but before we do that, it is useful to review what is said about r_H . As defined in [1], r_H is called the maximal co-ordinate distance a photon can travel in space-time in a given time, t.

FWIW, we will provisionally in the regime of z (red shift) > 1100 set for inflation from a Planck time interval up to 10^-20 seconds, when the expansion radii of the universe was about a meter, i.e.

$$r_H\big|_{\min} \sim O(l_{Planck}) < r_H < r_H\big|_{\max} \sim 1 \;\; meter \tag{3}$$

What we will do in later parts of this paper , to get an approximation as to what the actual value of r_H is, and to use this to comment upon the development of entropy.

2a. Relevance of Eq. (1) to the concept of dimensionless entropy

Cai, in [2] has an abbreviated version of entropy as part of a generalized information measurement protocol which we will render as having T.F.A.E.

$$
\begin{aligned}
&S \le \tilde{N} \Leftrightarrow \\
&\Lambda \sim \tilde{N} \Leftrightarrow \\
&e^{\tilde{N}} states \Leftrightarrow \\
&set \quad of \quad all \quad \Lambda\left(\tilde{N}\right) \quad of \quad space-times \Leftrightarrow \\
&\tilde{N} = 3G / G\Lambda
\end{aligned}
\tag{4}
$$

We will assume that $N = \tilde{N}$, and then connect the entropy of Eq.(4) with Ng's entropy [3] with the result that

$$
S \approx \tilde{N} = N \tag{5}
$$

While assuming Eq. (5) we will through [3] be examining the consequences of infinite quantum statistics for which , if the "Horizon" value r_H as defined above is made roughly commensurate with say graviton wavelength

$$
\begin{aligned}
&r_H \sim \lambda(wavelength)\ \& \\
&S \sim N \cdot \left[\log(V(volume) / \left[\lambda(wavelength)\right]^3) + \frac{5}{2} \right] \\
&\propto N \cdot \left[+ \frac{5}{2} \right] \sim N
\end{aligned}
\tag{6}
$$

The entropy so mentioned, above, is commensurate with the following identification, namely how to link a measure of distance with scale factor $a(t)$. We will as a starting point use the following identification , namely start with the radiation dependence of $a(t)$ [4,7]

$$
\begin{aligned}
&a(t) \sim (t / t(present))^{1/2} \\
&\Leftrightarrow t = \left[1/6\pi \cdot G\rho\left(t\right) \right]^{1/2} \\
&\rho\left(t\right) \sim a(t)^{-4}
\end{aligned}
\tag{7}
$$

Our starting point for the rest of the article will lie in making sense of the following inputs into the scale factor as the last part of Eq.(7) grouping of mathematical relations, namely we will look at time defined via [5] . of time $t = 1\Big/\sqrt{6\pi G\rho\left(t\right)}$ And the following for defining the density, via its scaled relationship to (1/ $a^4(t)$) , with the minimum value of $a(t)$, as given by Camara [4] as , using a frequency ω, B_0 an initial E and M field given at the start of creation itself, and of course a cosmological 'constant' parameter Λ which will be defined later, with the following linked to a minimum scale factor, i.e. if we look at Camara [4]

$$\alpha_0 = \sqrt{\frac{4\pi G}{3\mu_0 c}} B_0$$
$$\hat{\lambda}(defined) = \Lambda c^2 / 3 \tag{8}$$

$$a_{\min} = a_0 \cdot \left[\frac{\alpha_0}{2\hat{\lambda}(defined)} \left(\sqrt{\alpha_0^2 + 32\hat{\lambda}(defined) \cdot \mu_0 \omega \cdot B_0^2} - \alpha_0 \right) \right]^{1/4}$$

The linkage to graviton mass, and heavy gravitons will build upon this structure so built up via [7] , and will comprise the capstone as to what to look for in GW research. A topic which the author is involved with. I.e. consequences of working with the following graviton mass will be brought up, namely by [7]

$$m_{graviton} = \frac{\hbar}{c} \cdot \sqrt{\frac{(2\Lambda)}{3}} \tag{9}$$

This above formula will de evolve, from a larger value, to having the mass of a graviton approximately as given about 10^-62 grams in the present era [9] .Also, if the above graviton mass is accepted, we will be considering the value of N defined within the event horizon r_H , with

$$N = N_{graviton}\Big|_{r_H} = \frac{c^3}{G \cdot \hbar} \cdot \frac{1}{\Lambda} \tag{10}$$

A specified value of a_0 will also be ascertained, in this document. We set it equal to 1, and then calculated the other values from there. From the above, we will specify a variance graviton mass, a minimum time, according to the above, and work out full consequences, with suggestions for finding exact values of the above parameters.

2. Filling in the magnetic field parameter , and initial cosmological Λ value

We will begin this by looking at [5] which will then have a critical density as defined by its page 83 with a capping of its k variable as k ~ 1/ Planck Length. Then

$$\rho(ZPE, k_{Max} \sim 1/l_{Planck}) = \lambda_{ZPE} \frac{m_{Planck}}{l_{Planck}^3} \approx \frac{m_{Planck}}{l_{Planck}^3}$$
$$\Leftrightarrow \lambda_{ZPE} \sim \mathrm{O}(1) \tag{11}$$
$$\& \rho(ZPE, k_{Max} \sim 1/l_{Planck}) \approx \frac{m_{Planck}}{l_{Planck}^3} \equiv \left(\rho \sim a_{\min}^{-4} \right)$$

If so then, we will define having

$$\frac{m_{Planck}}{l_{Planck}^{3}} \equiv \left(\rho \sim a_{\min}^{-4}\right) \& \Lambda(small)$$
$$\Leftrightarrow \frac{m_{Planck}}{l_{Planck}^{3}} \cdot a_{0}^{-4} \sim 16\widehat{\lambda}(defined) \cdot \mu_{0}\omega \cdot B_{0}^{2}$$
$$\Leftrightarrow B_{0}^{2} \sim \frac{m_{Planck}}{l_{Planck}^{3}} \cdot \frac{a_{0}^{-4}}{16\widehat{\lambda}(defined) \cdot \mu_{0}\omega} \tag{12}$$
$$\Leftrightarrow B_{0}^{2} \sim \frac{m_{Planck}}{l_{Planck}^{3}} \cdot \frac{1}{16\widehat{\lambda}(defined) \cdot \mu_{0}\omega} if \quad a_{0}^{-4} \sim \mathrm{O}(1)$$

The magnitude of the magnetic field would be, then very closely tied to the strength of the cosmological ' constant' parameter due to $\widehat{\lambda}(defined) = \Lambda c^{2}/3$. We will be commenting upon the strength of Λ next.

3. Estimating the strength of the Λ parameter . Questions and implications.

First, now the treatment of entropy due to early universe Gravitons. In the beginning of this analysis, we start with Ali and Das's cosmology from Quantum potential article[11], where a derived cosmological "constant is given by, if l_{Planck}^{2} ~10^-70 meters squared, and $l_{Radius-Universe}^{2}$ ~ 10^52 meters squared, so that

$$\Lambda_{Einstein-Const.} = 1/l_{Radius-Universe}^{2} \tag{13}$$

Eq.(13) should be compared to an expression given by T. Padmanabhan [12], if the $E_{Planck} \sim 10^{28} eV$, and $m_{graviton} \sim 10^{-32} eV$, and $E \sim N_{graviton} \cdot m_{graviton}$

$$\Lambda_{Einstein-Const.Padmanabhan} = 1/l_{Planck}^{2} \cdot \left(E/E_{Planck}\right)^{6} \tag{14}$$

This would be dependent upon the value of N, and this is where we will be making some predictions.

I.e. if N were a graviton count, and very small, then we would have , say

$$\Lambda_{Einstein-Const.Padmanabhan} = 1/l_{Planck}^{2} \cdot \left(E/E_{Planck}\right)^{6}$$
$$\sim O(\Lambda_{today} \equiv \Lambda_{Einstein-Const.} = 1/l_{Radius-Universe}^{2}) \tag{15}$$
$$\Leftrightarrow E\left(allowed\right) \Rightarrow N_{Graviton}\Big|_{initial} \sim S_{initial} \propto 10^{\alpha}; 0 < \alpha \leq 4$$

This would mean, say that at the onset of inflation, we would have a very small entropy count, and this would next reflect upon what would be conditions for Planck's constant as given in Eq. (1) above. I.e. this is with an instant of time not that different from Planck time, and a radii almost Plank length.

This value of the entropy, if one is assuming initial conditions should be compared to what entropy would be if one is looking at a graviton count in today's era

Giovanni [14], with the upper end to graviton frequencies calculated as follows [13]

$$\begin{aligned}
&S_{gravitons-present.era} = V(volume)\times\int_{v0}^{v1} r(v)dv \\
&\approx (10^{29})^3 \times \left(H_1 / M_p\right)^3 \sim (10^{29})^3 \sim 10^{87} \\
&\Leftrightarrow v0 \sim 10^{-18}Hz \,\&\, v1 \sim 10^{11}Hz
\end{aligned} \tag{16}$$

This gap of 10^ 82 in magnitude from initial and final entropy will have consequences we will examine as to the initial time step, and the necessary and sufficient conditions needed to satisfy Eq. (1) as to fixing the value of Planck's constant, h bar.

4. Conclusion. Order of magnitude estimate as to necessary and sufficient conditions as to calculation of h bar in the early Universe. Leading to effective initial time not zero

We will now give a first order estimate as to calculation of h bar, i.e. Eq.(1). i.e. isolate the actual spatial length, for the creation of a present day h bar Planck's constant. To do this look at [14,15]

$$\Delta x \Delta p \geq \hbar + \frac{l_{Planck}^{2}}{\hbar}\cdot\left(\Delta p\right)^2 \tag{17}$$

Then TFAE. The idea would be that the Planck constant, h bar would be formulated as of the present day value ,. Also, the modification for the string length, would have $\Delta x|_{\min} \sim 10^{\beta} l_{Planck}$, so then

$$\begin{aligned}
&\& \Delta x|_{\min} \Delta p \approx \hbar + \frac{l_{Planck}^{2}}{\hbar}\cdot\left(\Delta p\right)^2 \\
&\& \hbar^2 - \hbar\, \Delta x|_{\min} \Delta p + l_{Planck}^{2}\cdot\left(\Delta p\right)^2 \approx 0 \\
&\hbar \approx \frac{\Delta x|_{\min} \Delta p}{2}\cdot\left(1+\sqrt{1-4\frac{l_{Planck}^{2}}{\left(\Delta x|_{\min}\right)^2}}\right) \\
&\hbar \approx \frac{\Delta x|_{\min} \Delta p}{2}\cdot\left(1+\sqrt{1-4\cdot 10^{-2\beta}}\right) \\
&\approx \Delta x|_{\min} \Delta p \cdot\left(1-\frac{2}{10^{2\beta}}\right)
\end{aligned} \tag{18}$$

Then,

$$if\,\Delta p \sim N_{graviton} \cdot m_{graviton} \cdot c$$

$$\hbar \approx \Delta x\big|_{\min} \cdot N_{graviton} \cdot m_{graviton} \cdot c \cdot \left(1 - \frac{2}{10^{2\beta}}\right) \tag{19}$$

$$\Delta x\big|_{\min} \approx \frac{\hbar}{N_{graviton} \cdot m_{graviton} \cdot c \cdot \left(1 - \frac{2}{10^{2\beta}}\right)}$$

This should be greater than a Plank length, mainly due to the situation of

$$\left(1 - \frac{2}{10^{2\beta}}\right)^{-1} \sim 1 + \frac{2}{10^{2\beta}} \tag{20}$$

We assume, here that this will be occurring in an interval of time approximately the value of Planck time given by

$$t\left(initial\right) \sim \hbar / \rho(initial) \cdot V\left(initial\right) \sim \frac{\hbar}{\left(\frac{m_{Planck}}{l_{Planck}^{3}}\right)} \left(\frac{\hbar}{N_{graviton} \cdot m_{graviton} \cdot c \cdot \left(1 - \frac{2}{10^{2\beta}}\right)}\right)^{-3} \tag{21}$$

Here, the number, N, is given in part by Eq. (10), and the important factor is that Eq.(21) is non zero, Whereas this will then lead to a fixed magnetic field behavior as to N being defined above, by Eq.(21) and the N so being defined, leading to a bound on Λ

We will, from now on give definite cases as to what these parameters should be in future work.

The upshot is that the entropy, at the close of the Inflationary era, would be dominated by Graviton production

We will consider what happens as of about the electroweak era, and this would have consequences as far as information , as can be seen by the approximation given by Seth Lloyd [8] on page 14 of the article, as to the number of operations # being roughly about

$$\# \leq (1/2\pi) \cdot (r/l_P) \cdot \left(t/t_P\right) \tag{22}$$

In the electro-weak era, we would be having Eq. (22) as giving a number of ‘computational steps' many times larger (10 orders of magnitude) than the entropy of the Electro-weak,

#(Electro-weak)~ 10^{49} (23)

In the immediate aftermath of inflation, this number would be, instead about $10^{5} - 10^{7}$

Some work so required will lead to an understanding of the number of steps needed , computationally for forming h bar will be done in the next rendition of this project. Whereas we would hope that the magnetic fields, would be shown to be commensurate with the E and M calculations as given in [16], while keeping in mind what was brought up by [17] about Graviton mass and other parameters.

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