Non Linear Electrodynamics Gedankenexperiment for modified Zero Point Energy and Planck's 'constant', h, in the beginning of Cosmological expansion, so $\hbar(today) = \hbar(initial)$

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Abstract: We initially look at a nonsingular 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 Zero Point Energy formalism. The Zero Point Energy formalism is modified as due to Matt Vissers's setting of an angular plane number in early universe cosmology as 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 . This would be in the spirit of Christi Stoica's removal of initial conditions of non-pathological initial starting points in Cosmology. What we want are necessary and sufficient conditions so $\hbar(today) = \hbar(initial)$

Keywords: Infinite Quantum Statistics; Gravitons

PACS Codes: 03.50.-z, 89.70.Cf, 98.80.-k, 98.80.Cq

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1. Introduction : Can $\hbar(today) = \hbar(initial)$?

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 as a way to ascertain a non zero finite, but extremely small quantum bounce and then we use the scaling, as given by Camara [4], that a resulting density, is scaled as by $\rho \sim a^{-4}$. The density of a given cosmological equation of state of the universe, ρ is proportional to a with a called the scale factor [5] , as of page 3 of [5] , which is a function of time which represents the relative expansion of the universe. It relates the proper distance (which can change over time, unlike the comoving distance which is constant) between a pair of objects, e.g. two galaxy clusters, moving with the Hubble flow in an expanding or contracting Friedmann Lemaitre Roberson Walker universe any arbitrary time t to their distance at some reference time t_0 . The formula for this is:

$$d(t) = a(t)d_0 \quad (1)$$

Where $d(t)$ is the proper distance at epoch time t, d_0 is the proper distance at epoch time t_0 and $a(t)$ is the scale factor [6] as defined in reference [6]'s page 6. Therefore by definition, $a(t_0) = 1$, In addition we will set this scaling as a way to set minimum magnetic field values, commensurate to the modified Zero Point Energy density value, as given by Visser [7] , with $\rho \sim a^{-4}$ paired off with [7]'s rescaling of density $\rho \sim mass(planck)/(length[Planck])^3$, so then the magnetic fields as given by [4] can in certain cases be then estimated. The reference to Planck length [8] and Planck mass[9] which is for the Density calculation will permit, after accessing Walecka's [10] result of comparison with a physical dimensional analysis derived time step(1)

$$\text{time step(1)} \sim 1/\text{ square root of } \rho \sim mass(planck)/(length[Planck])^3 \quad (2)$$

This will be compared to another time step(2) based on [10]

$$\text{time step(2)} \sim 1/\text{ square root of } \rho \sim a^{-4} \quad (3)$$

Further analysis will be assumed in the case where there is an equality between Eq.(2) and Eq.(3) so that by [4] we are giving further constraints upon magnetic fields and a cosmological "constant" Λ. [11] The Cosmological constant for now is provisionally assumed to have todays value, with

$$\Lambda_{today} = \Lambda = 2.036 \times 10^{-35} s^{-2} \quad (4)$$

Doing so, will then permit us to make further use of [8] and its relationship between 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 [2,3] will allow us to use Seth Lloyd supposition of [13] 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 with $\hbar$ invariant over time. Note that what Seth Lloyd is doing is the result of making a relationship between computational bits, of information producing cosmic computer operations, in explicit relationships. What we will do, is to use the Ng identification [3] of entropy, S ~ N, a count of gravitons, initially produced, with this number then equal 3/4th in power magnitude to the number of computational cosmic computer steps taken by a cosmic 'computer' . I.e. what we will see later is that the gravitons produced up to the present day will be about 10^90, equal to the the 3/4th power of

10^120, where the value of 10^120 is the number of operations necessary to produce the equivalence of initial Planck constant, $\hbar$ (initial) with today's value of Planck's constant $\hbar(today)$ [14] , with

$$\hbar(initial) = E(initial)\cdot t\left(initial\right) = \rho(initial)\cdot V\left(initial\right)\cdot t\left(initial\right) \ = \ \hbar(today) \tag{5}$$

Note that $\hbar(today)$ was the proportionality constant between the minimal increment of energy of a hypothetical electrically charged oscillator in a cavity that contained black body radiation, and the frequency of its associated electromagnetic wave. In 1905 the value of minimal energy increment of a hypothetical oscillator, was associated by Einstein with a "quantum" of the energy of the electromagnetic wave itself. The light quantum eventually was called the photon. This is what [14] is about, and our paper is to indicate conditions permitting $\hbar(today) = \hbar(initial)$ in Eq.(5). It is closely tied into what is calculated as of Eq.(8) , a one meter or so initial radii, for r_H

2. Calculations as to Entropy, and what it says about bouncing, versus non singular universes

The term non singular universe is short hand for an initial starting point as to the expansion of the universe which is not at a singular point of space-time. Reference [4] begins with this supposition, as well as does [15], i.e. the quantum bounce idea of Loop quantum gravity. Having said that, such effects do seem to tie in also with work the author has done in [16] which is in its own way a partial confirmation of [15] as a starting point. We will use this while assuming in our calculations r_H does not go to zero. In this paper, this radii, is similar to what is done in black hole physics, as is noted by [1], and gets to the heart of the entropy calculation. That we are modeling the acquisition of initial non zero entropy in the universe with a one to one equivalence with black hole physics is what motivates the rest of this paper. In doing so, we will urge more advanced readers of this document to access [17] to get an idea of how tricky this initial condition stuff in early universe cosmology actually is.

For the record, the usual interpretation of r_H in terms of black hole physics, is in terms of what is called an event horizon. An event horizon is a boundary in space-time beyond which events cannot affect an outside observer. i.e. in black hole physics, once a person passes through this radial distance from a black hole, it supposedly is such that the observer cannot escape the pull of the black hole gravity gradient. [18] gives a review of current work with this concept in loop quantum gravity, i.e. conditions in which the usual space-time conditions break down, and we note that we are , through [1] referencing a mathematical equivalence between black hole physics, and the initial construction of space-time physics. [19] starting on page 65 gives a treatment commensurate with more traditional cosmological thinking, but also has linkage to worm hole physics as well.

So, we will assume a linkage between black hole physics event horizons, as defined, and early universe cosmology in the manner brought up by [1]

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

$$S\left(universe\right) \sim .3 r_H^2 \big/ a(grid)^2 \tag{6}$$

The specifics of what were done with r_H , is what will be discussed in this section, and Eq.(1) has its counterpart 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 [1] .

$$S(Harmonic.oscillators) \sim \frac{.3}{4\pi} \cdot \left(\frac{4\pi R^2}{a(grid)_{H.O.}{}^2} \right) \tag{7}$$

The main import of Eq. (5) 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.

$$r_H\big|_{\min} \sim O(l_{Planck}) < r_H < r_H\big|_{\max} \sim 1 \quad meter \tag{8}$$

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. (5) 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.

$$\begin{aligned} & S \le \tilde{N} \Leftrightarrow \\ & \Lambda \sim \tilde{N} \Leftrightarrow \\ & e^{\tilde{N}} states \Leftrightarrow \\ & set \quad of \quad all \quad \Lambda\left(\tilde{N}\right) \quad of \quad space-times \Leftrightarrow \\ & \tilde{N} = 3G / G\Lambda \end{aligned} \tag{9}$$

We will assume that $N = \tilde{N}$, and then connect the entropy of Eq.(7) with Ng’s entropy [3] with the result that

$$S \approx \tilde{N} = N \tag{10}$$

While assuming Eq. (9) 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

$$\begin{aligned} & r_H \sim \lambda(wavelength) \,\& \\ & S \sim N \cdot \left[\log(V(volume) / [\lambda(wavelength)]^3) + \frac{5}{2} \right] \\ & \propto N \cdot \left[+ \frac{5}{2} \right] \sim N \end{aligned} \tag{11}$$

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]

$$a(t) \sim (t/t(present))^{1/2}$$
$$\Leftrightarrow t = \left[1/6\pi \cdot G\rho(t)\right]^{1/2} \qquad (12)$$
$$\rho(t) \sim a(t)^{-4}$$

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.(11) grouping of mathematical relations, namely we will look at time defined via [10] . of time $t = 1\big/\sqrt{6\pi G\rho(t)}$ 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, with the following linked to a minimum scale factor, i.e. if we look at Camara [4], keeping in mind that c is the speed of light and that G is invariant. For now we will avoid what was done in [20], i.e. quoting the abstract, we could assume time varying G

quote

It has recently been asserted that a universe with a time-varying gravitational "constant" G *necessarily implies creation if the rest mass of matter particles is constant. It is shown that this is not necessarily true. An example of a cosmological model with variable* G *and Λ is presented, in which there is no creation and in which the rest mass of matter particles is constant*

End of quote

The author is for now avoiding a time varying G, as it is creating Partial Differential equations the author has no idea of how to solve, for the time being, so we assume that G is invariant and use the Eq.(13) result at this time,[21]

i.e.

$$G = 6.67408(31)\times 10^{-11}\, m^3\, kg^{-1}\, s \qquad (13)$$

Then we use, by [4]

$$\alpha_0 = \sqrt{\frac{4\pi G}{3\mu_0 c}} B_0$$
$$\widehat{\lambda}(defined) = \Lambda c^2/3 \qquad (14)$$
$$a_{\min} = a_0 \cdot \left[\frac{\alpha_0}{2\widehat{\lambda}(defined)}\left(\sqrt{\alpha_0^2 + 32\widehat{\lambda}(defined)\cdot \mu_0\omega \cdot B_0^2} - \alpha_0\right)\right]^{1/4}$$

The linkage to graviton mass, and heavy gravitons will build upon this structure so built up via [12] , 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 [12], and assuming a present rest mass of the graviton as given by [22]

$$m_{graviton} = \frac{\hbar}{c}\cdot\sqrt{\frac{(2\Lambda)}{3}} \qquad (15)$$

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 [22] .Also, if the above graviton mass is accepted, we will be considering the value of N defined within the event horizon r_H , with [12]

$$N = N_{graviton}\Big|_{r_H} = \frac{c^3}{G \cdot \hbar} \cdot \frac{1}{\Lambda} \tag{16}$$

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.

3. Filling in the parameters, what it says about initial cosmological conditions

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 [23], where a derived cosmological "constant is given by, if l^2_{Planck} ~10^-70 meters squared, and $l^2_{Radius-Universe}$~ 10^52 meters squared, so that

$$\Lambda_{Einstein-Const.} = 1/l^2_{Radius-Universe} \tag{17}$$

Eq.(11) should be compared to an expression given by Padmanabhan [24], if the $E_{Planck} \sim 10^{28} eV$, and $m_{graviton} \sim 10^{-32} eV$, and $E \sim N_{graviton} \cdot m_{graviton}$

$$\Lambda_{Einstein-Const.Padmanabhan} = 1/l^2_{Planck} \cdot \left(E/E_{Planck}\right)^6 \tag{18}$$

Then the entropy at the end of the electro weak era is, assuming this is commensurate with graviton production, with the value of the Horizon radius at the upper end of Eq. (7) above, namely about 1 meter

$$S_{gravition} \sim 10^{39} \tag{19}$$

Given this, we can now consider what would be the magnetic field, initially, and the other parameters as given in the end of the last section. Doing so, if so, we can have frequency as high as

$$\omega_{initial}\Big|_{r_H \sim 1meter} \sim 10^{21} Hz \tag{20}$$

'

Using inflation, this would be redshifted at a minimum of 11 orders of magnitude, down to about 10^10 Hz today, at the highest end. The nature of the E and B fields, also as fill in would have to be commensurate with what was given in [25]

Still though, as a rule of thumb, we would have that the MINIMUM value of the magnetic field, in question would have to be [4]. I.e. for high frequencies, the minimum value of the magnetic field would actually be very low!

$$B > \frac{1}{2\cdot\sqrt{10\mu_0\cdot\omega}} \qquad (21)$$

1. Conclusions; Why we have a non zero initial entropy

Why we pursued this datum of an initial non zero entropy ? In a word, to preserve the fidelity of physical law from cosmological cycle to cycle. I.e. the bits we calculated with, came from Seth Lloyd [14] , and also from Giovanni [26], with the upper end to graviton frequencies calculated as [14]

$$\begin{aligned} S_{gravitons-present.era} &= V(volume)\times\int_{v0}^{v1} r(v)dv \\ &\approx (10^{29})^3\times\left(H_1/M_p\right)^3 \sim (10^{29})^3 \sim 10^{87} \\ &\Leftrightarrow v0 \sim 10^{-18}\,Hz\,\&\,v1 \sim 10^{11}\,Hz \end{aligned} \qquad (22)$$

S.Lloyd, sets, in [14]

$$\begin{aligned} &I(number-bits) \sim (\#)^{3/4} \sim 10^{90}(present-era) \\ &\Leftrightarrow \# \le (1/2\pi)\cdot(r/l_P)\cdot\left(t/t_P\right) \sim 10^{122}(present-era) \end{aligned} \qquad (23)$$

The first part of Eq.(22) in terms of ' bits' is approximately similar to Eq.(23) , and more tellingly,

$$\begin{aligned} &I(number-bits) \sim (\#)^{3/4} \sim 10^{37}(EW-era) \\ &\Leftrightarrow \# \le (1/2\pi)\cdot(r/l_P)\cdot\left(t/t_P\right) \sim 10^{49}(EW-era) \end{aligned} \qquad (24)$$

The upper part of Eq.(23) overlaps, a bit with Eq.(3) and Eq. (24), whereas Eq.(23) is only a few orders of magnitude higher than the formal numerical count for the number of operations, # of Eq. (24), i.e. the number of bits, given in Eq.(24) is similar to the graviton entropy count given in Eq. (23), However, most tellingly, the initial non zero graviton count, given when the universe is 1 meter in diameter, or so, is initiated by negative pressure, which we recount, below

We state, first of all, that with we use Lloyd [14], and also Corda, et.al [27]

$$\begin{aligned} &\#operations \sim \rho_{crit}\times t^4 \sim (t/t_p)^2 \\ &\Leftrightarrow \rho_{crit} \sim 1/t^2 \propto \rho_\gamma = \frac{16}{3}\cdot c_1\cdot B^4 \\ &\Leftrightarrow \#operations \sim (t/t_p)^2/B^8 \\ &\sim 1/(t_pB^4) \sim 1/B^4 \end{aligned} \qquad (25)$$

The upshot is that the entropy, at the close of the Inflationary era, would be dominated by Graviton production 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 [14] on page 14 of the article [14], as to the number of operations # being roughly about

$$\# \leq (1/2\pi)\cdot(r/l_P)\cdot(t/t_P) \qquad (26)$$

In the electro-weak era, we would be having Eq. (21) as giving a number of 'computational steps' many times larger (10 orders of magnitude) than the entropy of the Electro-weak,

$$\#(\text{Electro-weak}) \sim 10^{49} \qquad (27)$$

In addition, making use of the above calculations, if we do so, we obtained that the minimum time step would be of the order of Planck time, i.e. of about 10^ -44 seconds , which is very small, but not zero, whereas, again, assuming a 1 meter radii, which we obtain at the end of inflation, with a time step the, at the end of inflation of 10^-20 seconds. This is significant, when the universe had a radii of 1 meter, is about when we would expect r to be about 1 meter to then get us a value of Eq.(27) in upper bound I.e. setting r about 1 meter would allow us to have to have the upper bound value of Eq.(26) being that of Eq.(27)

This set of number of operations would be about when we would expect Planck's constant to be set, with the values as given in [14] . In addition, there is no way that the initial entropy would be zero, largely on account of Eq. (5) above. As to Stoica's work, [28] we will say that the removal of a chance for a non zero pathological singularity, as he mentioned, would be altered to cover a nonzero bounce, but one which was nearly zero. I.e. the initial graviton count would be immeasurably lower than the present day era value, as given in Eq. (19) above.

Acknowledgments

This work is supported in part by National Nature Science Foundation of China grant No. 11375279

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