Defining an Arrow of Time at the start of Inflation using the Penrose cyclic conformal cosmology?

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First, we state an argument as to form a cosmological constant near the beginning of inflation. Afterwards ,this investigation sets forth initial conditions for a start of the arrow of time in cosmology based upon the idea that of having initial degrees of freedom set as $g_* \sim 1000$ initially. Finally, we use all of the above to examine the introduction of causal relationships, for the universe

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I. INTRODUCTION

We reference the variation of cyclic conformal cosmology derived by the author[1], which sets the template for an early universe cosmology with graviton mass proportional to the square root of the cosmological constant. This creation of gravitons serves as the template for particle counting using the Ng idea of infinite quantum statistics[2] , as a basis for introducing entropy. The causal structure argument will be to use the initial counting of gravitons, as a way to initiate the arrow of time[3][4][5][6].

For the start of causal structure, we will state the following. Mainly that Causal structure[4] in this environs was initiated via the beginning of counting of gravitons, with increasing time steps, of the form Δt being formed at a minimum interval of time which would be the start of causal structure[4].

The beginning of this manuscript is consistent with forming the cosmological constant. The earliest place where the cosmological constant forms, in the early universe would then be defacto to onset of causal structure forming for counting gravitons, as in lieu of a counting algorithm for getting a handle on the following

In mathematical physics, the **causal structure** of a Lorentzian manifold describes the causal relationships between points in the manifold[4]. Here we have the initial causal structure put in place by the creation of the cosmological constant, leading to Graviton mass (very small) forming

In this situation we define causal relationships [7]as follows A **causal** relation between two events exists if the occurrence of the first causes the other. The first event is called the cause and the second event is called the effect

Here we have that the creation of a cosmological constant, at the onset of the universe is the cause for graviton production (with a definite mass) leading to a particle count which by its own nature is the start of entropy. How we start off with this idea is that a nonsingular start to the universe [8]will entail a space-time bubble with a wall tension , σ with an initial density of states, $\rho = 2|\sigma|$ being the case where we have the Hubble parameter =0, for reasons we will discuss later in this text i.e. the immediate aftermath of this will be where we have the onset of causal structure, the formation of entropy and the start of times' arrow

II. Methods for forming the cosmological constant. We will first of all modify creating vacuum energy

There is one idea which is that there is a huge vacuum energy, as in [9] to drive the expansion of the universe. Our idea is to , instead, stick with the vacuum energy commensurate to todays Cosmological constant, as given in [10].

We will first start off with the redone calculation as to the Vacuum energy as given in [10] and how we rescale them to be in sync as to the observed experimental value for vacuum energy which is of the present era. This methodology is consistent with the Zero-point energy calculation, we start off with the following as given by [10]

$$\frac{1}{2}\cdot\sum_i \omega_i \equiv V\left(volume\right)\cdot\int_0^{\hat{\lambda}}\sqrt{k^2+m^2}\,\frac{k^2dk}{4\pi^2}\approx\frac{\hat{\lambda}^4}{16\pi^2}$$
$$\xrightarrow[\hat{\lambda}=M_{Planck}]{}\rho_{boson}\approx 2\times 10^{71}GeV^4\approx 10^{119}\cdot\left(\rho_{DE}=\frac{\Lambda}{8\pi G}\right) \quad (1)$$

In stating this we have to consider that $\rho_{DE}=\frac{\Lambda}{8\pi G}\approx\hbar\cdot\frac{\left(2\pi\right)^4}{\lambda_{DE}{}^4}$, so then that the equation we have to consider is a wavelength $\lambda_{DE}\approx 10^{30}\ell_{Planck}$ which is about 10^{30} times a Plank length radius of a space-time bubble [8] as a nonsingular expansion point for Cosmology, at the start of inflation with the space-time bubble of about a Plank length radius in size. . Having said that , how do we get having the Penrose [11] multiverse condition in this problem[1], for

$$\lambda_{DE}\approx 10^{30}\ell_{Planck} \quad (2)$$

before the near singularity, then the existence of

$$\rho_{DE}=\frac{\Lambda}{8\pi G}\approx\hbar\cdot\frac{\left(2\pi\right)^4}{\lambda_{DE}{}^4} \quad (3)$$

Will be then, if we use the value of Eq. (2) fully consistent with regards to a value in line with the DE density seen today, i.e. cutting the value of Eq. (1) by 10^120 or

IIa. The existence of the factor of 10^30 in Eq. (2) permitted Eq. (3) to lead to the observed today value of DE and the cosmological constant.

Our next challenge is to account for a pre Planckian regime of space-time for which we have at least 10^30 times the spatial unit of Planck length. i.e. the bubble of space-time is presumed to be of Planck length radii and we present the existence of this bubble of space-time to create the following bounce cosmology value of [1][8]

$$\left(\frac{\dot{a}}{a}\right)^2=H^2_{bounce-\cos}=\frac{8\pi}{3M_P^2}\cdot\left(\rho-\frac{\rho^2}{2\left|\sigma\right|}\right) \quad (4)$$

Our preliminary hypothesis is as follows. i.e. if the right hand side of Eq. (4) is not equal to zero, we then have the following. Provided that we can form gravitons of mass[11]

$$m_g = \frac{\hbar}{c} \cdot \sqrt{\Lambda} \tag{5}$$

And that we have the value of density up to a point consistent with Eq. (5), in some fashion, i.e. at the surface of the space-time bubble, we not only have the density equivalent Eq.(3) that also we look at inflaton physics[12]

$$\phi = \sqrt{\frac{\gamma}{4\pi G}} \ln\left\{\sqrt{\frac{8\pi G V_0}{\gamma(3\gamma - 1)}} \cdot t\right\} \tag{6}$$

And what we will use the "inflaton potential "we write as[1][12]

$$V = V_0 \cdot \left\{\sqrt{\frac{8\pi G V_0}{\gamma(3\gamma - 1)}} \cdot t\right\}^{\sqrt{\frac{\gamma}{4\pi G}} - \sqrt{\frac{8\pi G}{\gamma}}} \tag{7}$$

Also

$$\rho \approx \frac{\dot{\phi}^2}{2} + V(\phi) \equiv \frac{\gamma}{8\pi G} \cdot t^2 + V_0 \cdot \left\{\sqrt{\frac{8\pi G V_0}{\gamma(3\gamma - 1)}} \cdot t\right\}^{\sqrt{\frac{\gamma}{4\pi G}} - \sqrt{\frac{8\pi G}{\gamma}}} \qquad (8)'$$

i.e. the following are equivalent, outside the 'bubble' of Planck radii, we have if $a(t) = a_{initial} t^{\gamma}$ [12]

$$\rho \approx \frac{\dot{\phi}^2}{2} + V(\phi) \equiv \frac{\gamma}{8\pi G} \cdot t^2 + V_0 \cdot \left\{\sqrt{\frac{8\pi G V_0}{\gamma(3\gamma - 1)}} \cdot t\right\}^{\sqrt{\frac{\gamma}{4\pi G}} - \sqrt{\frac{8\pi G}{\gamma}}}$$

$$\rho_{DE} = \frac{\Lambda}{8\pi G} \approx \hbar \cdot \frac{(2\pi)^4}{\lambda_{DE}{}^4} \tag{9}$$

$$m_g = \frac{\hbar}{c} \cdot \sqrt{\Lambda}$$

$$\lambda_{DE} \approx 10^{30} \ell_{Planck}$$

This in particular necessitates having 10^30 multiplied into Planck length, so where do we get the pre Planck space-time so the working parts of Eq (9) tie together ?. Note that for the record we are making the following identification of $\Delta\rho\Delta t \approx \hbar / V_{volume}$ so as to have a first step , for the initiation of the Times arrow as having the following value

$$\Delta t \approx \hbar / \left(V_{volume} \rho \right) \qquad (10)'$$

We will say more about getting the space and its relationship to Eq. (10) for initiating times arrow in the next section

Before doing that though note the following relationship stated by Winitzki, in [13] which is as follows for a flat space inflaton evolution

$$\ddot{\phi} + \frac{\dot{\phi}}{M_{planck}} \cdot \sqrt{24\pi \cdot \left(\frac{\dot{\phi}^2}{2} + V(\phi) \right)} + \frac{dV(\phi)}{d\phi} = 0 \qquad (11)$$

Using '[1]

$$\rho = \left(\frac{\dot{\phi}^2}{2} + V(\phi) \right) \qquad (12)$$

We get

$$\frac{1}{t^2} - \frac{\sqrt{96\pi G\hbar / V_{volume}\gamma}}{t^{3/2}} + \frac{8\pi G}{\gamma} \cdot V_0 \cdot \sqrt{\frac{4\pi G}{\gamma}} \cdot \left(\frac{8\pi G V_0}{\gamma(3\gamma - 1)} \right)^{\sqrt{\frac{\gamma}{4\pi G}} - \sqrt{\frac{8\pi G}{\gamma}}} t^{\sqrt{\frac{\gamma}{4\pi G}} - \sqrt{\frac{8\pi G}{\gamma}}} = 0 \qquad (13)$$

Solve the above for t numerically and then if the volume is set to be approximately ℓ^3_{planck}

Then if we use the following Planckian unit normalization we have $\hbar = \ell_{planck} = G = 1$ we then have Eq.(13) as

$$\frac{1}{t^2} - \frac{\sqrt{96\pi / \gamma}}{t^{3/2}} + \frac{8\pi}{\gamma} \cdot V_0 \cdot \sqrt{\frac{4\pi}{\gamma}} \cdot \left(\frac{8\pi V_0}{\gamma(3\gamma - 1)} \right)^{\sqrt{\frac{\gamma}{4\pi}} - \sqrt{\frac{8\pi}{\gamma}}} t^{\sqrt{\frac{\gamma}{4\pi}} - \sqrt{\frac{8\pi}{\gamma}}} = 0 \qquad (14)$$

Assuming Eq (14) we can get an optimal time we can set for obtaining $t = \Delta t$ so if we go back to Eq. (10) after getting numerical inputs for $t = \Delta t$ we can then write to good order having

$$\Lambda \approx \frac{8\pi}{V_{volume-input} \Delta t} \qquad (15)$$

A four-dimensional input volume could then be defined after assuming $\Delta t \approx t_{Planck}$ via treating the time axis, normally as in 3+1 geometry, as in the pre-lanckian geometry to instead be 4 spatial axis

$$V_{volume-input} \approx (\lambda)^4 = \left(10^{30} \ell_{Planck} \right)^4 \xrightarrow[\ell_{Planck}=1]{} \left(10^{30} \right)^4 \qquad (16)$$

Our idea is that one of the four spatial axis would then in the context of inflation become a time axis. i.e. in Pre Planck space have 4 (spatial) axis changed to in Plank space 3(spatial) + 1 (time) like geometry. If so then

Our task then would be to find out where to get the generalized embedding length of

$$x_{embedding} = 10^{30} \ell_{Planck} \xrightarrow[\ell_{Planck}=1]{} \left(10^{30}\right) \quad (17)$$

To do that we would assume Eq.(14) would be used to find γ , with

$$a \equiv a_{\min} \left(t / t_{Planck}\right)^{\gamma} \xrightarrow[t_{Planck}=1]{} a_{\min} t^{\gamma} \quad (18)$$

Hence we will then devote the next section into finding where the facto of 10^{30} came from. And from there assume the creation, at the causal boundary of radii ℓ_{Planck} we have the start of the arrow of time at the beginning of forming Δt , with the then resultant creation of a cosmological constant, call it Λ leading to setting the conditions for creation of gravitons of mass proportional to the square root of Λ, due to [11] leaving us to obtain a counting algorithm for the introduction of entropy

III **Looking now at the Modification of the Penrose CCC (Cosmology) to obtain the** 10^{30} factor seen in Eq.(16)

We now outline the generalization for Penrose CCC(Cosmology)[1], [14] just before inflation which we state we are extending Penrose's suggestion of cyclic universes, black hole evaporation, and the embedding structure our universe is contained within, This multiverse has BHs and may resolve what appears to be an impossible dichotomy .That there are N universes undergoing Penrose 'infinite expansion' (Penrose) [14] contained in a mega universe structure[1]. Furthermore, each of the N universes has black hole evaporation, . If each of the N universes is defined by a partition function[1][15], called $\left\{\Xi_i\right\}_{i \equiv N}^{i \equiv 1}$, then there exist an information ensemble of mixed minimum information correlated about $10^7 - 10^8$ bits of information per partition function [1][15] in the set $\left.\left\{\Xi_i\right\}_{i \equiv N}^{i \equiv 1}\right|_{before}$, so minimum information is conserved between a set of partition functions per universe [1][15]

$$\left.\left\{\Xi_i\right\}_{i \equiv N}^{i \equiv 1}\right|_{before} \equiv \left.\left\{\Xi_i\right\}_{i \equiv N}^{i \equiv 1}\right|_{after} \quad (19)$$

However, there is non-uniqueness of information put into partition function $\left\{\Xi_i\right\}_{i \equiv N}^{i \equiv 1}$ .Also Hawking radiation from black holes is collated via a strange attractor collection in the mega universe structure to form a new inflationary regime for each of the N universes represented

Our idea is to use what is known as CCC cosmology[1],[14], which can be thought of as the following.

First. Have a big bang (initial expansion) for the universe which is represented as given by structure $\left\{\Xi_i\right\}_{i \equiv N}^{i \equiv 1}$ Verification of this mega structure compression and expansion of information with stated non-uniqueness of information placed in each of the N universes favors ergodic mixing of initial values for each of N universes expanding from a singularity beginning. The n_f stated value, will be using (Ng) $S_{entropy} \sim n_f$. [2] . How to tie in this energy expression, as in Eq.(12) will be to look at the formation of a nontrivial gravitational measure as a new big bang for each of the N universes as by $n(E_i)\cdot$ the density of states at energy E_i for partition function[1],[15].

Note that there is in [16] a reference which gives us an upper bound as to the number of universes in a mega universe, but we will be calling this number, N for the time being.

$$\{\Xi_i\}_{i\equiv 1}^{i\equiv N} \propto \left\{ \int_0^{\infty} dE_i \cdot n(E_i) \cdot e^{-E_i} \right\}_{i\equiv 1}^{i\equiv N} . \qquad (20)$$

Each of E_i identified with Eq.(20) above, are with the iteration for N universes [1],and [14](Penrose, 2006) Then the following holds, by asserting the following claim to the universe, as a mixed state, with black holes playing a major part, i.e. we are doing an averaging procedure to remove the Anthropic principle[17] via

CLAIM 1

See the below[1] representation of mixing for assorted N partition function per CCC cycle [14]

$$\frac{1}{N} \cdot \sum_{j=1}^{N} \Xi_j \Big|_{j-before-nucleation-regime} \xrightarrow[vacuum-nucleation-tranfer]{} \Xi_i \Big|_{i-fixed-after-nucleation-regime} \quad (21)$$

Furthermore, the main point is done in [1] in terms of general ergodic mixing[18][19][20] [21] is given by using the Penrose ccc idea in modified

What is done in **Claim 1 [1]** is to come up as to how a multi dimensional representation of black hole physics enables continual mixing of spacetime [1],[18],[20],[21] largely as a way to avoid the Anthropic principle[17], as to a preferred set of initial conditions

Then the main methodology in the Penrose proposal has been in Eq. (21) evaluating a change in the metric g_{ab} by a conformal mapping $\hat{\Omega}$ to [1][14]

$$\hat{g}_{ab} = \hat{\Omega}^2 g_{ab} \qquad (22)$$

Penrose's suggestion has been to utilize the following [1] [14]

$$\hat{\Omega} \xrightarrow[ccc]{} \hat{\Omega}^{-1} \qquad (23)$$

In fall into cosmic black hopes has been the main mechanism which the author asserts would be useful for the recycling apparent in Eq(23) above with the caveat that $\hbar$ is kept constant from cycle to cycle as represented by $\hbar_{old-\text{cosmology}-cycle} = \hbar_{present-\text{cosmology}-cycle}$ We claim that the invariance of the Planck $\hbar$ combined with Eq. (21) above gives a good indication of a uniform mass to a graviton, per cycle, as far as heavy gravity, provided that $\hbar_{old-\text{cosmology}-cycle} = \hbar_{present-\text{cosmology}-cycle}$ holds' [1] . Having said that we need to consider where quantum effects in terms of entropy and gravity really hold

IV **. Having set conditions for an embedding, what can we say about quantum conditions and where they apply as to our early universe problem? And its relevance to entropy**

And now our conclusing words as to a quantization limit to pursue, if the early universe has characteristics of a pre planckian black hole In order to do this we adapt an argument used by [22] as using the quantization of an action which we write using [22] first in the case of no cosmological constant, namely if $\Im$ is an action integral with the form of the Einstein – Hilbert least action of which :L is a radius , and

$$\delta\Im = 0 \quad (24)$$

$$\Im \le \hbar \quad (25)$$

Equation (25) is an imposed upon quantization limit where we use from [22]

$$\Im = \frac{c^4}{16\pi G}\int \Re\sqrt{-g}\,d^4x \approx \left.\frac{2\pi^4 \rho L^4 c}{3}\right|_{t=L/c} \le \hbar \quad (26)$$

In case of using a black hole limit and constant energy density ρ, [22] argues for L Quantization near singularity if

$$L \le 2\ell_{Planck} \quad (27)$$

In the case of when the comological constant is NOT zero we impose

$$\Im = \frac{c^4}{16\pi G}\int \left(\Re - 2\Lambda\right)\cdot\sqrt{-g}\,d^4x \approx \left.\frac{2\pi^4 \rho L^4 c}{3}\right|_{t=L/c} - \frac{2L^4}{c}\cdot\Lambda \le \hbar \quad (28)$$

Here, ρ is an energy density and in the case of no cosmological constant we would use

$$\rho L^2 \le \left(3c^2 / 8\pi G\right) if \quad \Lambda = 0 \quad (29)$$

And

$$\Im = \frac{c^4}{16\pi G}\int \left(\Re\right)\cdot\sqrt{-g}\,d^4x \approx \left.\frac{2\pi^4 \rho L^4 c}{3}\right|_{t=L/c} \le L^2 c^3 / 4G \quad (30)$$

We argue as does [4] that when there is no cosmological costant that Eq. (19) and Eq(25) hold we are obtaining Eq. (20) so that

$L \le 2\ell_{Planck}$ as a quantum length limit. (31)

In the case where we use Eq. (28) instead of Eq. (29) we would instead see quantization

$L \le \ell_{Planck}$ as a quantum limit (32)

If so, then we have due to the production of gravitons near the Planck length starting radius condtions as to

Ng counting for infinite quantum statistics a defacto quantum origin for the onset of Entropy and the arrow of time due to the above argument.

V. Creating entropy farther away from the quantum regime, what can we say about entropy and the arrow of time ?

Having said that what can we say about non quantum gravity limits as to the origin of the arrow of time.

Beckwith asked [23]if the following could occur, i.e. this is for radiation regime of cosmology induced entropy

$$S \equiv [E - \mu N]/T \to S \propto T^3 \qquad (33)$$

by setting the chemical potential $\mu \to 0$ with initial entropy $S \sim 10^5$ at the beginning of inflation

What we found to our surprise is that as the chemical potential disappeared in the quantum regime of space-time that Eq. (33) would be replaced by a counting algorithm, of say n gravitons and that scaling the initial temperature by T to the cube power would only work early on if there was a cold cosmology without a causal barrier

If a causal barrier existed , then the build up of temperature T, would be effectively masked from the initial entropy contribution.

. Conventional discussions of the arrow of time states that as the Universe grows its temperature drops, which leaves less energy available to perform useful work in the future than was available in the past. Thus the Universe itself has a well-defined thermodynamic arrow of time. The problem of the initial configuration of the arrow of time, however, is not brought up. This paper is to initiate how to set up a well defined initial starting point for the arrow of time. Specifically re setting the degrees of freedom of about $g_* \sim 100-120$ [23] [24]of the electro weak era, to $g_* \sim 1000$ at the onset of inflation [23] , may permit $S_{initial} \propto T^3$. Say past the electroweak regime of cosmology and way past red shift z ~ 10^ 25

If the initial temperature of an emerging universe were very low corresponding to adding in content from the multiverse treatment of influx of matter energy, prior to entering the Planck sized bubble of space time , scaling $S \propto T^3$ may be a way to get an arrow of time, with respect to thermal temperatures, alone, with the graviton count a later, emergent particle phenomenon

Here is the problem. We are constituting a bubble of space-time which is largely a causal barrier to counting gravitons, whereas we cannot even make a linkage before the causal barrier to entropy. I.e. the entropy would come due to Ng counting of items like gravitons, first, and NOT initial temperature fluctuations. I.e. we argue that the Ng infinite quantum statistic counting would come first, before temperature fluctuations.

VI,.What can be said initially about usual arrow of time formulations of early cosmology ?

Usual treatments of the arrow of time, i.e. the onset of entropy . The discussion below makes the point that expansion of the universe in itself does not 'grow' entropy

The entropy density s of a radiation field of temperature T is s ~ T^3. The entropy S in a given comoving volume V is S = sV . Since the commoving volume V increases as the universe expands, we have V ~ R^3. And since the temperature of the microwave background goes down as the universe expands: T ~ 1/R, we have the result that the entropy of a given comoving volume of given space S ~ $R^{-3} * R^3$ = constant. Thus the expansion of the universe by itself is not responsible for any entropy increase. There is no heat exchange between different parts of the universe. The expansion is adiabatic and isentropic: **d S expansion** = 0. I.e. a process has to be initiated in order to start entropy production[23]

i.e. merely expanding the volume of space-time will not yield increase in entropy. i.e. we need an initial starting phenomena which we outlined in the quantum regime , and its emphasis upon counting gravitons. [23]

This discussion above in the quantum limit is to emphasize the importance of an initial process for the onset and the growth of entropy . We will initiate candidates for making sense of the following datum

VII. As far as the CMBR we can say the following, about redshift Z = 1000 or so, i.e.

To measure entropy in cosmology we can count photons. If the number of photons in a given volume of the universe is N, then the entropy of that volume is S ~ kN where k is called here Boltzmann's constant[23]

In the treatment we are working with, we are instead considering Z ~ 10^ 25, in the quantum regime. I.e. in that limit, we will forget about counting photons (none at Z ~ 10^ 25)

In the early quantum limit we are going to use the Ng infinite quantum statistics program.

Note that Y. Jack Ng. has [2] , from a very different stand point derived $S \sim n$ based upon string theory derived ideas , with **n** a 'particle' count , which in Y. Jack Ng's procedure is based upon the number of dark matter candidates in a given region of phase space..Y. Jack Ng's idea was partly based upon the idea of quantum ' infinite ' statistics, and a partition function.

This counting procedure is different from traditional notions . This entails, as we will detail , having increased number of degrees of freedom, initially, with re setting the degrees of freedom of about $g_* \sim 100-120$ of the electro weak era[24] , to $g_* \sim 1000$ at the onset of inflation,[23] I.e. what will be examined will be the feasibility of the following:

We will have a vanishing of the chemical potential in the neighborhood of quantum regime Planckian physics, right after a causal barrier so we would instead write in the immediate aftermath of the causal barrier[23]

$$S \equiv [E - \mu N]/T \xrightarrow[\mu \to 0]{} S \propto T^3 \approx n , \qquad (34)$$

with n an initial 'quantum unit' count in phase space of Planckian dimensions, where $S \sim 10^5$ at the beginning of inflation. Let us now look at how to initiate such a counting algorithm if one is looking at , say, highly energized gravitons , initially, as part of a counting 'algorithm' .

If so, let us now examine how the entropy behaves in the electroweak regime of space-time

VIII . The electro weak generation regime of space time for Entropy and early universe Graviton production up to the eletro weak transitions

For one our Hubble parameter changes, and this affects the behavior of entropy [23]

A typical value and relationship between an inflaton potential $V[\phi]$, and a hubble parameter value, H is [1] in say the regime after the Planckian regime to electroweak regime of space-time, i.e. say in the electroweak regime[23]

$$H^2 \sim V[\phi]/m_{Planck}^2 \qquad (35)$$

Also, if we look at the temperature T^* occurring about the time of the Electro weak transition , if $T \leq T^*$ when $T^* = T_c$ was a critical value, (of which we can write v(Tc) /Tc >1 , where v(Tc) denotes the Higgs vacuum expectation value at the critical temperature Tc., i.e. v(Tc)/Tc >1 according to C. Balazc et al (2005) [6] and denotes that the electro weak transition was a 'strongly first order phase transition') then one can write , by conventional theory that

$$H \sim 1.66 \cdot \left[\sqrt{\tilde{g}_*}\right] \cdot [T^2 / m_{Planck}^2] \qquad (36)$$

Here, the factor put in, of $\tilde{g}_*$ is the number of degrees of freedom. Kolb and Turner [24] put a ceiling of about $\tilde{g}_* \approx 100-120$ [24]in the early universe as of about the electro weak transition. If , however, $\tilde{g}_* \sim 1000$ 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 [23]

$$S \sim 3 \frac{m_{Plank}^2 \left[H = 1.66 \cdot \sqrt{\tilde{g}_*} \cdot T^2 / m_{planck} \cdot \right]^2}{T} \sim 3 \cdot \left[1.66 \cdot \sqrt{\tilde{g}_*} \right]^2 T^3 \qquad (37)$$

Now here is the counter factual narrative, i.e. what if the causal barrier did NOT exist.

Should the degrees of freedom hold, for temperatures much greater than T^*, and with $\tilde{g}_* \approx 1000$ at the onset of inflation, for temperatures, rising up to , say T ~ 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 $\tilde{g}_* \approx 1000$ or even higher even if T ~ 10^{19} GeV >> T^*, then there is the possibility that $S \propto T^3$ when $\tilde{g}_* \approx 1000$ could also hold, [23]

Tremendous. Just one little problem. That early universe causal barrier construction. If the causal barrier construction did not exist, the following is verbatim accurate

Equation (37) holds if there is no causal barrier, and if there is a rising build up of temperature in Pre Planckian space-time which reaches a huge thermal peak. **I.e. Equation (37) holds if the following is true**

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

In the case where there is a causal barrier we are back instead again at Equation (34)

So now what would be our interpretation of elevated levels of degrees of freedom ? This involves both [25][26]

IX. Justification for setting $\tilde{g}_* \approx 1000$ initially .

H. de La Vega, in conversations with the author in Colmo, Italy, 2009 [27]. flatly ruled out having $\tilde{g}_* \approx 1000$ initially. What will be presented here will be a justification to make sense out of initial conditions appropriate for $S \propto T^3 \sim n$ when $\tilde{g}_* \approx 1000$. The count, n, would be in terms of a procedure brought up by Mukhanov [28] on page 82 of his book leading to a Bogoluybov particle number density of becoming exponentially large, where η_1 is a time evolution factor, which we can set $|\eta_1| \sim O(\beta \cdot t_{Planck})$, with β some numerical multiplicative factor for the Planck interval of time t_{Planck} [28]

$$n \sim \cdot \sinh^2 [m_0 \eta_1] \qquad (38)$$

If so, then one can also ask if there is a linkage between the initial conditions, as pertinent to early inflation, and Beckwith's model of re acceleration of the universe one billion years ago. We refer the reader to [29]

X . Conclusions

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 Seth Lloyd's **[26]** shorthand for entropy,

$$I = S_{total} / k_B \ln 2 = [\#operations]^{3/4} = \left[\rho \cdot c^5 \cdot t^4 / \hbar\right]^{3/4} \qquad (39)$$

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. (39) 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 Ea. (39) if one sees no way of implementing what Ng. suggested via his infinite quantum statistics [2] would be to look at thermal inputs from a prior to the present universe, as suggested by L. Glinka[30][31]

$$n_f = [1/4] \cdot \left[\sqrt{\frac{\nu(a_{initial})}{\nu(a)}} - \sqrt{\frac{\nu(a)}{\nu(a_{final})}} \right] \qquad (40)$$

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

$$\Omega_{gw}(\nu) \cong \frac{3.6}{h_0^2} \cdot \left[\frac{n_f}{10^{37}} \right] \cdot \left(\frac{\nu}{1kHz} \right)^4 \qquad (41)$$

If we take into consideration having $a \sim a_{final}$, then Eq. (40) above will, in most cases be approximately

$$n_f = [1/4] \cdot \left[\sqrt{\frac{\nu(a_{initial})}{\nu(a)}} - 1 \right] \sim [1/4] \cdot \left[\sqrt{\frac{\nu(a_{initial})}{\nu(a)}} \right] \qquad (42)$$

THIS HOLDS if there is no causal barrier . and say we have a cold initial start to the universe.

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 Grishkuk [15] $\nu(a_{final}) \approx 10^0 - 10^2$ Hz near the present era, and $a \sim [a_{final} = 1] - \delta^+$, i.e. close to the final value of today's scale value,

If there is, instead a causal barrier, we have to start, not with this construction but the onset of, a counting algorithm even in the regime of Planckian physics

. I.e. if one can use [2]

$$S \approx n \qquad (43)$$

Keep in mind in the case of a causal barrier, that there is an argument as given in [25] with regards to information which is different from the quantum computer given by Seth Lloyd'[26]

X. What if there is a causal barrier, i.e. how do we introduce information in our universe and its connections between gravitons and quantum states in the Planckian regime of space-time ?

In that case the initial configuration of a universe may have the behavior of the Rosen model for early universe cosmology[32]

XI. We can compare this closed within a causal wall initial configuration start with the Rosen[32] value of energy for a mini universe

(from a Schrodinger equation) with ground state mass of $m = \sqrt{\pi} M_{Planck}$ **and an energy of**

$$E_{\hat{n}} = \frac{-Gm^5}{2\pi^2 \hbar^2 \hat{n}^2} \quad \textbf{(44)}$$

Our preliminary supposition is that Eq. (44) could represent the initial energy of a Pre Planckian Universe and that thermal energy is dumped in due to the use of Cyclic Conformal cosmology (maybe in multiverse form) so that if there is a build up of energy greater than Eq.(40) due to thermal buildup of temperature due to infall of matter-energy, we have a release of Gravitons in great number which would commence as a domain wall broke down about in the Planckian era with a temperature of the magnitude of Planck Energy for a volume of radius of the order of Plank Length. Now for expanding Eq. (40), we look at [32], where we have then an information number of N(information) for which we have a total Graviton mass of

$$M_{graviton-total} = n_{graviton} \cdot m_{graviton} \quad \textbf{(45)}$$

Where we will be looking at a value of “information” of initially[25]

$$\mathbb{N}(\inf) = \frac{9\pi}{\ln 2} \cdot \left(\frac{n_{graviton} \cdot m_{graviton}}{m_{planck}} \right)^2 \approx \frac{9\pi \cdot \left(n_{graviton}\right)^2}{\ln 2} \cdot 10^{-120} \quad \textbf{(46)}$$

Now use the following approximation of the Universe, initially having the entropy of a black hole, i.e, we are using Ng Infinite Quantum statistics, [2]

$$S_{Universe} \propto S_{BH} \cong \frac{A(area)}{4 \cdot \ell^2_{Planck}} \approx \frac{9n_Q}{4} \approx n_{graviton} \quad \textbf{(47)}$$

In taking this step, we are making use of [32] having the following radius used, namely using in our model of a black hole, the quantum “atom” approximation

$$r(n_Q) \approx \frac{3\sqrt{n_Q} \cdot \ell_{Planck}}{2\sqrt{\pi}} \quad \textbf{(48)}$$

In order to have non vanishing information according to [32] we would need to specify having

$$\mathbb{N}(\inf) = \frac{9\pi}{\ln 2} \cdot \left(\frac{n_{graviton} \cdot m_{graviton}}{m_{planck}} \right)^2 \approx \frac{729\pi \cdot (n_Q)^2}{16 \cdot \ln 2} \cdot 10^{-120} \geq 1$$

$$\Rightarrow E_{\hat{n}=n_Q} = \frac{-G \cdot \left(m = \sqrt{\pi n_Q} \cdot m_{planck} \right)^5}{2\pi^2 \hbar^2 n_Q{}^2} \approx \frac{-G \cdot \left(\sqrt{\pi n_Q} \cdot \left(m_{planck} \right)^5 \right)}{2\hbar^2} \quad (49)$$

$$\xrightarrow[\hbar = m_{planck} = G = 1]{} E_{\hat{n}=n_Q} \simeq \frac{-\left(\sqrt{\pi n_Q} \cdot \right)}{2} \approx l \arg e - negative - value$$

In point of fact, thermal energy from cyclic conformal cosmology would be dumped into the preplanckian configuration and when it exceeded Eq (49) presumably cancelling out the negative sign, we would see large scale graviton production probably in sync with entropy being dominated by the behavior of equation 43.

XII. Open Question, do we have a match up with Smoot's Ercole Challonge table? Guess as to possible outcomes presented

In a colloquium presentation done by Dr. Smoot in Paris [33] (2007); he alluded to the following information theory constructions which bear consideration as to how much is transferred between a prior to the present universe in terms of information 'bits'.

0) Physically observable bits of information possibly in present Universe - 10^{180}
1) Holographic principle allowed states in the evolution / development of the Universe - 10^{120}
2) Initially available states given to us to work with at the onset of the inflationary era- 10^{10}
3) Observable bits of information present due to quantum / statistical fluctuations -10^{8}

Our guess is as follows. That the thermal flux from a prior to the present universe may account for up to 10^{10} bits of information. These could be transferred from a prior universe to our present , and that there could be , perhaps 10^{120} minus 10^{10} bytes of information temporarily suppressed during the initial changing of fermion states of matter to a bosonic phase of matter right at the onset of the big bang itself .

'Then after the degrees of freedom dramatically drops during the beginning of the descent of temperature from about $T \approx 10^{32}\, Kelvin$ to at least three orders of magnitude less, as we move out from an initial red shift

$$z \approx 10^{25} \quad (50)$$

To [34]

$$T \approx \sqrt{\varepsilon_V} \times 10^{28}\, Kelvin \sim T_{Hawkings} \cong \frac{\hbar \cdot H_{initial}}{2\pi \cdot k_B} \quad (51)$$

Whichever model we can come up with that does this is the one we need to follow, experimentally. And it gives us hope in confirming if or not we can eventually analyze the growth of structure in the initial phases of quantum nucleation of emergent space time [35] .In the end, in future research, we will delineate how this idea which is offered above, ties in with cosmological expansion. In particular, we wish to investigate what is brought up in [36] which we do not believe is correct.

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