What violations of the Null Energy Condition tell us about information exchange between prior to present universes? How to obtain spectral index confirmation?

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Abstract

The universe is now dominated by DE leading to renewed acceleration, so what we can do is to examine how DE arose in the first place, and what role cosmologies not obeying the null energy condition play in terms of facilitating information exchange from a prior to the present universe. So how do we test for this, and what are the data collection protocols? Based upon a Rencontres De Moriond, 2008 article, we present a glimpse as to how to ascertain data collection procedures via inputs into a spectral index model.

Introduction

Our presentation takes note of the following. That if, as stated by Steinhardt, and Wesley [1], one has cosmologies congruent with the null energy condition, with inflation only viable if the initial dark energy phase consistent with observations only possible if both Newton's gravitational constant and the dark energy equation-of-state vary with time. What we have is a dark energy time varying equation of state, due to vacuum energy being altered as below. IF we do not put in Newton's constant changing with time, we then have very strange cosmological behavior which may nix out the idea of not only initial dark energy but the entire working hypothesis of exchange of information from a prior to the present universe. We refer to the concept of the null energy condition and how we can then look at if it is kept, or violated as part of the confirmation of if conditions exist for the Null energy condition. Furthermore, we will also state how issues connected with the null energy condition are of essential importance as to if information can be exchanged between a prior to the present universe. We will state why, and make recommendations as to how confirmation of this last point can be tested via data. The main point of this document will be in, by use of an article by Finelli, Cerioni, and Gruppuso, [2] [3] that there is a way to test for inputs as to the spectral index, n_S . A case by case analysis of what can be ascertained via such inputs will be presented, with recommendations as to how to get these inputs set up experimentally. We will next get to what is needed as far as appropriate vacuum energy

Vacuum energy, sources and commentary

Begin first with looking at different value of the cosmological vacuum energy parameters, in four and five dimensions [4]

$$\left|\Lambda_{5-\dim}\right| \approx c_1 \cdot \left(1/T^{\alpha}\right) \tag{1}$$

in contrast with the more traditional four-dimensional version of the same, minus the minus sign of the brane world theory version. The five-dimensional version is actually connected with Brane theory and higher dimensions, whereas the four-dimensional version is linked to more traditional De Sitter space-time geometry, as given by Park (2003) [5] , Subsequent work by Barvinsky [5] as observed by the author gives additional refinements [4]

$$\Lambda_{4-\dim} \approx c_2 \cdot T^{\beta} \tag{2}$$

Right after the gravitons are released, one still sees a drop-off of temperature contributions to the cosmological constant .Then one can write, for small time values $t \approx \delta^1 \cdot t_P$, $0 < \delta^1 \le 1$ and for temperatures sharply lower than $T \approx 10^{12}\,Kelvin$, Beckwith (2008), where for a positive integer n [4]

$$\frac{\Lambda_{4-\dim}}{|\Lambda_{5-\dim}|} - 1 \approx \frac{1}{n} \tag{4}$$

If there is order of magnitude equivalence between such representations, there is a quantum regime of gravity that is consistent with fluctuations in energy and growth of entropy. An order-of-magnitude estimate will be used to present what the value of the vacuum energy should be in the neighborhood of Planck time in the advent of nucleation of a new universe. The significance of Eq. (4) is that at very high temperatures, it re enforces what the author brought up with Tigran Tchrakian, in Bremen, [6] August 29th, 2008. I.e., one would like to have a uniform value of the cosmological constant in the gravitating Yang-Mills fields in quantum gravity in order to keep the gauges associated with instantons from changing. When one has, especially for times $t_1, t_2 <$ Planck time t_P and $t_1 \ne t_2$, with temperature $T(t_1) \ne T(t_2)$, then $\Lambda_4(t_1) \ne \Lambda_4(t_2)$. I.e., in the regime of high temperatures, one has $T(t_1) \ne T(t_2)$ for times $t_1, t_2 <$ Planck time t_P and $t_1 \ne t_2$, such that gauge invariance necessary for soliton (instanton) stability is broken [7]. That breaking of instanton stability due to changes of $\Lambda_4(t_1) \ne \Lambda_4(t_2)$ will be our point of where we move from an embedding of quantum mechanics in an analog reality, to the quantum regime. I.e. as one reaches to high temperature, analog reality mimics digital quantum mechanics. Let us now look at different characterizations of the discontinuity, which is the boundary between analog reality, and Octonian gravity [7] [8]. Figure 1 below is also using material from Barvinsky [9], and will be useful

Figure 1

Time $0 \le t << t_P$	**Time** $0 \le t < t_P$	**Time** $t \ge t_P$	**Time** $t > t_P \rightarrow$ **today**
$\|\Lambda_5\|$ undefined, $T \approx \varepsilon^+ \rightarrow T \approx 10^{32} K$ $\Lambda_{4-\dim} \approx$ almost ∞	$\|\Lambda_5\| \approx \varepsilon^+$, $\Lambda_{4-\dim} \approx$ extremely large $10^{32} K > T > 10^{12} K$	$\|\Lambda_5\| \approx \Lambda_{4-\dim}$, T much smaller than $T \approx 10^{12} K$	$\|\Lambda_5\| \approx$ huge, $\Lambda_{4-\dim} \approx$ constant , $T \approx 3.2K$

For times $t > t_P \rightarrow$ today, a stable instanton is assumed, along the lines brought up by t'Hooft [10], due to the stable $\Lambda_{4-\dim} \approx$ constant ~ very small value, roughly at the value given today. This assumes a radical drop-off of the cosmological constant for, say right after the electroweak transition. This would be in line with Kolb's assertion of the net degrees of freedom in space-time drop from about 1000 to less than two, especially if $t > t_P \rightarrow$ today in terms of the value of time after the big bang. The supposition we are making here is that the value of N so obtained is actually proportional to a numerical graviton density we will refer to as <n>., provided that there is a bias toward HFGW, which would mandate a very small value for $V \approx R_H^3 \approx \lambda^3$ .Furthermore, structure formation arguments, as given by Perkins [11] give ample evidence that if we use an energy scale, m , over a Planck mass value M_{Planck} , as well as contributions from field amplitude ϕ , and using the contribution of scale factor behavior $\frac{\dot{a}}{a} \equiv H \approx -m \cdot \frac{\phi}{3 \cdot \dot{\phi}}$, where we assume $\ddot{\phi} \cong 0$ due to inflation

$$\frac{\Delta\rho}{\rho} \sim H\Delta t \sim \frac{H^2}{\dot{\phi}} \sim \left(\frac{m}{M_{Planck}}\right) \times \left(\frac{\phi}{M_{Planck}}\right) \sim 10^{-5} \tag{10}$$

At the very onset of inflation, $\phi << M_{Planck}$, and if m (assuming $\hbar = c = 1$) is due to inputs from a prior universe, we have a wide range of parameter space as to ascertain where $\Delta S \approx \Delta N_{gravitons} \neq 10^{88}$ [9] comes from and plays a role as to the development of entropy in cosmological evolution In the next Chapter, we will discuss if or not it is feasible / reasonable to have data compression of prior universe 'information'. It suffices to say that if $S_{initial} \sim 10^{5}$ is transferred from a prior universe to our own universe at the onset of inflation,, at times less than Planck time $t_P \sim 10^{-44}$ seconds, that enough information **MAY** exit for the preservation of the prior universe's cosmological constants, i.e. $\hbar, G, \alpha$ (fine structure constant) and the like. We do not have a reference for this and this supposition is being presented for the first time. Times after t= 10^-44 are not less important. Issues raised in [8], [9], [10], [11], [12], [`3], [14] are important as to the research protocols

Consider now what could happen with a phenomenological model bases upon the following inflection point i.e. split regime of different potential behavior

$$V(\phi) = g \cdot \phi^{\alpha} \tag{11}$$

De facto, what we come up with pre, and post Planckian space time regimes, when looking at consistency of the emergent structure is the following. Namely by adjusting what is done by Weinberg [15] we have [16],

$$V(\varphi) \propto \phi^{|\alpha|} \qquad \text{For } t < t_{PLanck} \tag{12}$$

Also, we would have

$$V(\varphi) \propto 1/\phi^{|\alpha|} \qquad \text{For } t >> t_{PLanck} \tag{13}$$

The switch between Eq. (12) and Eq. (13) is not justified analytically. I.e. it breaks down. Beckwith et al (2011) designated this as the boundary of a causal discontinuity. Now according to Weinberg [15], if

$\in = \frac{\lambda^2}{16\pi G}, H = 1/\in t$ so that one has a scale factor behaving as [15]

$$a(t) \propto t^{1/\in} \tag{14}$$

Then, if [14]

$$|V(\phi)| << (4\pi G)^{-2} \tag{15}$$

there are no quantum gravity effects worth speaking of. I.e., if one uses an exponential potential a scalar field could take the value of, when there is a drop in a field from ϕ_1 to ϕ_2 for flat space geometry and times t_1 to t_2 [15]

$$\phi(t) = \frac{1}{\lambda} \ln\left[\frac{8\pi G g \in^2 t^2}{3}\right] \tag{16}$$

Then the scale factors, from Planckian time scale as [15]

$$\frac{a(t_2)}{a(t_1)} = \left(\frac{t_2}{t_1}\right)^{1/\in} = \exp\left[\frac{(\phi_2 - \phi_1)\lambda}{2\in}\right] \tag{17}$$

The more $\frac{a(t_2)}{a(t_1)} >> 1$, then the less likely there is a tie in with quantum gravity. Note those that the way this potential is defined is for a flat , Roberson-Walker geometry, and that if and when $t_1 < t_{Planck}$ then what is done in Eq. (11) no longer applies, and that one is no longer having any connection with even an Octonionic Gravity regime.

Increase in degrees of freedom in the sub Planckian regime.

Starting with [16], [17]

$$E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \left[\Omega_0 \breve{T}\right] \sim \tilde{\beta} \tag{18}$$

The assumption is that there would be an initial fixed entropy arising, with $\overline{N}$ as a nucleated structure arising in a short time interval as a temperature $T_{temperature} \varepsilon\left(0^+, 10^{19} GeV\right)$ arrives. One then obtains, dimensionally speaking [16], [17]

$$\frac{\Delta\tilde{\beta}}{dist} \cong \left(5k_B \Delta T_{temp} / 2\right) \cdot \frac{\overline{N}}{dist} \sim qE_{net-electric-field} \sim \left[T\Delta S / dist\right] \tag{19}$$

The parameter, as given by $\Delta\tilde{\beta}$ will be one of the parameters used to define chaotic Gaussian mappings. Candidates as to the inflation potential would be in powers of the inflation, i.e. in terms of ϕ^N, with N=4 effectively ruled out, and perhaps N=2 an admissible candidate (chaotic inflation). For N = 2, one gets [16], [16]

$$\left[\Delta S\right] = \left[\hbar/T\right] \cdot \left[2k^2 - \frac{1}{\eta^2}\left[M_{Planck}^2 \cdot \left[\left[\frac{6}{4\pi} - \frac{12}{4\pi}\right] \cdot \left[\frac{1}{\phi}\right]^2 - \frac{6}{4\pi} \cdot \left[\frac{1}{\phi^2}\right]\right]\right]\right]^{1/2} \sim n_{Particle-Count} \tag{20}$$

If the inputs into the inflation, as given by ϕ^2 becomes a random influx of thermal energy from temperature, we will see the particle count on the right hand side of Eq. (20) above a partly random creation of $n_{Particle-Count}$ which we claim has its counterpart in the following treatment of an increase in degrees of freedom. The way to introduce the expansion of the degrees of freedom from nearly zero, at the maximum point of contraction to having **N(T)~ 10^3** is to first define the classical and quantum regimes of gravity in such a way as to minimize the point of the bifurcation diagram affected by quantum processes.[16]. The diagram, in a bifurcation sense would look like an application of the Gauss mapping of [16]. [17]

$$x_{i+1} = \exp\left[-\tilde{\alpha} \cdot x_i^2\right] + \tilde{\beta} \tag{21}$$

In dynamical systems type parlance, one would achieve a diagram, with tree structure looking like what was given by Binous [18], using material written up by Lynch [19] .Now that we have a model as to what could be a change in space time geometry, let us consider what may happen during the Higgs mechanism and why it may not apply as expected in very early universe geometry

Higgs Mechanism and its consequence in the onset of inflation. I.e. why it could break down

Let us The main point as to why the Higgs paradigm may break down lies in the fact that emergent structure can be formulated without use of a broken symmetry potential as given by $m^2\left(\phi\phi + \phi^*\phi^*\right)$. [20]

Relevance to Octonian Quantum gravity constructions? Where does non commutative geometry come into play?

Crowell [21] wrote on page 309 that in his Eq. (8.141), namely

$$\left[x_j, p_i\right] \cong -\beta \cdot \left(l_{Planck} / l\right) \cdot \hbar T_{ijk} x_k \to i\hbar\delta_{i,j} \tag{22}$$

Here, β is a scaling factor, while we have, above, after a certain spatial distance, a Kroniker function so that at a small distance from the confines of Planck time, we recover our quantum mechanical behavior. Our contention is, that since Eq. (22) depends upon Energy- momentum being conserved as an average about quantum fluctuations, that if energy-momentum is violated, in part, that Eq. (22) falls apart. How

Crowell forms Eq. (22) at the Planck scale depends heavily upon Energy- Momentum being conserved. [21] Our construction VIOLATES energy – momentum conservation. N. Poplawski [22], [23] also has a very revealing construction for the vacuum energy, and cosmological constant which we reproduce, here

$$\Lambda = \left[\frac{3\kappa^2}{16}\right]\cdot\left(\overline{\psi}\gamma_j\gamma^5\psi\right)\cdot\left(\overline{\psi}\gamma^j\gamma^5\psi\right) \text{ And } \rho_\Lambda = \left[\frac{3\kappa}{16}\right]\cdot\left(\overline{\psi}\gamma_j\gamma^5\psi\right)\cdot\left(\overline{\psi}\gamma^j\gamma^5\psi\right) \quad (23)$$

Poplawski writes that formation of the above is:

"Such a torsion-induced cosmological constant depends on spinor fields, so it is not constant in time (it is constant in space at cosmological scales in a homogeneous and isotropic universe). However, if these fields can form a condensate then the vacuum expectation value of (**Eq. 23**) *will behave like a real cosmological constant"*

Poplawski [22], [23] write his formulation in terms of a quark- gluon QCD based condensate. Our contention is that once a QCD style condensate breaks up there will be NO equivalent structure to Eq. (22) and Eq. (23) at the beginning of inflation right after the break down of space time particle transfer .Once that condensate structure is not possible then by Eq. (8.140) of Crowell [21], the following will not hold:

$$\oint p_i \, dx_k = \hbar\delta_{i,k} \quad (24)$$

Eq. (8.40) of the Crowell [21] manuscript also makes the additional assumption, that non flat space has a geometric non-commutativity protocol which is delineated by the following spatial relationship. When Eq. (25) goes to zero, we recover the regime in which quantum mechanics holds.

$$\left[x_j, x_k\right] = \beta \cdot l_P \cdot T_{j,k,l} \cdot x_l \quad (25)$$

Does the (QCD) condensate occur post Plankian, and not work for pre Plankian regime? Yes. The problem lies with Eq. (8.140) of Crowell [21] with the final equality not holding. If one were integrating across a causal barrier,

$$\oint [x_j, p_i]dx_k \approx -\oint p_i[x_j, dx_k] = -\beta \cdot l_P \cdot T_{j,k,l} \oint p_i dx_l \neq -\hbar\beta \cdot l_P \cdot T_{i,j,k} \quad (26)$$

Very likely, across a causal boundary, between $\pm l_P$ across the boundary due to the causal barrier, one would have

$$\oint p_i \, dx_k \neq \hbar\delta_{i,k}, \oint p_i \, dx_k \equiv 0 \quad (27)$$

I.e.

$$\left.\oint_{\pm l_P} p_i dx_k\right|_{i=k} \to 0 \quad (28)$$

If so, then [21]

$$\left[x_j, p_i\right] \neq -\beta \cdot \left(l_{Planck} / l\right) \cdot \hbar T_{ijk} x_k \quad and \quad does \quad not \to i\hbar\delta_{i,j} \quad (29)$$

Eq. (29) in itself would mean that in the pre Planckian physics regime, and in between $\pm l_P$, QM no longer applies. What we will do next is to begin the process of determining a regime in which Eq. (29) may no longer hold via experimental data sets

Summary as to what is known, and not known about the Null Energy Condition in Cosmology. And information exchange between Prior to Present Universes.

As stated in [1], the NEC is linked to the following, i.e. look at the general null energy condition first

The null energy condition stipulates that for every future-pointing null vector field (for all of the GR) $\vec{k}$

$$\rho = T_{ab}\, k^a\, k^b \geq 0. \quad (30)$$

With respect to a frame aligned with the motion of the matter particles, the components of the matter tensor take the diagonal form, in Euclidian space that

$$T^{\hat{a}\hat{b}} = \begin{bmatrix} \rho & 0 & 0 & 0 \\ 0 & p & 0 & 0 \\ 0 & 0 & p & 0 \\ 0 & 0 & 0 & p \end{bmatrix} . \tag{31}$$

The simplest statement of the Null energy condition is that he null energy condition stipulates that

$$\rho + p \geq 0. \tag{32}$$

I.e. the equation of state to consider is, if $w \leq -1$, then if what [1] suggests is true, then there will be a reason to consider the relative import of Eq. (30), Eq. (31), and Eq. (32) in terms of contributions. I.e. we do have problems with the idea of variance of the cosmological constant, G, and will reference it. We also will build upon the consequences of $w \leq -1$, and Eq. (30), Eq. (31), and Eq. (32) as far as first principle treatments of if information exchange between a prior to present universe is feasible and experimentally testable. One of the simplest examples of a break down of the NEC, is the Casmir effect. We can generalize this idea to initial domain wall physics. Spherical geometry as we know it does not violate the NEC. Further domain wall physics may lead to a break down of the NEC [1]. We also refer to a treatment of the NEC, and its possible consequences if we look at an effective Friedman equation as given by [15], as seen by

$$H_a^2 = \left[\frac{\dot{a}}{a}\right]^2 = \frac{8\pi G}{3} G \cdot \rho + \left(\frac{\kappa^2}{24 \cdot (3+n)}\right) \cdot [2 + n \cdot [1 - 3 \cdot (\nu - w)]] \cdot \rho^2 - e \tag{33}$$

The scaling done in this situation has [15], especially if e is a constant in Eq. (33)

$$\rho = a^{-3 \cdot [1+w]} \tag{34}$$

As stated in [16]. We expect that there will be flat space geometry almost in the beginning of the early big bang. I.e. this will lead to Eq. (34), if $w < -1$ implying that $\rho = a^{-3 \cdot [1+w]} \sim a^{+\varepsilon} \to 0^+$ if there is a violation of the NEC. As quoted from [16]. We consider t he inter play of bits to information. I.e. as seen in a colloquium presentation done by Dr. Smoot in Paris [24] (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 accounts for perhaps 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 bozonification phase of matter right at the onset of the big bang itself . Beckwith [25] stated criteria as far as graviton production, and a toy model of the universe. If one has Eq. (2) [2] shut off due to $w < -1$, so then that $\rho = a^{-3\cdot[1+w]} \sim a^{+\varepsilon} \to 0^{+}$ occurs, then the causal discontinuity so references in [26], [27] by Beckwith et al, will have major consequences as far as a away to determine if gravitons have a small mass, and if there is a way to determine if a prior universe has contribution as to the information transferred as to the present universe. We will now assume, that the catastrophe given as stated by $\rho = a^{-3\cdot[1+w]} \sim a^{+\varepsilon} \to 0^{+}$ does not occur. We will then refer to how one could have

First principles argument as to large scale values of the absolute magnitude of the cosmological vacuum energy

Look at an argument provided by Thanu Padmanabhan [28], leading to the observed cosmological constant value suggested by Park. Assume that $l_P \sim 10^{-33} cm \xrightarrow[Quantum-Gravity-threshold]{} \tilde{N}^{\alpha} \cdot l_P$, but that when we make this substitution that $1 \leq \tilde{N}^{\alpha} \leq 10^{2}$ [28], [29]

$$\begin{aligned} \rho_{VAC} &\sim \frac{\Lambda_{observed}}{8\pi G} \sim \sqrt{\rho_{UV} \cdot \rho_{IR}} \\ &\sim \sqrt{l_{Planck}^{-4} \cdot l_{H}^{-4}} \sim l_{Planck}^{-2} \cdot H_{observed}^{2} \end{aligned} \qquad (35)$$

$$\Delta\rho \approx \text{a dark energy density} \sim H_{observed}^{2} / G \qquad (36)$$

We can replace $\Lambda_{observed}, H_{observed}^{2}$ by $\Lambda_{initial}, H_{initial}^{2}$. In addition we may look at inputs from the initial value of the Hubble parameter to get the necessary e folding needed for inflation, according to

$$\begin{aligned} &E-foldings = H_{initial} \cdot \left(t_{End\, of\, \inf} - t_{beginning\quad of\, \inf} \right) \equiv N \geq 100 \\ &\Rightarrow H_{initial} \geq 10^{39} - 10^{43} \end{aligned} \qquad (37)$$

Leading to

$$a(End - of - \inf) / a(Beginning - of - \inf) \equiv \exp(N) \qquad (38)$$

If we set $\Lambda_{initial} \sim c_1 \cdot \left[T \sim 10^{32}\, Kelvin \right]$ implying a very large initial cosmological constant value, we get in line with what Park suggested for times much less than the Planck interval of time at the instant of nucleation of a vacuum state

$$\Lambda_{initial} \sim \left[10^{156} \right] \cdot 8\pi G \approx huge \quad number \qquad (39)$$

It is easy to infer, with minimum effort that Eq. (2) and Eq. (39) give much the same information. Provided that $w < -1$, our argument that inflation needs Eq. (2) is confirmation as to what was said in [1]. If we avoid then, having $w < -1$, then the following may hold and needs experimental verification.

Minimum amount of information needed to initiate placing values of fundamental cosmological parameters

A.K. Avessian's [30] article (2009) about alleged time variation of Planck's constant from the early universe depends heavily upon initial starting points for $\hbar(t)$, as given below, where we pick our own values for the time parameters, for reasons we will justify in this manuscript:

$$\hbar(t) \equiv \hbar_{initial}\left[t_{initial} \le t_{Planck}\right] \cdot \exp\left[-H_{macro} \cdot \left(\Delta t \sim t_{Planck}\right)\right] \tag{40}$$

The idea is that we are assuming a granular, discrete nature of space time. Furthermore, after a time we will state as t ~ t $_{Planck}$ there is a transition to a present value of space time, which is then probably going to be held constant. It is easy to, in this situation, to get an inter relationship of what $\hbar(t)$ is with respect to the other physical parameters, i.e. having the values of α written as $\alpha(t) = e^2 / \hbar(t) \cdot c$, as well as note how little the fine structure constant actually varies. Note that if we assume an unchanging Planck's mass $m_{Planck} = \sqrt{\hbar(t)c/G(t)} \sim 1.2 \times 10^{19}\, GeV$, this means that G has a time variance, too. This leads to us asking what can be done to get a starting value of $\hbar_{initial}\left[t_{initial} \le t_{Planck}\right]$ recycled from a prior universe, to our present universe value. What is the initial value, and how does one insure its existence? We obtain a minimum value as far as 'information' via appealing to Hogan's [31] (2002) argument where we have a maximum entropy as

$$S_{\max} = \pi / H^2 \tag{41}$$

, and this can be compared with A.K. Avessian's article [40] (2009) value of, where we pick $\Lambda \sim 1$

$$H_{macro} \equiv \Lambda \cdot \left[H_{Hubble} = H\right] \tag{42}$$

I.e. a choice as to how $\hbar(t)$ has an initial value, and entropy as scale valued by $S_{\max} = \pi / H^2$ gives us a ball park estimate as to compressed values of $\hbar_{initial}\left[t_{initial} \le t_{Planck}\right]$ which would be transferred from a prior universe, to today's universe. If $S_{\max} = \pi / H^2 \sim 10^5$, this would mean an incredibly small value for the INITIAL H parameter, i.e. in pre inflation, we would have practically NO increase in expansion, just before the introduction vacuum energy, or emergent field energy from a prior universe, to our present universe. Typically though, the value of the Hubble parameter, during inflation itself is HUGE, i.e. H is many times larger than 1, leading to initially very small entropy values. This means that we have to assume, initially, for a minimum transfer of entropy/ information from a prior universe, that H is neligible. If we look at Hogan's holographic model, this is consistent with a non finite event horizon [31]

$$r_0 = H^{-1} \tag{43}$$

This is tied in with a temperature as given by

$$T_{black-hole} = (2\pi \cdot r_0)^{-1} \tag{44}$$

Nearly infinite temperatures are associated with tiny event horizon values, which in turn are linked to huge Hubble parameters of expansion. Whereas initially nearly zero values of temperature can be arguably linked to nearly non existent H values, which in term would be consistent with $S_{\max} = \pi / H^2 \sim 10^5$ as a starting point to entropy. Doing this will require that we keep in mind, as Hogan writes, that the number of distinguishable states is writable as [31]

$$N = \exp(\pi H^{-2}) \quad (45)$$

If , in this situation, that N is proportional to entropy, i.e. N as ~ number of entropy states to consider, , then as H drops in size, as would happen in pre inflation conditions, we will have opportunities for N ~ 10^5

. Determination if the NEC is valid is essential as establishing a necessary condition for transfer of information from a prior universe to Today's Cosmos;

How to do this? I.e. how to determine if, as an example there is a thermal, flux from a prior universe carrying prior universe information? We will briefly revisit a first principle introduction as to inflaton fluctuations in the beginning which may be part of how to obtain experimental falsifiable criterion. From Weinberg [15], we can write, from page 192-93, if an inflaton potential $V(\phi) \sim M^{4+\alpha}\phi^{-\alpha}$ then, the inflaton potential has the fluctuation behavior given by

$$\delta\phi \sim t^{\gamma} \quad (46)$$

Then, this assumes

$$\gamma = -.25 \pm \sqrt{\frac{1}{16} - \frac{(6+\alpha)\cdot(1+\alpha)}{(2+\alpha)^2}} \quad (47)$$

The resulting contributions to the CMBR, if worked out, and also connections to gravitational wave astronomy as can be gleaned eventually can be used to pin point an eventual CMBR physics behavior as referred to by Beckwith [32] may after time start giving us ideas if the NEC holds, or does not hold.

How to calculate the Spectral index n_S for a dissipative regime of the inflaton?

We are largely borrowing in this introduction from work done by Finelli, Cerion, and Gruppuso [2], [3] and we will introduce the motivation behind their work as well as the actual Spectral index n_S. To begin with look at what FInelli at al [1], [2] postulate as to the case of warm inflation. I.e. as given by [2], [3], if the equation of state $\omega_F = p_F / \rho_F$ is linked to $[3H\rho_F \cdot (1+\omega_F)] \cong \Gamma\dot{\phi}^2$ so then we get the statement of

$$\ddot{\phi} + [3H + \Gamma]\dot{\phi} + \left(\frac{\partial V}{\partial \phi}\right) = 0 \quad (48)$$

We can count the term given as $[3H + \Gamma]\dot{\phi}$ as a damping term, as well as consider

$$[3H + \Gamma]\dot{\phi} + \left(\frac{\partial V}{\partial \phi}\right) \cong 0 \quad (49)$$

The above dynamics, if $V_{\phi\phi} = \frac{d^2V}{d\phi^2}$, and $\Gamma = \Gamma_0 \cdot \left[\frac{\phi}{\phi_0}\right]^b \cdot \left[\frac{\sqrt[4]{\rho_F}}{M}\right]^C$, and

$$\gamma = \frac{\Gamma}{3H}, \varepsilon = -\frac{\dot{H}}{H^2}, \eta_{\phi\phi} = \frac{V_{\phi\phi}}{3H^2} \quad (50)$$

For the sake of convenience, we can use $V_{\phi\phi}$ ~ constant, i.e. the quadratic scalar potential. But this is a special case of what we will refer to later. If so, then the equations for perturbations, inflaton perturbations, Q_ϕ, Q_F as respectively the inflaton, and the fluid fluctuations leads to initial conditions of

$$Q_{\phi|k} \cong \exp[-ik \cdot (\tau - \tau_i)] \Big/ \left(a^{1+\frac{3}{2}\gamma} \sqrt{2k} \right),$$
$$Q_{F|k} \cong \exp[-ik \cdot (\tau - \tau_i)] \Big/ \left(a^{1+\frac{3}{2}(1+\omega_F)(1-g)} \sqrt[4]{4k^2 \omega_F} \right) \tag{51}$$

The upshot is that one gets the following as far as a running index [2], [3]

$$n_S - 1 \cong -3\gamma^* + \frac{2}{1+\gamma^*}\eta^* - 6 \cdot \left[\frac{1 + \frac{4}{3}\gamma^* + \frac{1}{2}[\gamma^*]^2}{1+\gamma^*} \right] \cdot \varepsilon^* \tag{52}$$

Here, the * factor is for values of the parameters when the cosmological evolution crosses a radius defined by (k_ = a_ H_). In [2] there are two tables as far as inputs/ out puts into running index, which have to take into account several constraints. I.e. when one has, as was stated a situation for which

$$\Gamma = \Gamma_0 \cdot \left[\frac{\phi}{\phi_0} \right]^b \cdot \left[\frac{\sqrt[4]{\rho_F}}{M} \right]^C = const \tag{53}$$

Either b= C = 0, which is possible, or one could have, if $b \neq 0, C \neq 0$, a situation for which one can have

$$\cdot \left[\frac{\phi}{\phi_0} \right]^b \cdot \left[\frac{\sqrt[4]{\rho_F}}{M} \right]^C = const \tag{54}$$

What if one had, ϕ_0 being a present day, very small value of a scalar field

$$\phi = const \cdot \phi_0 \cdot \left[\frac{M}{\sqrt[4]{\rho_F}} \right]^{C/b} \tag{55}$$

We can probably assume in all of this that M as a mass scale is fixed. When the author looks at Eq. (55), it appears to be implying the relative value of density, i.e. ρ_F varies with time. I.e. if one looked at the Octonian gravity formation regime we could look at variation of looking maybe like $\rho_F \sim H^2_{observed} \big/ G$ The term about the relationship of [33], where a is a constant, and $g^*(T)$ is the number of degrees of freedom,

$$\rho_F \sim H^2_{observed} \big/ G \approx 4\pi \cdot aT^4 g^*(T)/3c^2 \tag{56}$$

There are two different scenarios as far as temperature build up and how it affects $g^*(T)$, and also initial temperatures.

1st, version of classical/ standard cosmology treatment of the start of inflation. I.e. the ultra high temperature regime to cooler temperatures

Here, as given by Kolb and Turner [34], $g^*(T)$ has a peak of about 100-120 during the electro weak regime, and that there is allegedly little sense in terms of modeling of talking about $g^*(T)$ before the electro weak regime. What it means? In so many words, we would then have ρ_F undefined before the electro weak regime. I.e. we are STUCK. ϕ would then be undefined before the electro weak regime. It does mean that at the start of the electro weak regime, we would see an increasing ϕ. Which is the opposite of what we see. I.e. we need ϕ decreasing. Meaning that either $g^*(T)$ is defined before the electro weak phase transition, or Eq. (54) no longer holds.

2nd, version of the classical/ standard cosmology treatment of the start of inflation. I.e. the ultra high temperature regime to cooler temperatures

Here, we have that the inflaton potential is not affected by Eq. (54). , and then we have, possibly, starting with Padmanabhan's formulas [28]:

$$V(t) \equiv V(\phi) \sim \frac{3H^2}{8\pi G} \cdot \left(1 + \frac{\dot{H}}{3H^2}\right) \tag{57}$$

$$\phi(t) \sim \int dt \cdot \sqrt{\frac{-\dot{H}}{4\pi G}} \tag{58}$$

Now for the incorrect argument which has Eq. (58) going to zero as time goes to zero. If $H = \dot{a}/a$ is a constant, Eqn. (58) gives us zero scalar field values at the beginning of quantum nucleation of a universe. At the point of accelerated expansion (due to the final value of the cosmological constant), it also gives an accelerating value of the cosmological scale-factor expansion rate. We justify this statement by using early-universe expansion models, which have $a(t_{INITIAL}) \sim e^{H \cdot t}$. This leads to the derivative of $H = \dot{a}/a$ going to zero. This is similar to present-time development of the scalar factor along the lines of $a(t_{later}) \sim e^{(\Lambda[present-day] \cdot t)}$, also leading to the derivative of $H = \dot{a}/a$ going to zero. When both situations occur, we have the scale factor $\phi = 0$. Between initial and later times, the scale factor no longer has exponential time dependence, due to it growing far more slowly, leading to $\phi \neq 0$. One big problem, i.e. $\dot{H} = \frac{d}{d\tau}[\dot{a}/a] \neq 0$, even at the start of the inflationary era. The proof of this is seen in $H = [\dot{a}/a] \sim g^*(T)T^4 \neq 0$ and changing in time due to different temperatures and as well as $H \sim \sqrt{(8/3)\pi G \rho}$ with ρ not constant in time. Furthermore, especially if one looks at race track models, we would have real and imaginary components to the scalar field which can be identified as of the form X_i for the real part to the scalar field ϕ^i, and Y_j for the imaginary part of the scalar field ϕ^j, as well as having

$$H^2 \equiv \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3} \cdot \left[\frac{1}{2} \cdot g^{ij} \dot{\phi}^i \dot{\phi}^j + V\right] \tag{59}$$

JJ Blainco-Pillado et al [35]. Use this methodology, using the physics of the Christoffel symbol as usually given by

$$\Gamma^i_{jk} = \frac{1}{2} \cdot g^{i,\sigma} \cdot \left(\partial_j g_{k,o} + \partial_k g_{\rho,j} - \partial_\rho g_{j,k}\right) \tag{60}$$

If one has no coupling of terms as in an expanding universe metric of the form [36]

$$dS^2 = -dt^2 + a^2(t) \cdot \delta^i_j dx^i dx^j \tag{61}$$

Then the Christoffel symbols take the form given by

$$\begin{aligned} \Gamma^{i}_{00} &= 0, \\ \Gamma^{i}_{j0} = \Gamma^{i}_{0j} &= \frac{\dot{a}}{a}\delta^{i}_{j}, \\ \Gamma^{i}_{jk} &= 0 \end{aligned} \tag{62}$$

The implications of the scalar evolution equation are that we have

$$\ddot{\phi}^{i} + 3H\dot{\phi}^{i} + (\dot{a}/a)\cdot\delta^{i}_{j}\dot{\phi}^{j}\dot{\phi}^{0} + g^{ij}\frac{\partial V}{\partial \phi^{j}} = 0 \tag{63}$$

If we can write as follows, i.e. say that we have $\dot{\phi}^{0} \sim 0$, as well as have $g^{ij} \equiv g^{ii} = \pm 1$,

$$g^{00} \equiv 1, g^{ii} = -1, \quad if \quad i = j \neq 0 \tag{64}$$

$$\ddot{\phi}^{i} + 3H\dot{\phi}^{i} + H\cdot\dot{\phi}^{i}\dot{\phi}^{0} + g^{ii}\frac{\partial V}{\partial \phi^{i}} = 0 \tag{65}$$

$$\dot{\phi}^{0} \sim 0 \Rightarrow \ddot{\phi}^{i} + 3H\dot{\phi}^{i} - \frac{\partial V}{\partial \phi^{i}} = 0 \tag{66}$$

On the other hand,

$$\dot{\phi}^{0} \sim 1 \Rightarrow \ddot{\phi}^{i} + 4H\dot{\phi}^{i} - \frac{\partial V}{\partial \phi^{i}} = 0 \text{ Provided } t \leq t_{P} \tag{67}$$

Otherwise, taking into account the causal discontinuity expression, we claim we will be working with

$$\ddot{\phi}^{i} + 3H\dot{\phi}^{i} - \frac{\partial V}{\partial \phi^{i}} = 0 \text{ Provided } t > t_{P} \tag{68}$$

For very short time duration, and looking at the case for chaotic inflation, we would be working with, in this situation $\frac{\partial V}{\partial \phi^{i}} \cong M_{P}\phi_{i}$. Set an ansatz with regards to

$$\ddot{\phi}^{i} + 4H\dot{\phi}^{i} - M_{P}^{2}\phi_{i} = 0 \text{ Provided } t \leq t_{P} \tag{69}$$

If $\phi_{i} \sim e^{bt}$, Eqn. (69) $\Rightarrow b^{2} + 4Hb - M_{P}^{2} = 0 \Rightarrow b = -2H \pm \sqrt{4H^{2} + 4M_{P}^{2}}$ (70)

This would lead to, if provided $t \leq t_{P}$, and for a short period of time, H is ALMOST a constant

$$\phi \approx c_{1}\exp\left[\left(-2\cdot H - \sqrt{4H^{2} + 4M_{P}^{2}}\right)\cdot t\right] + c_{2}\exp\left[\left(-2H + \sqrt{4H^{2} + 4M_{P}^{2}}\right)\cdot t\right] \tag{71}$$

Similarly, for $t > t_P$, assuming for a short period of time that H is approximately a constant.

$$\phi \approx c_1 \exp\left[(-\frac{3}{2} \cdot H - \sqrt{\frac{9}{4}H^2 + 4M_P^2}) \cdot t \right] + c_2 \exp\left[(-\frac{3}{2}H + \sqrt{\frac{9}{4}H^2 + 4M_P^2}) \cdot t \right] \qquad (72)$$

Ups shot is that for $t > t_P$, there is a greater rate of growth in the ϕ scalar field than is the case when $t \le t_P$

How to tie in the entropy with the growth of the scale function? Racetrack models of inflation, assuming far more detail than what is given in this simplistic treatment provide a power spectrum for the scalar field given by

$$P \sim \frac{1}{150\pi^2} \cdot \frac{V(\phi)}{\in} \qquad (74$$

This is assuming a slow roll parameter treatment with $\in << 1$, and for $t > t_P$. Eqn. (71), and Eq. (72) would be growing fairly rapidly in line with what is said about Eqn. (74) above. An increase in scalar power, is then proportional to an increase in entropy via

$$\left| \frac{\Delta E}{l_P^3} \right| \sim \left| \frac{\Delta P \in 150\pi^2}{l_P^3} \right| \approx |\Delta S| \qquad (75)$$

This presumes that we have a well defined $V(\phi)$ before the start of the Planck time interval. That is, if we want to make the equivalent statement $|\Delta S|$ ~ n for a numerical relic count, as done by Ng [12] does not tell us where the relic particles came from, As we also note in [20] we can employ Sherrer k essence arguments as to how to form relic particles without using a potential explicitly for times less than Planck time interval.

1st , new treatment of the start of inflation. I.e. first low temperature, then ultra high temperature regime to cooler temperatures (low to high then low temperature evolution)

This involves using the initial analysis, except that one has $g^*(T)$ defined initially as of about 2 in pre Planckian space time, rising to about 1000, as of Planck time, and then from there declining. The initial temperature would be low, which would rise to a peak temperature, i.e. Planck temperature value, and then subsequently moving to values seen today. This scenario is outlined in [20], and has the advantage of explaining at least before to about the Planck time interval, how Eq. (55) could resort to a rising temperature. Now, having said, that, what is the advantage toward having $\Gamma = \Gamma_0 \cdot \left[\frac{\phi}{\phi_0}\right]^b \cdot \left[\frac{\sqrt[4]{\rho_F}}{M}\right]^C$ constant with rising inflaton value, ϕ and with $b \neq 0, C \neq 0$?

Advantages of $\Gamma = const$, with rising inflaton value, ϕ up to Planck time interval?

1st we have a natural reason for $\Lambda_{4-\dim}$ *varying, and also* $\rho_F \neq const$ **.**

2nd we have a reason for avoiding $\omega_F < -1$. Note that by [20], that $\omega_F < -1$ means it is likely that prior information from a previous universe would likely not be exchanged with our present universe. This by use of Eq. (34)

3rd, within a very short interval of time, Eq. (48) and Eq. (49) in the case of chaotic inflation (Quadratic scalar inflation potential) are a simple SHO with damping. I.e. this is similar to:

Observe the following argument as given by V. F. Mukhanov, and S. Winitzki,[37],[38] as to additional particles being 'created' due to what is an infusion of energy in an oscillator , obeying the following equations of motion , [37], [38]

$$\ddot{q}(t) + \omega_0^2 q(t) = 0, \text{ For } t < 0 \text{ and } t > \breve{T};$$

$$\ddot{q}(t) - \Omega_0^2 q(t) = 0, \text{ For } 0 < t < \breve{T} \tag{76}$$

Given $\Omega_0 \breve{T} >> 1$, with a starting solution of $q(t) \equiv q_1 \sin(\omega_0 t)$ if t <0, (Mukhanov) that for, [36], [37] $t > \breve{T};$

$$q_2 \approx \frac{1}{2}\sqrt{1 + \frac{\omega_0^2}{\Omega_0^2}} \cdot \exp\left[\Omega_0 \breve{T}\right] \tag{77}$$

The Mukhanov et al argument, [36] leads to an exercise which Mukhanov claims is solutions to the exercise yields an increase in number count, as can be given by setting the oscillator in the ground state with $q_1 = \omega_0^{-1/2}$, with the number of particles linked to amplitude by $\breve{n} = [1/2] \cdot (q_0^2 \omega_0 - 1)$, leading to, [37], [38]

$$\breve{n} = [1/2] \cdot \left(1 + \left[\omega_0^2 / \Omega_0^2\right]\right) \cdot \sinh^2\left[\Omega_0 \breve{T}\right] \tag{78}$$

I.e. for non zero $\left[\Omega_0 \breve{T}\right]$, Eq. (78) leads to exponential expansion of the numerical state. [37], [38]. This imput of energy i.e. exactly similar to when avoiding $\omega < -1$ as presented in [20]. As well as a temperature dependent $\Lambda_{4-\dim}$ value.

Comparing the re acceleration of the universe, via deceleration parameter, initially and finally speaking

The use of Eq. (79) below to have re-acceleration in this formulation is dependent upon 'heavy gravity' as the rest mass of gravitons in four dimensions has a small mass term. This equation below is developed by Beckwith [39], [40], and [41]

$$q = -\frac{\ddot{a}a}{\dot{a}^2} \tag{79}$$

We wish next to consider what happens not a billion years ago, but at the onset of creation itself. If a correct understanding of initial graviton conditions is presented, it **may** add more credence to the idea of a small graviton mass, in a rest frame, which may give backing – in part – to Beckwith's use of Eq. (1.2) for re-acceleration of the universe, in a manner usually associated with Dark Energy. 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 $l_{Planck} \sim 10^{-35}$ meters [42] [43].

$$m_{graviton}\Big|_{RELATIVISTIC} < 4.4\times10^{-22} h^{-1} eV / c^2$$
$$\Leftrightarrow \lambda_{graviton} \equiv \frac{\hbar}{m_{graviton}\cdot c} < 2.8\times10^{-8} meters \quad (80)$$

For looking at the onset of creation, with a LQG bounce; if we look at $\rho_{\max} \propto 2.07\cdot\rho_{planck}$ for the LQG **quantum bounce** with a value put in for when $\rho_{planck} \approx 5.1\times10^{99}$ grams/ meter^3, where

$$E_{eff} \propto 2.07\cdot l_{Planck}^3\cdot\rho_{planck} \sim 5\times10^{24} GeV \quad (81)$$

Then, taking note of this, one is obtaining having scaled entropy of $S \equiv E/T \sim 10^5$ when one has an initial Planck temperature $T \approx T_{Planck} \sim 10^{19} GeV$. One then needs to consider, if the energy per given graviton is, if a frequency $\nu \propto 10^{10} Hz$ and $E_{graviton-effective} \propto 2\cdot h\nu \approx 5\times10^{-5} eV$, then

$$S \equiv E_{eff}/T \sim \left[10^{38}\times E_{graviton-effective}\left(\nu\approx10^{10} Hz\right)\right]/\left[T\sim10^{19} GeV\right] \approx 10^5 \quad (82)$$

Having said that, the $\left[E_{graviton-effective} \propto 2\cdot h\nu \approx 5\times10^{-5} eV\right]$ is 10^{22} greater than the rest mass energy of a graviton if $E \sim m_{graviton}\left[red-shift \sim .55\right] \sim \left(10^{-27} eV\right)$ grams is taken. If that is true, the approximation so offered may be de facto

$$H \sim 1.66\cdot\left[\sqrt{\tilde{g}_*}\right]\cdot[T^2/m_{Planck}^2] \quad (83)$$

Here, the factor put in, of $\tilde{g}_*$ is the number of degrees of freedom. Kolb and Turner [34] put a ceiling of about $\tilde{g}_* \approx 100-120$ 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

$$S \sim 3\frac{m_{Plank}^2\left[H = 1.66\cdot\sqrt{\tilde{g}_*}\cdot T^2/m_{planck}\cdot\right]^2}{T} \sim 3\cdot\left[1.66\cdot\sqrt{\tilde{g}_*}\right]^2 T^3 \quad (84)$$

What we should consider is the **interplay between Eq. (82) and Eq. (84)**. It so happens the following may be relevant. Should the degrees of freedom hold, for temperatures much greater than a given temperature T^*, and with $\tilde{g}_* \approx 1000$ at the onset of inflation, for temperatures, rising up to, say T* ~ T ~ 10 to the 19 power GeV, from initially a very low level pre-inflation, then this may be enough to explain how and why certain particles may arise in a nucleated state, with information necessarily being transferred from a prior to a present universe. This, however, assumes that one does have low temperatures in Pre Planckian physics, which become very high in the Planckian regime, and which sharply declines afterwards.

Conclusion. What to make of Pre – Planckian physics

Finelli et al {2} claims that $\gamma^* \geq .01$ does not match observations, with $\gamma = \frac{\Gamma}{3H}$. We gave arguments in the prior session as to the feasibility of having Γ as a constant, which often appears to create serious difficulties. If one has Γ as a constant, with rising inflaton value, ϕ up to Planck time interval we have a natural reason for $\Lambda_{4-\dim}$ varying, and also $\rho_F \neq const$, assuming that with rising inflaton value, ϕ up to Planck time interval?

1st we have a natural reason for $\Lambda_{4-\dim}$ varying, and also $\rho_F \neq const$ $g^*(T)$ with rising inflaton value, ϕ up to Planck time interval?

1st we have a natural reason for $\Lambda_{4-\dim}$ varying, and also $\rho_F \neq const$ varies with $g^*(T)$ varying from 2 to 1000 before the electro weak era, and $\rho_F \neq const$ having $S \sim 3 \cdot \left[1.66 \cdot \sqrt{\tilde{g}_*}\right]^2 T^3$ increasing in a net temperature increase up to at least 10^5 from nearly zero, initially. A useful consideration. The author is convinced that quantum physics is part of a more general non linear theory [8]. The author has communicated with people in Frontiers of Fundamental physics 11 as to how, also, inflation physics may need to be revisited. This was at the heart of the work done by the author in Chonquing, PRC during November 2010, on a joint USA-Chinese gravitational wave detector project, and with due consideration, a new science article [44] is being written by that team , which the author is part of which may enable investigations as to the issues brought up in this document.

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