

# Entropy growth in the early universe, and the search for determining if gravity is classical or quantum , part II (Do physical laws/ physics parameter constants remain invariant from a prior universe, to the present universe?)

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## Abstract

The invariance of physical law between a prior to a present universe is brought up, as a continuation of analyzing entropy in today's universe, and the relationship of entropy to information content in a prior universe. If or not there is enough information to preserve the amount of physical law also may play a role as to if or not additional dimensions for cosmological dynamics is necessary.

## Introduction.

The author, Beckwith, is aware of how data compression, and organized information from a prior universe to a present universe is often mistakenly conflated with intelligent design. In order to avoid such specious logic, the present paper's inquiry is restricted to the essentials of finding what minimum amount of information transfer from a prior to a present universe is necessary to possibly preserve the minimum structure and character of physical law from prior to present universe. I.e. Dr. Beckwith has no interest in following in the foot steps of Dr. Tipler. Secondly, the author, Beckwith, is fully aware that photons in our present day have no mass. A speculation as to a tiny effective minimum photon mass, is presented along the line's of Honig's (1974) document before red shift values of  $Z=1100$ . Before 380 thousand years after the big bang, there was still photon related cosmological evolutions as defined by J. A. S. Lima (1996), which can be summarized, for temperature related behavior as photons having number and energy densities

specified as  $n_r|_{Photons} \sim T^3, \rho_r|_{Photons} \sim T^4$ , so that for an instantaneous co moving number of photons,

Lima write  $N_r|_{Photons} = n_r|_{Photons} \cdot T$ , where  $T$  is for background temperature and states that this value

$N_r|_{Photons}$  must be a constant. Lima quotes a researcher, Steigman in saying that "Unless the number of co moving photons in a co moving volume is constant, a blackbody distribution (of photons) is destroyed as the universe evolves". In addition, Lima's key result which can be summarized as follows, that even if

$N_r|_{Photons}$  has a changing time component that there exists entropy associated with photons,  $S_r|_{Photons}$  so

that the following relationship holds for any Friedman style cosmology, namely  $\dot{S}_r|_{Photons} / S_r|_{Photons} = \dot{N}_r|_{Photons} / N_r|_{Photons}$ , where the dot is time . If what is suggested by Beckwith

(2009), with respect to his revision of Y.Ng's counting algorithm is correct, with respect to early universe conditions is correct, i.e.  $\dot{S}_r|_{gravitons} / S_r|_{gravitons} = \dot{N}_r|_{gravitons} / N_r|_{gravitons}$  is also equal to a ratio of the

time derivative of the number of gravitons, over the number of gravitons, and this in term is equal to the time derivative of entropy of graviton production, over entropy of graviton production at the onset of the universe, then in fact what one is working with is, de facto, one is looking at , then for initial conditions of

$$\dot{S}_r|_{Photons} / S_r|_{Photons} = \dot{N}_r|_{Photons} / N_r|_{Photons} \sim \dot{S}_r|_{gravitons} / S_r|_{gravitons} = \dot{N}_r|_{gravitons} / N_r|_{gravitons} \quad (0)$$

This should be a starting point to the analysis which proceeds in this paper, I.e. Eqn. (0) as compared with the  $S_{max} = \pi / H^2 \sim 10^5$  or larger at the origins of the big bang will be a starting point in information

/data comparison. Note, if Eqn.(0) holds, and  $m_{graviton} \sim 10^{-65}$  grams, then maybe photons have tiny mass

## How to compare Eqn. (0) with photon entropy “information” compared with graviton entropy information

We will now begin to try to make an equivalence between  $S_{\max} = \pi/H^2 \sim 10^5$ , and Eqn (0) above.

This after a time lead Beckwith to adopt a tiny mass to the graviton, in line with Honig’s paper doing the same, Note that this present **paper**, written by Beckwith is to evaluate what is the minimum amount of INFORMATION from a prior universe to our present which would permit the same sort of physical laws in a prior universe, to our present universe. If the basic physical constants remain the same from a prior to our present universe, then the basic characteristic of physical law will remain invariant. Otherwise, different universe cycles will have different physics. For our own universe, experimental evidence places an upper limit on how much the "constants" could have changed. Broadly, the answer is: at most one percent over the lifetime of the universe, in our present cycle of creation. One nice piece of evidence comes from Supernova 1987a, which was special because it was not very far away. Theory predicts that such a supernova would create about 0.1 solar masses of nickel-56, which is radioactive. Nickel-56 decays with a half-life of 6.1 days into cobalt-56, which in turn decays with a half-life of 77.1 days. Both kinds of decay give off very distinctive gamma rays. Analysis of the gamma rays from SN1987a showed mostly cobalt-56, exactly as predicted. And, the amount of those gamma rays died away with exactly the half-life of cobalt-56. For more details, read: Neil Gehrels et al (1993), and Whitelock et al.(1991). Two possibilities. First is that from a prior to a present universe, there is essentially the same range of physical constants. Secondly is that from a prior to our present universe, that the values of the physical constants varied significantly. A third possibility is that if multiple universes existed, i.e. the typical ‘baby’ universes, with a brute ‘Darwinian selection’ criteria as to which universe may, or may not have survived, leading to say the present cosmos as one of the few lucky survivors of emergence from a prior cycle. If this third possibility is the case, then there would be no need for any data compression to preserve continuity of physical laws. In the article ‘Quantum entanglement of baby universes’, Aganagic, Mina; Okuda, Takuya; Ooguri, Hiroshi in (2007) elucidate the possibility that the parent ( prior ) universe generates baby universes by brane/anti-brane pair creation, and baby universes are correlated by conservation of non-normalizable D-brane charges under the process. I.e. this leaves unsaid if or not there is a selection process favoring the existence of a favored ‘baby universe’ which survived to become our universe, but it offers a mechanism as to how a family of universes could arise. The author, Beckwith, gave his version of such a hypothesis (2009) in one of his earlier ‘entropy’ articles , as a take off of Penrose’s (2007) supposition of a variant of a cyclic universe hypothesis which does not explicitly use branes and anti branes. This seems to assume that the physical constants are the same. How would we know that? Answer, is that we do **not** know it. Part two by necessity breaks down the possible outcomes into three cases. The first case by necessity would mandate some form of data compression. Of which then a methodology is proposed as to how to conserve a minimum amount of information needed for a 1-1 mapping of physical constants from a prior universe to our present. The second and third case may be in sync with the hypothesis of causal discontinuity, as stated by A.W. Beckwith’s (2008,2009) where he turned Fay Dowkers hypothesis of causal ordering on its head. And, the issue of how entropy, and its generation from a point of causal break down will be part of a resolution which the author, Beckwith, will present as relevant to determining if or not there is a way to distinguish between LQG and String/ Brane theory .

## Minimum amount of information needed to initiate placing values of fundamental cosmological parameters, as opposed to the baby universe / Darwinian selection

A.K. Avessian’s 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:

$$\hbar(t) \equiv \hbar_{\text{initial}} [t_{\text{initial}} \leq t_{\text{Planck}}] \cdot \exp[-H_{\text{macro}} \cdot (\Delta t \sim t_{\text{Planck}})] \quad (1)$$

The idea is that we are assuming a granular , discrete nature of space time. Futhermore, after a time we will state as  $t \sim t_{\text{Planck}}$  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  $\alpha$  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  $\hbar_{initial} [t_{initial} \leq t_{Planck}]$  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 Hogans (2002) argument where we have a maximum entropy as

$$S_{max} = \pi/H^2 \quad (2)$$

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

$$H_{macro} \equiv \Lambda \cdot [H_{Hubble} = H] \quad (3)$$

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  $\hbar_{initial} [t_{initial} \leq t_{Planck}]$  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 negligible. If we look at Hogan’s holographic model, this is consistent with a non finite event horizon

$$r_0 = H^{-1} \quad (4)$$

This is tied in with a temperature as given by

$$T_{black-hole} = (2\pi \cdot r_0)^{-1} \quad (5)$$

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. We next then must consider how the values of initial entropy are linkable to other physical models. I.e. can there be a transfer of entropy/ information from a pre inflation state to the present universe. Doing this will require that we keep in mind, as Hogan writes, that the number of distinguishable states is writable as

$$N = \exp(\pi H^{-2}) \quad (6)$$

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  $N \sim 10^5$

### **Is data compression a way to distinguish what information is transferred to the present universe ?**

The peak temperature as recorded by Weinberg (1972) is of the order of  $10^{32}$  Kelvin, and that would imply using the expansion parameter, H, as given by Eqn (5) above. Likely before the onset of inflation, due to dimensional arguments, it can be safe to call the pre inflation temperature, T as very low. I.e. there was a build up of temperature, T, at the instant before inflation, which peaked shortly afterwards. Such an eventuality would be consistent with use of a worm hole bridge from a prior to a present universe. Beckwith (2008) at STAIF used such a model as a transfer of energy to the present universe, using formalism from Lawrence Crowell’s book (2005)

A useful model as far as rapid transfer of energy would likely be a quantum flux, as provided for in Deformation quantization. We will follow the following convention as far as initiating quantization, i.e. the reported idea of Weyl quantization which is as follows: For a classical  $u(p, q)$  , a corresponding quantum observable is definable via

$$\Omega(u(p,q)) = \int_{\mathfrak{R}} \tilde{u}(\xi, \eta) \cdot \exp[i \cdot (p \cdot \xi + q \cdot \eta) / \hbar] \cdot w(\xi, \eta) \cdot d^l \xi \cdot d^l \eta \quad (7)$$

Here,  $\mathcal{C}$  is the inverse fourier transform, and  $w(\cdot)$  is a weight function, and  $p$ , and  $q$  are canonical variables fitting into  $[p_\alpha, q_\beta] = i\hbar \cdot \delta_{\alpha,\beta}$ , and the integral is taken over weak topology. For a quantized procedure as far as refinement of poisson brackets, the above, Weyl quantization is, as noted by S. Gutt and S. Waldemann (2006) equivalent to finding an operation  $\Omega$  for which we can write

$$\Omega(1) = id \quad (8)$$

As well as for Poisson brackets,  $\{u, v\}$ , obeying  $(d/dt)u = -\{H, u\}$ , and  $(i/\hbar) \cdot [u, H] = du/dt$

$$[\Omega(u), \Omega(v)] = i\hbar \Omega(\{u, v\}) \quad (9)$$

For very small regimes of spatial integration, we can approximate Eqn. (7) as a finite sum, with

$$\tilde{u}(\xi, \eta) \sim \Omega(u) \quad (10)$$

What we are doing is to give the following numerical approximate value of, de facto, as follows

$$\Omega(u(p,q)) = \int_{\mathfrak{R}} \tilde{u}(\xi, \eta) \cdot \exp[i \cdot (p \cdot \xi + q \cdot \eta) / \hbar] \cdot w(\xi, \eta) \cdot d^l \xi \cdot d^l \eta \propto \tilde{u}(\xi_{initial}, \eta_{initial}) \quad (11)$$

, and then we can state that the inverse transform is a form of data compression of information. Here, we will state that  $\tilde{u}(\xi, \eta) \sim \Omega(u) \sim \{\text{information bits for } \hbar_{initial} [t_{initial} \leq t_{Planck}]\}$  as far as initial values of the plancks constant are concerned. Please see **Appendix IV** as to how for thin shell geometries the Weyl quantization condition reduces to the Wheeler De Witt equation. I.e. a wave functional approximately presentable as

$$\Psi \sim [R/R_{eq}]^{3/2} \quad (12)$$

, where  $R$  refers to a spatial distance from the center of a spherical universe. **Appendix IV** is an accounting of what is known as a pseudo time dependent solution to the Wheeler de Witt equation involving a worm hole bridge between two universes. The metric assumed in Appendix I is a typical maximally symmetric metric, whereas Appendix 2 is using the Reissner- Nordstrom metric. We assume, that to first order, if the value of  $R$  in  $\Psi \sim [R/R_{eq}]^{3/2}$  is nearly  $R \propto l_p \sim 10^{43}$  centimeters, I.e. close to singularity conditions, that the issue of how much information from a prior universe, to our own may be addressed, and that the solution  $\Psi \sim [R/R_{eq}]^{3/2}$  is consistent with regards to Weyl geometry. So let us consider what information is transferred. We claim that it centers about enough information with regards to preserving  $\hbar$  from universe cycle to cycle.

To begin this inquiry, it is appropriate to note that we are assuming that there is a variation in the value of  $\Psi \sim [R/R_{eq}]^{3/2}$  with a minimum value of  $R \propto l_p \sim 10^{-43}$  centimeters to work with. Note that Honig's (1973) article specified a general value of about  $3.68 \times 10^{-48}$  grams, per photon, and that each photon has an energy of  $E[photon] = \frac{hc}{\lambda} = m_{photon} \cdot c^2$ . If one photon is, in energy equivalent to  $10^{12}$  gravitons,

then, if  $\lambda \sim l_p = \text{Planck's length}$ , gives us a flux value as to how many gravitons / entropy units are transmited. The key point is that we wish to determine what is a minimum amount of information bits/attendant entropy values needed for transmission of  $\hbar_{initial} [t_{initial} \leq t_{Planck}]$ . In order to do this, note the article, i.e. a "A minimum photon "rest mass" — Using Planck's constant and discontinuous electromagnetic waves which as written in September, 1974 by **William Honig specifies a photon rest mass of the order of  $3.68 \times 10^{-48}$  grams per photon.** If we specify a mass of about  $10^{-60}$  grams per graviton, then to get at least one photon, and if we use photons as a way of 'encapsulating'

$\hbar_{initial} [t_{initial} \leq t_{Planck}]$ , then to first order, we need about  $10^{12}$  gravitons / entropy units ( each graviton, in the beginning being designated as one ‘carrier container’ of information for one unit of  $\hbar_{initial} [t_{initial} \leq t_{Planck}]$  . If as an example, as calculated by Beckwith (2008) that there were about  $10^{21}$  gravitons introduced during the onset of inflation , this means a minimum copy of about one billion  $\hbar_{initial} [t_{initial} \leq t_{Planck}]$  information packets being introduced from a prior universe, to our present universe, i.e. more than enough to insure introducing enough copies of  $\hbar_{initial} [t_{initial} \leq t_{Planck}]$  to insure continuity of physical processes. For those who doubt that  $10^{-60}$  grams per graviton can be reconciled with observational tests with respect to the Equivalence Principle and all classical weak-field tests , we refer the readers to Matt Visser’s (1998) article about “Mass for the graviton”. The heart of Matt Visser’s calculation for a non zero graviton mass involve placing appropriate small off diagonal terms to the usual stress tensor T (u,v) calculation, a development which in certain ways fore shadows what was done by C.S. Unnikrishnan’s (2009) revisionment of special relativity, in ways which will be described in this document.

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### **Entropy, comparing values from T(u,v) stress energy , black holes, and general entropy values obtainable for the universe**

We start off with looking at Vacuum energy and entropy. This suggests that entropy scaling is proportional to a power of the vacuum energy, i.e., entropy ~ vacuum energy, if is interpreted as a total net energy proportional to vacuum energy, i.e. go to equation 10 above. What will be done is hopefully, with proper analysis of T(u,v) at the onset of creation, is to distinguish, between entropy say of what Mathur wrote, as  $S \sim E^{(D-1/D)}$  , and see how it compares with the entropy of the center of the galaxy, as given by equation 25, as opposed to the entropy of the universe, as given by equation 16 below. The entropy which will be part of the resulting vacuum energy will be writable as either Black hole entropy and / or the Universe’s entropy. I.e. for black hole entropy, from Sean Carroll (2005), the entropy of a huge black hole of mass M at the center of the milky way galaxy. Note there are at least a BILLION GALAXIES, and M is ENORMOUS

$$S_{Black-Hole} \sim 10^{90} \cdot \left[ \frac{M}{10^6 \cdot M_{Solar-Mass}} \right]^2 \quad (13)$$

This needs to be compared with the entropy of the universe, as given by Sean Carroll, as stated by

$$S_{Total} \sim 10^{88} \quad (14)$$

The claim made here is that if one knew how to evaluate T(u,v) properly, that the up to  $10^9$  difference in equations 13 and 14 will be understandable, and that what seems to be dealt with directly. So, how does one do this ? The candidate picked which may be able to obtain some commonality in the different entropy formalisms is to confront what is both right and wrong in Seth Lloyd’s entropy treatment in terms of operations as given below. Furthermore, what is done should avoid the catastrophe inherent in solving the problem which Mithras gave the author, that of  $dS/dt = \infty$  at  $S=0$  in Kochi, India, as a fault of classical GR which should be avoided. One of the main ways to perhaps solve this will be to pay attention to what C. S. Unnikrishnan put up in 2009, i.e. his article about the purported one way speed of light, and its impact upon perhaps a restatement of T(u,v). A re statement of how to evaluate T(u,v) may permit a proper frame of reference to close the gap between entropy values as given in Equations 13 and 14 above.

### **Simple relationships to consider (with regards to equivalence relation ships used to evaluate T(u,v))**

What needs to be understood and evaluated is, if there is a re structuring of an appropriate frame of reference for T(u,v) and its resultant effects upon how to reconcile black hole entropy, A good place to start would be to obtain T(u,v) values which are consistent with slides on the two way versus one way light speed presentation of the ISEG 2009 conference. We wish to obtain T(u,v) values properly analyzed with respect to early universe metrics, and PROPERLY extrapolated to today so that ZPE energy extraction, as pursued by many, will be the model for an emergent field development of entropy. Note the easiest

version of T(u,v) as presented by Wald . If metric g(a,b) is for curved space time, the simplest matter energy stress tensor is ( Klein Gordon)

$$T_{ab} = \nabla_a \phi \cdot \nabla_b \phi - \frac{1}{2} \cdot g_{ab} \cdot (\nabla_c \phi \cdot \nabla^c \phi + m^2 \phi) \quad (15)$$

What is affected by Unnikrishnan's presented (2009) hypothesis is how to keep g(a,b) properly linked observationally to a Machian universe frame of reference, not the discredited aether, via CMBR spectra behavior. If the above equation is held to be appropriate, and then elaborated upon, the developed T(u,v) expression should adhere to Wald's unitary equivalence principle. **The structure of unitary equivalence is foundational to space time maps, and Wald states it as being**

$$C\mu_1(\psi, \psi) \leq \mu_2(\psi, \psi) \leq C'\mu_1(\psi, \psi) \quad (16)$$

**While stating this, it is important to keep in mind that Wald defines**

$$\mu(\psi_1, \psi_2) = \text{Im} \tilde{\Omega}(K\psi_1, K\psi_2) = \frac{1}{2} \cdot \langle \psi_1, |A| \psi_2 \rangle \quad (17)$$

We defined the operation, where A is a bounded operator, and < > an inner product via use of

$$\langle \psi_1, |A| \psi_2 \rangle = \int_{\Sigma} [T_{ab}(\psi_1, |A|\psi_2)] \xi^a \eta^b \sqrt{h} \cdot d^3x \quad (18)$$

### **Data compression, continuity, and Dowker's space time sorting algorithm**

This is closely tied in with data compression and how much 'information' material from a prior universe is transferred to our present universe. In order to do such an analysis of data compression and what is sent to out present universe from a prior universe, it is useful to consider how there would be an eventual increase in information / entropy terms, from  $10^{21}$  to  $10^{88}$ . Too much rapid increase would lead to the same problem ZPE researchers have . I.e. if Entropy is maximized too quickly, we have no chance of extracting ZPE energy from a vacuum state, i.e. no emergent phenomena is possible. What to avoid is akin to avoiding

$$S_{gw} = V \cdot \int_{v^0}^{v^1} r(v) \cdot v^2 dv \cong (10^{29})^3 \cdot (H_1/M_p)^{3/2} \approx 10^{87} - 10^{88} \quad (19)$$

Eqn (22) is from Giovanni, and it states that all entropy in the universe is solely due to graviton production.

This absurd conclusion would be akin, in present day parlance, to having  $10^{88}$  entropy 'units' created right at the onset of the big bang. This does NOT happen.

What will eventually need to be explained will be if or not  $10^7$  entropy units, as information transferred from a prior big bang to our present universe would be enough to preserve  $\hbar$ , G, and other physical values from a prior universe, to today's present cosmology. Inevitably, if  $10^7$  entropy/ information units are exchanged via data compression from a prior to our present universe. Eqn (14) , and resultant increases in entropy up to  $10^{88}$  entropy 'units' will involve the singularity theorems of cosmology, as well as explanations as to how  $\Delta S|_{relic-HFGW} \approx \Delta N \sim 10^{21}$  could take place, say right at the end of the inflationary era. The author claims that to do so, that Eqn (14) , and a mechanism for the assembly of gravitons from a kink- anti kink structure is a de rigor development. We need to find a way to experimentally verify this tally of results. And to find conditions under which the abrupt reformulation of a near-constant cosmological constant, i.e., more stable vacuum energy conditions right after the big bang itself, would allow for reformulation of SO(4) gauge-theory conditions.

### **What is the bridge between low entropy of the early universe and its rapid build up later?**

Penrose in a contribution to a conference, (2006) on page two of the Penrose conference (2006) document refers to the necessity of reconciling a tiny initial starting entropy of the beginnings of the universe with a much larger increased value of entropy substantially later. As can be read from the article by Penrose (2006) "A seeming paradox arises from the fact that our best evidence for the existence of the

big bang arises from observations of the microwave background radiation-“..... “ This corresponds to maximum entropy so we reasonably ask: how can this be consistent with the Second law, according to which the universe started with a tiny amount of entropy” . Penrose then goes on to state that “ The answer lies in the fact that the high entropy of the microwave background only refers to the matter content of the universe, and not the gravitational field, as would be enclosed by its space-time background in accordance to Einstein’s theory of general relativity”. Penrose then goes on to state that the initial pre red shift equals 1100 background would be remarkably homogeneous. I.e. for red shift values far greater than 1100 the more homogeneous the universe would become according to the dictum that “ gravitational degrees of freedom would not be excited at all” Beckwith (2008) then asks the question of how much of a contribution the baryonic matter contribution would be expected to make to entropy production. . The question should be asked in terms of the time line as to how the universe evolved, as specified by both Steinhardt and Turok (2007) on pages 20-21 of their book, as well as by NASA . And a way to start this would be to delineate further the amplitude vs frequency GW plot as given below. It is asserted that the presence of the peak in gravity wave frequency at about  $10^{10}$  Hertz has significant consequences for observational cosmology. Finding an appropriate phase transition argument for the onset of entropy creation and graviton production

$$s_{Density} = \frac{2 \cdot \pi^2}{45} \cdot g_* \cdot T^3 \quad (20)$$

is akin to explaining how, and why temperature changes in T, lead to , if the temperature increases, an emergent field description of how gravitons arose. We claim that this is identical to obtaining a physically consistent description of entropy density would be akin to, with increasing , then decreasing temperatures a study as to how kink- anti kink structure of gravitons developed . This would entail developing a consistent picture , via SO(4) theory of gravitons being assembled from a vacuum energy back ground and giving definition as to Seth Lloyd’s computation operation description of entropy. Having said this, it is now appropriate to raise what gravitons/ HFGW may tell us about structural evolution issues in today’s cosmology. Here are several issues the author is aware of which may be answered by judicious use of HFGWs.As summarized by Thanu Padmanabhan (IUCAA) in the recent 25th IAGRG presentation he made, “G ravity: The Inside Story “, entropy can be thought of as due to ‘ignored’ degrees of freedom, classically, and is generalized in general relativity by appealing to extremizing entropy for all the null surfaces of space time. Padmanabhan claims the process of extremizing entropy then leads to equations for the background metric of the space-time. I .e. that the process of entropy being put in an entremal form leads to the Einsteinian equations of motion. What is done in this present work is more modest. I.e. entropy is thought of in terms of being increased by relic graviton production, and the discussion then examines the consequence of doing that in terms of GR space time metric evolution. How entropy production is tied in with graviton production is via recent work by Jack Ng. It would be exciting if or not we learn enough about entropy to determine if or not we can identify null surfaces, as Thanu brought up in his presentation in his Calcutta (2009). presentation. The venue of research brought up here we think is a step in just that direction. Furthermore, let us now look at large scale structural issues which may necessitate use of HFGW to resolve. Job one will be to explain what may the origins of the enormous energy spike in Figure 1 above, by paying attention to Relic gravitational waves , allowing us to make direct inferences about the early universe Hubble parameter and scale factor (“birth” of the Universe and its early dynamical evolution). According to Grishchuk: energy density requires that the GW frequency be on the order of (10 GHz), with a sensitivity required for that frequency on the order of  $10^{-30}$   $\delta m/m$ . Once this is obtained, the evolution of cosmological structure can be investigated properly, with the following as targets of opportunity for smart applications of HFGW detectors.

### **How the CMBR permits , via maximum frequency, and maximum wave amplitude values, an upper bound value for massive graviton mass $m_g$**

Camp and Cornish (2004) , as does Fangyu Li (2008) use the typical transverse gravitational gauge  $h_{ij}$  with a typically traceless value summed as  $0 + h_+ - h_+ + 0$  and off diagonal elements of  $h_x$  on each side of the diagonal to mix with a value of

$$h_{ij} \equiv \frac{G_N}{c^4} \cdot \frac{2}{r} \cdot \left[ \frac{d^2}{dt^2} Q_{ij} \right]_{retarded}^{TT} \quad (21)$$

This assumes  $r$  is the distance to the source of gravitational radiation, with the *retarded* designation on Eqn. (34) denoting  $\frac{d}{dt}$  replaced by a retarded time derivative  $\frac{d}{d[t - (r/c)]}$ , while TT means take the transverse projections and subtract the trace. Here, we call the quadrupole moment, with  $\rho(t, x)$  a density measurement. Now, the following value of the  $Q_{ij}$  as given gives a luminosity function  $L$ , where  $R$  is the ‘characteristic size’ of a gravitational wave source. Note that if  $M$  is the mass of the gravitating system

$$Q_{ij} = \int d^3x \left[ x_i x_j - \frac{1}{3} \cdot \delta_{ij} \cdot x^2 \right] \cdot \rho(t, x) \quad (22)$$

$$L \approx \frac{1}{5} \cdot \frac{G_N}{c^5} \cdot \frac{d^3 Q_{ij}}{dt^3} \cdot \frac{d^3 Q^{ij}}{dt^3} \cong \frac{\pi \cdot c^5}{G_N} \cdot \left( \frac{G_N M}{R \cdot c^2} \right)^2 \quad (23)$$

After certain considerations reported by Camp and Cornish (2004), one can recover a net GW amplitude

$$h \sim 2 \cdot \left[ \frac{G_N \cdot M}{R \cdot c^2} \right] \cdot \left[ \frac{G_N \cdot M}{r \cdot c^2} \right] \quad (24)$$

This last equation requires that  $R > R_G = \frac{G_N M}{c^2} \equiv$  gravitational radius of a system, with a black hole resulting if one sets  $R < R_G = \frac{G_N M}{c^2}$ . Note that when  $R \sim R_G = \frac{G_N M}{c^2}$  we are at an indeterminate boundary where one may pick our system as having black hole properties.

Now for stars, Camp and Cornish (2004) give us that

$$h \approx 10^{-21} \cdot \left[ \frac{15 \cdot Mpc}{r} \right] \cdot \left[ \frac{M}{2.8 M_{solar-mass}} \right]^2 \cdot \left( \frac{90km}{R} \right) \quad (25)$$

$$f \equiv \text{frequency} \approx \sqrt{\frac{M}{2.8 M_{solar-mass}}} \cdot \sqrt{\frac{90km}{R}} \cdot 100Hz \quad (26)$$

As well as a mean time  $\tau_{GW}$  for half of gravitational wave potential energy to be radiated away as

$$\tau_{GW} \approx \frac{R}{2\pi \cdot c} \cdot \left[ \frac{G_N M}{R \cdot c^2} \right]^{-3} \sim \left( \frac{R}{90km} \right)^4 \cdot \left[ \frac{2.8 M_{solar-mass}}{M} \right]^3 \cdot \left( \frac{1}{2} \cdot \text{sec} \right) \quad (27)$$

The assumption we make is that if we model  $R \sim R_G = \frac{G_N M}{c^2}$ , for a sufficiently well posed net mass  $M$



that the star formulas roughly hold for early universe conditions, provided that we can have a temperature  $T$  for which we can use the approximation  $\approx \sqrt{\frac{M}{2.8M_{solar-mass}}} \cdot \sqrt{\frac{90km}{R}} \cdot 100Hz$  that we also have

$\left[ \frac{T}{TeV} \right] \sim 10^{13}$  or higher, so, that at a minimum we recover Grishchuck's (2007) value of

$$f_{Peak} \approx (10^{-3} Hz) \cdot \left[ \frac{T}{TeV} \right] \sim 10^{10} Hz \quad (28)$$

$$\approx \sqrt{\frac{M}{M_{solar-mass}}} \cdot \sqrt{\frac{90km}{R}}$$

Eqn (28) places, for a specified value of  $R$ , which can be done experimentally, an upper bound as far as what a mass  $M$  would be. Can this be exploited to answer the question of if or not there is a minimum value for the Graviton mass?

The key to the following discussion will be that  $\sqrt{\frac{M}{2.8M_{solar-mass}}} \cdot \sqrt{\frac{90km}{R}} \approx 10^8$ , or larger.

### Inter relationship between graviton mass $m_g$ and the problem of a sufficient number of bits of $\hbar$ from a prior universe, to preserve continuity between fundamental constants from a prior to the present universe

P. Tinyakov (2006) gives that there is, with regards to the halo of sub structures in the local Milky Way galaxy an amplitude factor for gravitational waves of

$$\langle h_{ij} \rangle \sim 10^{-10} \cdot \left[ \frac{2 \cdot 10^{-4} Hz}{m_{graviton}} \right] \quad (29)$$

If we use LISA values for the Pulsar Gravitational wave frequencies, this may mean that the massive graviton is ruled out. On the other hand  $\sqrt{\frac{M}{2.8M_{solar-mass}}} \cdot \sqrt{\frac{90km}{R}} \approx 10^8$  leads to looking at, if

$$\langle h_{ij} \rangle \sim h \sim 10^{-5} \cdot \left[ \frac{15Mpc}{r} \right]^{1/2} \cdot \left[ \frac{M}{2.8 \cdot M_{solar-mass}} \right]^{1/2} \approx 10^{-30} \quad (30)$$

If the radius is of the order of  $r \geq 10$  billion light-years  $\sim 4300 Mpc$  or much greater, so then we have, as

an example  $\langle h_{ij} \rangle \sim 10^{-10} \cdot \left[ \frac{2 \cdot 10^{-4} Hz}{m_{graviton}} \right] \approx 5.9 \cdot 10^{-7} \cdot \left[ \frac{M}{2.8 \cdot M_{solar-mass}} \right]^{1/2}$

$$\left[ \frac{10^{-7} Hz}{m_{graviton}} \right] \approx \left[ \frac{5.9}{\sqrt{5.6}} \right] \cdot \sqrt{\frac{M}{M_{solar-mass}}} \quad (31)$$

This Eqn. (46) is in units where  $\hbar = c = 1$ .

If  $10^{-60}$  grams per graviton, and 1 electron volt is in rest mass , so

$1.6 \times 10^{-33}$  grams  $\Rightarrow$  gram =  $6.25 \times 10^{32}$  eV . Then

$$\left[ \frac{10^{-7} \text{ Hz}}{m_{\text{graviton}}} \right] \equiv \left[ \frac{10^{-7} \text{ Hz} \cdot [6.582 \times 10^{-15} \text{ eV} \cdot \text{s}]}{[10^{-60} \text{ grams} \equiv 6.25 \times 10^{-28} \text{ eV}] \cdot [2.99 \times 10^9 \text{ meter / sec}]^2} \right] \sim \frac{10^{-22}}{10^{-9}} \sim 10^{-13}$$

Then, there exist

$$M \sim 10^{-26} M_{\text{solar-mass}} \approx 1.99 \times 10^{33-26} \equiv 1.99 \times 10^7 \text{ grams} . \quad (32)$$

If each photon, as stated above is  $3.68 \times 10^{-48}$  grams per photon, then

$$M \sim 5.44 \times 10^{54} \text{ initially transmitted photons} . \quad (33)$$

Futhermore, if there are , today for a back ground CMBR temperature of 2.7 degrees Kelvin  $5 \times 10^8$  photons / cubic – meter , with a wave length specified as  $\lambda_{\text{max}} \approx 1 \cdot \text{cm}$  . This is for a numerical density of photons per cubic meter given by

$$n_{\text{photon}} := \frac{\sigma \cdot (T)^4 \cdot (\lambda_{\text{max}})}{h \cdot c^2} \quad (34)$$

As a rough rule of thumb, if , as given by Weinberg (1973) that early quantum effects , for quantum gravity take place at a temperature  $T \approx 10^{33}$  Kelvin, then, if there was that temperature for a cubic meter of space, the numerical density would be , roughly  $10^{132}$  times greater than what it is today. Forget it. So what we have to do is to consider a much smaller volume area. If the radii of the volume area is  $r \cong 4 \times 10^{-35}$  meters  $\equiv l_p = \text{Planck} - \text{length}$  ,then we have to work with a de facto initial volume  $\approx 64 \times 10^{-105} \sim 10^{-103} (\text{meters})^3$  . I.e. the numerical value for the number of photons at  $T \approx 10^{33}$  , if we have a per unit volume area based upon planck length, in stead of meters, cubed is  $10^{29} \times (5 \times 10^8) \approx 5 \times 10^{37}$  photons for a cubic area with sides  $r \cong 4 \times 10^{-35}$  meters  $\equiv l_p$  at  $T|_{\text{quantum-effects}} \approx 10^{33}$  Kelvin However,  $M \sim 5.44 \times 10^{54}$  initially transmitted photons! Either the minimum distance ,i.e. the grid is larger, or  $T|_{\text{quantum-effects}} \gg 10^{33}$  Kelvin

### **Tie in with string theory to resolve the $10^{19}$ difference in number of photons transmitted from a prior universe to our present**

Typically, the minimum length as stated by string theory, we have

$$l_{\text{min-length-string}} \equiv 10^\alpha \cdot l_{\text{Planck}} \quad (35)$$

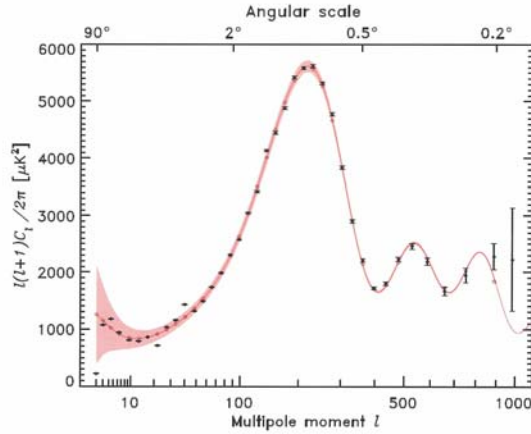
Here, we either have  $\alpha \cong 6.3$  , or  $T|_{\text{quantum-effects}} \gg 10^{33}$  Kelvin

Another issue as to the tensor/ scalar ratio is one of if there is a simple consistency relation from the running of the tensor-to-scalar ratio. As noted by Jinn-Ouk Gong,(2007), this new relation is first order in the slow-roll approximation. While for single field models we can obtain what can be found by using other observables, multi-field cases in general give non-trivial contributions dependent on the geometry of the field space and the inflationary dynamics, which can be probed observationally from this relation. Gong asserts that laser interferometry will allow to determine if inflaton theories should be either single field variety, or multiple field variety, and this is , if confirmed not that different from determining the nature of emergent gravity. I.e examing if or not Kuchiev, M. Yu's supposition appearing in Classical and Quantum gravity of if or not the polarization of instantons affect / control how gravity appears in the onset of

inflation . If multiple fields are confirmed, this may necessitate looking at inhomogenities in the CMBR, as postulated by Hunt and Sarkar (2008) . In any case, the basic physics of how to interpret scalar and tensor contributions to the CMBR are briefly alluded to in **Appendix I** and **Appendix II** of this paper. The Hunt-Sarkar (2008) case of multiple fields may, by necessity lead to analyzing multiple race track inflation, as allude to, in **Appendix III**

In fact the ‘power-law  $\Lambda$ CDM model’ does not fit *WMAP* data very well

Best-fit:  $\Omega_m h^2 = 0.13 \pm 0.01$ ,  $\Omega_b h^2 = 0.022 \pm 0.001$ ,  $h = 0.73 \pm 0.05$ ,  $n = 0.95 \pm 0.02$



But the  $\chi^2/\text{dof} = 1049/982 \Rightarrow$  probability of only  $\sim 7\%$  that this model is correct!

**Figure 2 : Self explanatory. From Subir Sarkar’sBad Honnif07 talk .  
Reproduced here with permission of Dr. Sakar in e mail communication**

## Conclusion

Let us first reference what can be done with further developments in deformation quantization and its applications to gravitational physics. The most note worthy centers upon grassman algebras and deformation quantization of fermionic fields. I.e. Galaviz (2007) showed that one can obtain a Dirac propagator from classical versions of Fermionic fields, and this was a way to obtain minimum quantization conditions for initially classical versions of fermionic fields as due to alterations of algebraic structures, in sutiable ways. One of the aspects of early universe topology we need to consider is how to introduce quantization in curved space time geometries. , and this is a problem which would , among other things permit a curved space treatment of  $\Psi \sim [R/R_{eq}]^{3/2}$ . I.e. as R gets of the order of  $R \sim \mathcal{G}(l_p)$  , say that the spatial geometry of early universe expansion is within a few orders of magnitude of Planck length, then how can we recover a field theory quantization condition for  $\Psi \sim [R/R_{eq}]^{3/2}$  in terms of path integrals.

We claim that deformation quantization , if applied successfully will eventually lead to a great refinement of the above Wheeler De Witt wave functional value, as well as allow a more through match up of a time independent solution of the Wheeler De Witt equation, as given in **Appendix IV**, with the more subtle pseudo time dependent evolution of the wave functional as given in **Beckwith(2009) in the third companion piece to this series of article, as well as Beckwith’s (2008,9) adaptation of L. Crowell’s (2005) book**. I.e. the linkage between time independent treatments of the wave functional of the universe, with what Lawrence Crowell wrote up in 2005, will be made more explicit. This will , in addition allow us to understand better how graviton production in relic conditions may add to entropy, as well as how to link

the number of gravitons, say  $10^{12}$  gravitons per photon, as information as a way to preserve the continuity of  $\hbar$  values from a prior universe to the present universe. The author claims that in order to do this rigorously, that use of the material in Gutt, and Waldmann ( ‘ Deformation of the Poisson bracket on a symplectic manifold’ ) as of 2006 will be necessary, especially to recover quantization of severely curved space time conditions which add more detail to  $\Psi \sim [R/R_{eq}]^{3/2}$ . Having said this, it is now important to consider what can be said about how relic gravitons/ information can pass through minimum vales of  $R \sim \mathcal{G}(l_p)$ .

We shall reference what the AW. Beckwith (2008) presented in 2008 STAIF, which we think still has current validity for reasons we will elucidate upon in this document. We use a power law relationship first presented by Fontana (2005), who used Park’s earlier (1955) derivation: when  $E_{eff} \equiv \langle n(\omega) \rangle \cdot \omega \equiv \omega_{eff}$

$$P(power) = 2 \cdot \frac{m_{graviton}^2 \cdot \bar{L}^4 \cdot \omega_{net}^6}{45 \cdot (c^5 \cdot G)} \quad (36)$$

This expression of power should be compared with the one presented by Massimo Giovannini (2008) on averaging of the energy-momentum pseudo tensor to get his version of a gravitational power energy density expression, namely

$$\bar{\rho}_{GW}^{(3)}(\tau, \tau_0) \cong \frac{27}{256 \cdot \pi^2} H^2 \cdot \left( \frac{H}{M} \right)^2 \cdot \left[ 1 + \mathcal{G} \cdot \left( \frac{H^4}{M^4} \right) \right] \quad (37)$$

Giovannini states that should the mass scale be picked such that  $M \sim m_{planck} \gg m_{graviton}$ , that there are doubts that we could even have inflation. However, it is clear that gravitational wave density is faint, even if we make the approximation that  $H \equiv \frac{\dot{a}}{a} \cong \frac{m\dot{\phi}}{\sqrt{6}}$  as stated by Linde (2008), where we are following

$\dot{\phi} = -m\sqrt{2/3}$  in evolution, so we have to use different procedures to come up with relic gravitational wave detection schemes to get quantifiable experimental measurements so we can start predicting relic gravitational waves. This is especially true if we make use of the following formula for gravitational radiation, as given by L. Kofman (2008), with  $M = V^{1/4}$  as the energy scale, with a stated initial inflationary potential V. This leads to an initial approximation of the emission frequency, using present-day gravitational wave detectors.

$$f \cong \frac{(M = V^{1/4})}{10^7 GeV} Hz \quad (38)$$

What we would like to do for future development of entropy would be to consider a way to ascertain if or not the following is really true, and to quantify it by an improvement of a supposition advanced by Kiefer, Polarski, and Starobinsky as of (2000) . I.e. the author, Beckwith , has in this document presented a general question of how to avoid having  $dS/dt = \infty$  at  $S=0$ ,

- 1, Removes any chance that early universe nucleation is a quantum based emergent field phenomena
2. Goldstone gravitons would arise in the beginning due to a violation of Lorentz invariance. I.e. we have a causal break , and merely having the above condition does not qualify for a Lorentz invariance breakdown

Kiefer, Polarski, and Starobinsky as of (2000) presented the idea of presenting the evolution of relic entropy via the evolution of phase spaces, with  $\Gamma/\Gamma_0$  being the ratio of ‘final (future)’ / ‘initial’ phase space volume, for k modes of secondary GW background.

$$S(k) = \ln \frac{\Gamma}{\Gamma_0} \tag{39}$$

If the phase spaces can be quantified, as a starting point of say  $l_{\text{min-length-string}} \equiv 10^\alpha \cdot l_{\text{Planck}}$ , with  $l_{\text{Planck}}$  being part of how to form the ‘dimensions’ of  $\Gamma_0$ , and  $l_{\text{min-length-string}}$  part of how to form the dimensions of  $\Gamma$ , and  $10^\alpha$  being, for a given  $\alpha > 0$ , and in certain cases  $\alpha \gg 0$ , then avoiding having  $\frac{dS}{dt} = \infty$  at  $S=0$  will be straight forward

We hope to come up with an emergent structure for gravitational fields which is congruent with obtaining  $10^\alpha$  naturally, so this sort of procedure is non controversial, and linked to falsifiable experimental measurement protocol, so quantum gravity becomes a de facto experimental science.

## Appendix I. Basic physics of achieving minimum

$l_{\text{min-length-string}} \equiv 10^\alpha \cdot l_{\text{Planck}}$  **precision in CMBR power spectra measurements**

Begin first of all looking at

$$\frac{\Delta T}{T} \equiv \sum_{l,m} a_{lm} Y_{l,m}(\theta, \phi) \tag{1}$$

This leads to consider what to do with

$$C_l = \langle |a_{l,m}|^2 \rangle \tag{2}$$

Samtleben et al (2007) consider then what the experimental variance in this power spectrum, to the tune of an achievable precision given by

$$\frac{\Delta C_l}{C_l} = \sqrt{\frac{2}{2l+1}} \cdot \left( \frac{1}{\sqrt{f_{\text{sky}}}} + \frac{4\pi \cdot (\Delta T_{\text{exp}})^2}{C_l} \cdot \sqrt{f_{\text{sky}}} \cdot e^{l^2 \sigma_b^2} \right) \tag{3}$$

$f_{\text{sky}}$  is the fraction of the sky covered in the measurement, and  $\Delta T_{\text{exp}}$  is a measurement of the total experimental sensitivity of the apparatus used. Also  $\sigma_b$  is the width of a beam, while we have a minimum value of  $l_{\text{min}} \approx (1/\Delta\Theta)$  which is one over the fluctuation of the angular extent of the experimental survey.

I.e. contributions to  $C_l$  uncertainty from sample variance is equal to contributions to  $C_l$  uncertainty from noise. The end result is

$$4\pi \cdot f_{\text{sky}} = C_l \cdot (\exp[-l^2 \sigma^2]) / (\Delta T)^2 \tag{4}$$

## Appendix II : Cosmological perturbation theory and tensor fluctuations (Gravity waves)

Durrer (2004) reviews how to interpret  $C_l$  in the region where we have  $2 < l < 100$ , roughly in the region of the Sachs-Wolf contributions due to gravity waves. We begin first of all by looking at an initial

perturbation , using a scalar field treatment of the ‘ Bardeen potential’  $\Psi$  This can lead us to put up, if  $H_i$  is the initial value of the Hubble expansion parameter

$$k^3 |\Psi|^2 \cong \left( \frac{H_i}{M_P} \right)^2 \quad (1)$$

And

$$\langle |\Psi|^2 \rangle \cdot k^3 = A^2 k^{n-1} \cdot \eta_0^{n-1} \quad (2)$$

Here we are interpreting  $A$  = amplitude of metric perturbations at horizon scale, and we set  $k = 1/\eta_0$ , where  $\eta$  is the conformal time, according to  $dt \equiv a d\eta$  = physical time, where we have  $a$  as the scale factor..Then for  $2 < l < 100$  , and  $-3 < n < 3$  , and a pure power law given by

$$\langle |H(k, \eta = 1/k)|^2 \rangle \cdot k^3 = A_T^2 k^{n_T} \cdot \eta_0^{-n_T} \quad (3)$$

We get for tensor fluctuation, i.e. gravity waves,, and a scale invariant spectrum with  $n_T = 0$

$$C_l^{(T)} \approx \frac{A_T^2}{(l+3) \cdot (l-2)} \cdot \frac{1}{15\pi} \quad (4)$$

### Appendix III: Managing what to do with racetrack inflation, as cool down from initial expansion commences

P. Brax, A. Davis et al devised a way to describe racetrack inflation as a way to look at how super gravity directly simplifies implementing how one can have inflation with only three T ( scalar ) fields . The benefit to what we work with is that we may obtain two gaugino condensates and look at inflation with a potential given by Brax , et al (2008)

$$V = V_0 + V_1 \cos(aY) + V_2 \cos(bY) + V_3 \cos(|a-b| \cdot Y) \quad (1)$$

This has scalar fields  $X, \phi$  as relatively constant and we can look at an effective kinetic energy term along the lines of

$$\mathfrak{S}_{Kinetic} = 3 \cdot (\partial Y)^2 / 4(\partial X)^2 \quad (2)$$

This ultra simple version of the race track potential is chosen so that the following conditions may be applied

- (1) Exist a minimum at  $Y = Y_0$ ; i.e. we have  $V'(Y_0) = 0$ , and  $V''(Y_0) > 0$ , when we are not considering scalar fields  $X, \phi$
- (2) We set a cosmological constant equal to zero with  $V(Y_0) = 0$
- (3) We have a flat saddle at  $Y \approx 0$ ; i.e.  $V''(0) = 0$

- (4) We re - scale the potential via  $V \rightarrow \lambda V$  so as to get the observed power spectra  
 $P = 4 \times 10^{-10}$

Doing all this though frequently leads to the odd situation that  $|a - b|$  must be small so that  $X \gg 1$  in a race track potential system when we analyze how to fit Eqn. (1) for flat potential behavior modeling inflation. This assumes that we are working with a spectra index of the form so that if the scalar field power spectrum is

$$P = \frac{V}{150\pi^2 \epsilon} \quad (3)$$

Then the spectral index of the inflaton is consistent with WMAP data. I.e. if we have the number of e foldings  $N > N_* \approx .55$

$$n_s = 1 - \frac{d \ln P}{dN} \approx .95 \pm .02 \quad (4)$$

These sort of restrictions on the spectral index will start to help us retrieve information as to possible inflation models which may be congruent with at least one layer of WMAP data. This model says nothing about if or not the model starts to fit in the data issues Subir Sarkar identified in his Pune, India lecture in 2007.

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