Supplying conditions for having up to 1000 degress of freedom in the onset of inflation, instead of 2 to 3 degrees of freedom, today, in space-time.

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The following document attempts to answer the role additional degrees of freedom have as to initial inflationary cosmology. A comparison is made to two representations of a scale evolutionary Friedman equation, with one of the equations based upon LQG, and another involving an initial Hubble expansion parameter with initial temperature $T_{Planck} \sim 10^{19} GeV$ used as an input into T^4 times N(T). The upshot is that initial assumptions as to the number of degrees of freedom has for $T_{Planck} \sim 10^{19} GeV$ a maximum value of N(T)~ 10^3. Making that upper end approximation for the value of permissible degrees of freedom is dependent upon a minimum grid size length as of about $l_{Planck} \sim 10^{33}$ centimeters. Should the minimum uncertainty and permissible grid size for space time be significantly higher than be much higher than $l_{Planck} \sim 10^{33}$ centimeters, the net effect will be to reduce to top level value of N(T)~ 10^3 to something lower. The author submits that such degrees of freedom is important for initial configurations for the initial configuration of the arrow of time , i.e entropy growth for reasons which will be made clear in the manuscript.

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A. INTRODUCTION

Recently, a big bounce has been proposed[1] as an alternative to singularity conditions that Hawkings, Ellis [1], and others use. Batistini **[2]** uses Snyder geometry to find a basis for a limiting approximation to determine either brane world or LQG conditions for cosmological evolution. We use LQG to delineate grid size in terms of the geometry of the regime of the quantum bounce regime, and then examine the geometry as to the minimum radius of this region of space – time... Modeling how much information to be carried by an individual graviton can be achieved by measuring the graviton. Normalized energy density of gravitational waves, as given by Maggiore **[3]** is

$$\Omega_{gw} \equiv \frac{\rho_{gw}}{\rho_c} \equiv \int_{\nu=0}^{\nu=\infty} d(\log \nu) \cdot \Omega_{gw}(\nu) \Rightarrow h_0^2 \Omega_{gw}(\nu) \cong 3.6 \cdot \left[\frac{n_\nu}{10^{37}}\right] \cdot \left(\frac{\nu}{1kHz}\right)^4 \tag{1.1}$$

Where n_ν is a frequency-based count of gravitons per unit cell of phase space? The question left over is how to determine acceptable configuration of the input n_ν above, in terms of frequency, and also initial temperature. The author is convinced an answer to the above will be be dependent upon the number of degrees of freedom present in early universe cosmology. In the LQG version by **[4],** how one writes the Friedman equation may be written as follows: If conjugate momentum is in many cases, "almost" or actually a constant,

$$\left(\frac{\dot{a}}{a}\right)^2 \equiv \frac{\kappa}{6} \cdot \frac{p_\phi^2}{a^6} \tag{1.2}$$

This assumes that the conjugate dimension in this case has a quantum connection specified via an effective scalar field, ϕ, obeying the relationship

$$\dot{\phi} = -\frac{\hbar}{i} \cdot \frac{\partial}{\partial \cdot p_\phi} \tag{1.3}$$

[1] Papers on LCQ at the 12th Marcell Grossman Meeting in 2009 (http://www.icra.it/MG/mg12/en/)

B . How to compare Eq. (1.2) with Friedman equation behavior, if thermal influences dominate initially with $T_{Planck} \sim 10^{19} GeV$

This inquiry explicitly assumes a Friedman equation dominated by temperature with N(T) a temperature dependent number of degrees of freedom present in a region of 'phase space' , and $\breve{a}$ a radiation constant, as given by Saunders(2005) [5]

$$H^2 = \left[4\pi G \cdot \breve{a} \cdot T^4 N(T) / 3c^2 \right] \tag{1.4}$$

If we make the following minimum uncertainty value for momentum as given by Baez-Olson [6] , we have that

$\Delta p \geq \hbar / l_{Planck}$ if $l_{Planck} \sim \Delta l$, i.e. what can we expect if there is a minimum value for the length of order Planck length, as opposed to the Ng and Van Damn [7] value of $\Delta p \geq \hbar / l^{1/3} l_{Planck}^{2/3}$, with $l >> l_{Planck}$. Having made this choice of a minimum uncertainty grid, and if we set $\Delta p \approx \hbar / l_{Planck} = P_{\phi}$ and put that into Eq. (1.2) one obtains the following to compare, as a way of obtaining N(T). Namely

$$\left[4\pi G \cdot \breve{a} \cdot T^4 N(T) / 3c^2 \right] \approx \frac{\kappa}{6} \cdot \frac{\left\lfloor p_{\phi}^2 = \left(\hbar / l_{Planck} \right)^2 \right\rfloor}{a^6} \tag{1.5}$$

The consequence of Eq. (1.5) would be to set conditions for which the following could be true.

$$N(T) \sim 10^3 \cong \left[\frac{c^2 \kappa \cdot \hbar}{8\pi G \cdot \breve{a}} \right] \cdot \frac{1}{T^4 a_{initial}^6 \cdot l_{Planck}^2} \tag{1.6}$$

If we take a dimensional re scaling of Eq. (1.6), with

$$N(T) \sim 10^3 \sim \frac{1}{\left[T^4 \approx T_{Planck}^4 \right] \cdot \left[a_{initial}^6 = 10^{6 \cdot \beta} \right] \cdot l_{Planck}^2} \tag{1.7}$$

One can then obtain an algebraic equation to the effect that

$$76 - 4\delta^+ - 66 + 6\beta \approx -3 \Rightarrow a_{initial} \sim 1 \tag{1.8}$$

This above approximation would be assuming that $T \sim 10^{19-\delta^+} GeV$ i.e. close to the Planck temperature

The other assumption is that the starting point for Planck expansion, has $a_{initial} = 1$ with an enormous value for a in the present era as opposed to another scaling convention that $a = [1/1+z]$ where one can have the red shift with values at the onset of inflation of the order of $z_{initial} \sim 10^{25}$ at the start of inflation, and $z_{CMBR} \sim 1100 - 1000$ at the moment of CMBR photon radiation 'turn on' with $z_{Today} = 0$ .in the present era. Examining what happens if one substitutes in for l_{Planck} $l^{1/3} l_{Planck}^{2/3}$ in Eq. 1.7 would mean a substantially lower value for $N(T)$ if the following holds, i.e. $l >> l_{Planck}$ making plausible even at the onset of inflation $N(T) \sim 10^2$ as reported by Kolb and Turner, 1991[8], which is the usual value for degrees of freedom for the case of the electro weak era. Next, if the additional degrees of freedom are warranted, comes the question of what are measurable protocol which may confirm / falsify this supposition. The following discussion will in part re cap and extend a discussion which the author, Beckwith has presented in DICE 2010, in Italy [9]

C. Consequences if there are up to 1000 degrees of freedom

A way to obtain traces of information exchange , from prior to present universe cycles is finding a linkage between information and entropy. If such a parameterization can be found and analyzed, then Seth Lloyd's **[10]** shorthand for entropy,

$$I = S_{total} / k_B \ln 2 = [\#operations]^{3/4} = [\rho \cdot c^5 \cdot t^4 / \hbar]^{3/4} \tag{1.9}$$

could be utilized as a way to represent information which can be transferred from a prior to the present universe.. then if, say, the total number of gravitons in inflation is of the order of $n \sim 10^{20}$ gravitons $\approx 10^{20}$ entropy counts, Eq. (1.9) implies up to $\approx 10^{27}$ operations. With an operation being equivalent to a bit of information.

The problem, though, is that there may be more than one graviton per information bit as given by Beckwith's calculations for entropy, and also energy carried per graviton. As given by Beckwith, in DICE 2010, Beckwith has made the following estimate, i.e.[9]

Note that J. Y. Ng uses the following . **[11]** I.e. for DM, $S \sim n$, but this is for DM particles, presumably of the order of mass of a WIMP, i.e. $m_{WIMP} \approx 100 \cdot GeV \sim 10^{11}$ **electron volts**, as opposed to a relic graviton mass – energy relationship [9]:

$$m_{graviton}(energy - \nu \approx 10^{10}\, Hz) \approx [100 \cdot GeV \sim 10^{11}\, eV - WIMP] \times 10^{-16} \sim 10^{-5}\, eV \tag{1.10}$$

If one drops the effective energy contribution to $\nu \approx 10^0 \sim 1Hz$, as has been suggested , then the relic graviton mass- energy relationship is:

$$m_{graviton}(energy - \nu \approx 10^{0}\, Hz) \approx [100 \cdot GeV \sim 10^{11}\, eV - WIMP] \times 10^{-26} \sim 10^{-15}\, eV \tag{1.11}$$

Finally, if one is looking at the mass of a graviton a billion years ago, with

$$m_{graviton}(red - shift - value \sim .55) \approx [100 \cdot GeV \sim 10^{11}\, eV - WIMP] \times 10^{-38} \sim 10^{-27}\, eV \tag{1.12}$$

I.e. if one is looking at the mass of a graviton, in terms of its possible value as of a billion years ago, one gets the factor of needing to multiply by 10^{38} in order to obtain WIMP level energy-mass values, congruent with Y. Jack Ngs $S \sim N$ counting algorithm [9], [11]. What the author is suggesting, as he brought up in DICE 2010 is that the extra degrees of freedom may be necessary for obtaining clumps of 10^{38} gravitons to form coherent clumps to obtain GW of sufficient semi classical initial conditions , to obtain conditions, initially to have the $S \sim N$ counting algorithm work

D. Conclusions. Extensions of this thought experiment, and comparison with entropy of photons.

Recently, the author has been fortunate enough to obtain Leff's [12] entropy of photons per unit volume paper where for a phase space volume, V, and temperature T,

$$S = (4/3)\ bVT^3 \tag{1.13}$$

This should be compared with Beckwith's derived "graviton clumping" entropy result [9] per unit volume of phase space as given by

$$S \sim 3 \cdot \left[1.66 \cdot \sqrt{\tilde{g}_*}\right]^2 T^3 \tag{1.14}$$

What the author supposes, is that fine tuning the inter play between these two formulas, from the onset of inflation when there was likely coupling between gravitons, clumps of gravitons, and photons , may permit experimental measurements permitting investigation if there is an interplay between E&M and gravity, and also modifications of gravity theory along the lines brought up by Sidharth [13] , i.e. if Eq. (1.13) and Eq. (1.14) are manistifications of a joint phenomenon as is suggested by Sidarth's (which incidently is for E and M radiation characterized by a given 'carrier wave' frequency)

$$A^{\mu} = \hbar \cdot \Gamma_{\mu}^{\mu \ \nu} \tag{1.15}$$

where A^{μ} can be identifed with the electromagnetic four potential The idea, as Beckwith sees it would be to determine if there could be coupling between E & M effects, and gravitation along the lines of employing the Quantum (coupled) oscillator frequency relationship for coherent "state" oscillation as given by Sidarth' via

$$G\hbar\omega_{\max} = c^5 \tag{1.16}$$

This would be to come up with a realistic way to talk about clumps of gravitons which may have coherent oscillatory behavior and to use this to make sense of the structure of say up to 10^{38} coherent gravitons to form coherent clumps to obtain GW of sufficient semi classical initial conditions , to obtain conditions, initially to have the $S \sim N$ counting algorithm work for gravitons as coherent clumps , allegedly in a structure defined by Eq. (1.16)

Then, after employing Eq. (1.16) to next examine the limits of, and interexchange of effects given in Eq. (1.13) and Eq. (1.14) to determine from there to what degree is Eq. (1.15) is giving us joint linkage of E&M and gravitational waves in early universe conditions. Also , the author hopes that examining a potential inter play of Eq. (1.12) to Eq. (1.16) that the datum that the 10^{38} coherent gravitons [9] to form coherent clumps to obtain GW is necessary derivation will also, allow for explaining further the inter play between the choice of minimum length and momentum , as given by $\Delta p \approx \hbar / l_{Planck} = P_{\phi}$ and the supposition of more initial degrees of freedom than is usually supposed by conventional cosmology , of the sort presented by Kolb And Turner's book on cosmology. Finally, once this task is done, the author thinks that L. Glinka's formula [14], [15] of

$$n_f = [1/4] \cdot \left[\sqrt{\frac{\nu(a_{initial})}{\nu(a)}} - \sqrt{\frac{\nu(a)}{\nu(a_{final})}} \right] \tag{1.17}$$

could be investigated as being part of the bridge between phenomenology of both photon gases, and their entropy, as well as a modified treatment of L. Glinka's graviton gas, with suitable inputs into the frequencies allowed for both 'gases'

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