DECELERATION PARAMETER Q(Z) AND EXAMINATION IF A JOINT DM-DE MODEL IS FEASIBLE, WITH APPLICATIONS TO " ATOMS OF SPACE TIME" THERMODYNAMCS AND BBN

A. Beckwith[1],

1) abeckwith@uh.edu, Chongquing University department of physics;, P.R. China, 400014, Beckwith@iibep.org, American Institute of Beamed Energy Propulsion (aibep.org); Seculine Consulting, USA
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The case for a four dimensional graviton mass (non zero) influencing reacceleration of the universe in five dimensions is stated, with particular emphasis upon if five dimensional geometries as given below give us new physical insight as to cosmological evolution. One noticeable datum, that a calculated inflaton $\phi(t)$ may partly re-emerge after fading out in the aftermath of inflation. The inflaton may be a contributing factor to, with non zero graviton mass, in re acceleration of the universe a billion years ago. Many theorists assume that the inflaton is the source of entropy. The inflaton also may be the source of re acceleration of the universe, especially if the effects of a re emergent inflaton are in tandem with the appearance of macro effects of a small graviton mass, leading to a speed up of the rate of expansion of the universe one billion years ago, at red shift value of Z ~ .423. The key formula, for joint DM-DE shows up in terms of deceleration parameter, Q(z). The choice of the DM-DE eqn. may eventually illuminate how early BBN may affect the formation of low levels of lithium for early star formation which we reference toward the end of this document. We also discuss what is necessary for not only proper BBN, but also to the implications for 'atoms' of space time congruent with relic GW production, i.e. the thermodynamics of emergent structure.

1 Introduction

1.1 What can be said about gravitational wave density value detection?

We will start with a first-principle introduction to detection of gravitational wave density using the definition given by Maggiore [1]

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

where n_f is the frequency-based numerical count of gravitons per unit phase space. The author suggests that n_f may also depend upon the interaction of gravitons with neutrinos in plasma during early-universe nucleation, as modeled by M. Marklund *et al* [2]. Having said that, the question is, what sort of mechanism is appropriate for considering macro affects of gravitons, and the author thinks that he has one, i.e. reacceleration of the universe, as far as a function of graviton mass, i.e. what Beckwith[3] did was to make the following presentation. Assume Snyder geometry and look at use of the following inequality for a change in the HUP, [4]

$$\Delta x \geq \left[\left(1/\Delta p\right) + l_s^2 \cdot \Delta p \right] \equiv \left(1/\Delta p\right) - \alpha \cdot \Delta p \qquad (2)$$

and that the mass of the graviton is partly due to the stretching alluded to by Fuller and Kishimoto,[5] a supposition the author[3] is investigating for a modification of a joint KK tower of gravitons, as given by Maartens[6] for DM. Assume the stretching of early relic neutrinos that would lead to the KK tower of gravitons--for when $\alpha < 0$, is[4],

$$m_n(Graviton) = \frac{n}{L} + 10^{-65} \text{ grams} \qquad (3)$$

Note that Rubakov[7] writes KK graviton representation as, after using the following normalization $\int \frac{dz}{a(z)} \cdot \left[h_m(z) \cdot h_{\tilde{m}}(z) \right] \equiv \delta\left(m - \tilde{m}\right)$ where J_1, J_2, N_1, N_2 are different forms of Bessel functions, to obtain the KK graviton/ DM candidate representation along RS dS brane world

$$h_m(z) = \sqrt{m/k} \cdot \frac{J_1(m/k) \cdot N_2\left(\left[m/k\right] \cdot \exp(k \cdot z)\right) - N_1(m/k) \cdot J_2\left(\left[m/k\right] \cdot \exp(k \cdot z)\right)}{\sqrt{\left[J_1(m/k)\right]^2 + \left[N_1(m/k)\right]^2}} \qquad (4)$$

This Eq. (4) is for KK gravitons having a TeV magnitude mass $M_Z \sim k$ (i.e. for mass values at .5 TeV to above a TeV in value) on a negative tension RS brane. What would be useful would be managing to relate this KK graviton, which is moving with a speed proportional to H^{-1} with regards to the negative tension brane with $h \equiv h_m\left(z \to 0\right) = const \cdot \sqrt{\frac{m}{k}}$ as an initial starting value for the KK graviton mass, before the KK graviton, as a 'massive' graviton moves with velocity H^{-1} along the RS dS brane. If so, and if $h \equiv h_m\left(z \to 0\right) = const \cdot \sqrt{\frac{m}{k}}$ represents an initial state, then one may relate the mass of the KK graviton, moving at high speed, with the initial rest mass of the graviton, which in four space in a rest mass configuration would have a mass lower in value, i.e. of $m_{graviton}(4 - Dim \;\; GR) \sim 10^{-48} eV$, as opposed to $M_X \sim M_{KK-Graviton} \sim .5 \times 10^9 eV$. Whatever the range of the graviton mass, it may be a way to make sense of what was presented by Dubovsky et.al. [8] who argue for graviton mass using CMBR measurements, of $M_{KK-Graviton} \sim 10^{-20} eV$ Dubosky et. al. [8] results can be conflated with Alves et. al. [9] arguing that non zero graviton mass may lead to an acceleration of our present universe, in a manner usually conflated with DE, i.e. their graviton mass would be about $m_{graviton}(4-Dim \quad GR) \sim 10^{-48} \times 10^{-5} eV \sim 10^{65}$ grams. Also assume that to calculate the deceleration, the following modification of the HUP is used: [2] $\Delta x \geq \left[(1/\Delta p) + l_s^2 \cdot \Delta p\right] \equiv (1/\Delta p) - \alpha \cdot \Delta p$, where the LQG condition is $\alpha > 0$, and brane worlds have, instead, $\alpha < 0$ [4]. Also Eq. (5) will be the starting point used for a KK tower version of Eq. (6) below. So from Maarten's [10] 2005 paper,

$$\dot{a}^2 = \left[\left(\frac{\tilde{\kappa}^2}{3}\left[\rho + \frac{\rho^2}{2\lambda}\right]\right)a^2 + \frac{\Lambda \cdot a^2}{3} + \frac{m}{a^2} - K\right] \tag{5}$$

Maartens [10] also gives a 2nd Friedman equation, as

$$\dot{H}^2 = \left[-\left(\frac{\tilde{\kappa}^2}{2} \cdot [p+\rho] \cdot \left[1 + \frac{\rho^2}{\lambda}\right]\right) + \frac{\Lambda \cdot a^2}{3} - 2\frac{m}{a^4} + \frac{K}{a^2}\right] \tag{6}$$

Also, if we are in the regime for which $\rho \cong -P$, for red shift values z between zero to 1.0-1.5 with exact equality, $\rho = -P$, for z between zero to **.5.** The net effect will be to obtain, due to Eq. (6)**,** and use $a \equiv [a_0 = 1]/(1+z)$. As given by Beckwith[3]

$$q = -\frac{\ddot{a}a}{\dot{a}^2} \equiv -1 - \frac{\dot{H}}{H^2} = -1 + \frac{2}{1 + \tilde{\kappa}^2[\rho/m] \cdot (1+z)^4 \cdot (1 + \rho \quad /2\lambda)} \approx -1 + \frac{2}{2+\delta(z)} \tag{7}$$

Eq. (6) assumes $\Lambda = 0 = K$, and the net effect is to obtain, a substitute for DE, by presenting how gravitons with a small mass done with $\Lambda \neq 0$, even if curvature **K** =0

2 Consequences of small graviton mass for reacceleration of the universe

In a revision of Alves *et. al*, [9] Beckwith[3] used a higher-dimensional model of the brane world and Marsden[6] KK graviton towers. The density ρ of the brane world in the Friedman equation as used by Alves *et. al*[9] is use by Beckwith[3] for a non-zero graviton

$$\rho \equiv \rho_0 \cdot (1+z)^3 - \left[\frac{m_g \cdot (c=1)^6}{8\pi G(\hbar = 1)^2}\right] \cdot \left(\frac{1}{14 \cdot (1+z)^3} + \frac{2}{5 \cdot (1+z)^2} - \frac{1}{2}\right) \tag{8}$$

I.e. Eq. (6) above is making a joint DM and DE model, with all of Eq. (6) being for KK gravitons and DM, and 10^{-65} grams being a 4 dimensional DE. Eq. (5) is part of a KK graviton presentation of DM/ DE dynamics. Beckwith[11] found at z ~ **. 4**, a billion years ago, that acceleration of the universe increased, as shown in Fig. 1.

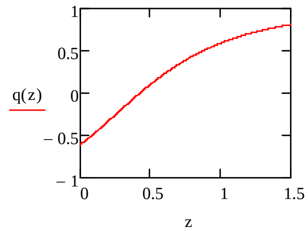

Fig. 1: Reacceleration of the universe based on Beckwith [3] **(note that q < 0 if z <.423)**

3. Suggesting a non standard way to accommodate small graviton mass in 4 D

If one is adding the small mass of $m_n(Graviton) = \frac{n}{L} + 10^{-65}$ grams[3], with $m_0(Graviton) \approx 10^{-65}$ grams, then the problem being worked with is a source term problem of the form given by Peskins[11] as of the type

$$\psi_n(x) \equiv \int d^3p \cdot \frac{1}{(2\pi)^3} \cdot \frac{1}{\sqrt{2E_P}} \cdot \left\{ \left(a_P + \frac{i}{\sqrt{2E_P}} \cdot FT(m_0(graviton)) \right) \exp(-ipx) + H.C. \right\} \quad (8)$$

This is, using the language V.A. Rubakov [7] put up equivalent to [3, 9],

$$\psi_m(x) \approx h_m(x) + \int d^3p \cdot \frac{1}{(2\pi)^3} \cdot \left(\frac{1}{\sqrt{2E_P}} \right)^2 \cdot \{ (i \cdot FT(m_0(graviton))) \exp(-ipx) + H.C. \} \quad (9)$$

If $m_0(graviton)$ is a constant, then the expression (9) has delta functions. This is the field theoretic identification. Another way is to consider an instanton-anti instanton treatment of individual gravitons, and to first start with the supposed stretch out of gravitons to enormous lengths. Assuming $m_0(Graviton) \approx 10^{-65}$ grams for gravitons in 4 dimensions, the supposition by Bashinsky[12] and Beckwith[3] is that density fluctuations are influenced by a modification of cosmological density ρ in the Friedmann equations by the proportionality factor given by Bashinsky,[12] $\left[1 - 5 \cdot (\rho_{neutrino}/\rho) + \vartheta\left([\rho_{neutrino}/\rho]^2 \right) \right]$ This proportionality factor for ρ as showing up in the Friedmann equations should be taken as an extension of results from Marklund *et. al* [2] , due to graviton-neutrino interactions as proposed by Marklund *et al*[2] , where neutrinos interact with plasmons and plasmons interact with gravitons. Thereby implying neutrino- graviton interactions Also, graviton wavelengths have the same order of magnitude of neutrinos. Note, from Valev, [13]

$$m_{graviton}\Big|_{RELATIVISTIC} < 4.4\times10^{-22}\, h^{-1} eV/c^{2}$$
$$\Leftrightarrow \lambda_{graviton} \equiv \frac{\hbar}{m_{graviton}\cdot c} < 2.8\times10^{-8}\, meters \qquad (10)$$

Extending M. Marklund *et al.*[2] and Valev[13], some gravitons may become larger [14], i.e.

$$\lambda_{graviton} \equiv \frac{\hbar}{m_{graviton}\cdot c} < 10^{4}\, meters \text{ or larger} \qquad (11)$$

A way to accommodate this wave length has been suggested by Beckwith,[3] as to an instanton-anti instanton packaging of gravitons, was to start with an analogy between Giovannini, [15] from a least action version of the Einstein – Hilbert action for 'quadratic' theories of gravity involving Euler- Gauss-Bonnet. Then Giovannini's [15] equation 6 corresponds to

$$\phi = \tilde{v} + \arctan\left((bw)^{\nu}\right) \qquad (12)$$

Givannini [15] represents of Eq. (12) as a kink, and makes references to an anti-kink solution, in Fig. 1 in Givannini [15] **.** Furthermore the similarity between Eq. (12) and $\phi_{+}(z,\tau) = 4\cdot\arctan\left(\exp\left\{\frac{z+\beta\cdot\tau}{\sqrt{1-\beta^{2}}}\right\}\right)$ in Beckwith's [3, 16] treatment with regards to density wave physics instantons is obvious. If $\arctan\left((bw)^{\nu}\right)$ is part of representing a graviton as
a kink-anti-kink combination, arising from a 5 dimensional line element**,** [15]

$$dS^{2} = a(w)\cdot\left[\eta_{uv}dx^{u}dx^{v} - dw^{2}\right] \qquad (13)$$

Then, noting as Beckwith[3] mentioned, there is the possibility of using t'Hoofts[17] classical embedding of "deterministic quantum mechanics" as a way to embed a nearly four dimensional graviton as having almost zero mass, in a larger non linear theory.

4. What if an inflaton partly re-emerges in space-time dynamics? At z ~ . 423?

Padmanabhan[18] has written up how the 2nd Friedman equation as of Eq. (5), which for **z ~ . 423** may be simplified to read as

$$\dot{H}^2 \cong \left[-2\frac{m}{a^4}\right] \qquad (14)$$

would lead to an inflaton value of , when put in, for scale factor behavior as given by $a(t) \propto t^{\lambda}, \lambda = (1/2) - \varepsilon^{+}, 0 \le \varepsilon^{+} << 1$, of, for the inflaton[18] and inflation of

$$\phi(t) = \int dt \cdot \sqrt{-\frac{\dot{H}}{4\pi G}} \qquad (15)$$

Assuming a decline of $a(t) \propto t^{\lambda}, \lambda = (1/2) - \varepsilon^{+}, 0 \le \varepsilon^{+} << 1$, Eq. (15) yields

$$\phi(t) \sim \sqrt{\frac{2m}{4\pi G}} \cdot \left[2\varepsilon^{+}\right] \cdot t^{2\cdot\varepsilon^{+}} \qquad (16)$$

As the scale factor of $a(t) \propto t^{\lambda}, \lambda = (1/2) - \varepsilon^{+}, 0 \le \varepsilon^{+} << 1$ had time of the value of roughly $a(t) \propto t^{\lambda}, \lambda = (1/2) - \varepsilon^{+}, 0 \le \varepsilon^{+} << 1$ have a power law relationship drop below $a(t) \propto t^{1/2}$, the inflaton took Eq. (16) 's value which may have been a factor as to the increase in the rate of acceleration, as noted by the q factor , given in Fig. 1. Note that there have been analytical work projects relating the inflaton, and its behavior to entropy via noting that inflation stopped when the inflaton field settled down into a lower lower energy state. The way to relate an energy state to the inflaton is , if $a(t) = a_0 t^{\lambda}$, then in the early universe, one has a potential energy term of [19]

$$V(\phi) = V_0 \cdot \exp\left[-\sqrt{\frac{16\pi G}{\lambda}} \cdot \phi(t)\right] \qquad (17)$$

A situation where both $\lambda = (1/2) - \varepsilon^{+}$ grows smaller, and, temporarily, $\phi(t)$ takes on Eq. (16)'s value, even if the time value gets large, and also, if acceleration of the cosmic expansion is taken into account, then there is infusion of energy by an amount dV. The entropy dS ≃dV/T, will lead, if there is an increase in V, as given by Eq. (17) a situation where there is an effective increase in entropy. If there is, as will be related to later, in page eight, circumstances, where $S \approx N =$ number of graviton states[3,18] as will be derived in Eq. (27), then at least in higher dimensions, we have an argument that the re emergence of an inflaton, with a corresponding reduction of Eq. (17) in magnitude may be part of gravitons playing a role in the re acceleration of the universe.

5. Other than five dimensions for cosmology? Problems which need resolutions

If a way to obtain a graviton mass in four dimensions is done which fits in with the as given higher 5 dimensions specified by a slight modification of brane theory, or Maarten's cosmological evolution[3,10] equations, what benefits could this approach accrue for other outstanding problems in cosmology ? Beckwith[3] claims that a re do of the Friedmann equations would result in deceleration parameter q(z) similar to Fig. 1 above. Snyder geometry for the four dimensional case with would specify Friedmann equations along the lines of $\alpha > 0$ in Eq. (2) above. If one follows $\alpha < 0$, then the Friedmann equations appear as giving details to the following equation [3, 20]

$$\Im = -\frac{1}{2}\int d^4 x h^0_{uv} \cdot T^{uv} \sim L^2 \approx \delta^+ \geq 0 \tag{18}$$

The construction done from sections 1 to 3 are for $\alpha < 0$. When $\alpha > 0$, the claim is that almost all the complexity is removed $\alpha > 0$, and what is left is a Taveras[20] treatment of the Friedmann equations, where he obtains, to first order, if ρ is a scalar field density,

$$\left(\frac{\dot{a}}{a}\right)^2 = [\kappa/3] \cdot \rho \tag{19}$$

and

$$\left(\frac{\ddot{a}}{a}\right) = -[2 \cdot k/3] \cdot \rho \tag{20}$$

The interpretation of ρ as a scalar field density [20], and if one does as Alves et al [9] uses Eq. (7) above. We need to interpret the role of ρ. In the LQG version by[21] , Eq. (20) may be rewritten as follows: If conjugate momentum is in many cases, "almost" or actually a constant, using $\dot{\phi} = -[\hbar/i] \cdot [\partial/\partial p_\phi]$

$$\left(\frac{\dot{a}}{a}\right)^2 \equiv [\kappa/6] \cdot \left[p^2_\phi / a^6\right] \tag{21}$$

Beckwith[11] claims that the deceleration parameter q (z) incorporating Eq. (19), Eq. (20) and Eq. (21) should give much the same behavior as Fig. 1 above. If so, then if one is differentiating between four and five dimensions by what is gained, in cosmology, one needs having it done via other criteria. The following is a real problem. As given by Maggiore [1] , the massless equation of the graviton evolution equation takes the form

$$\partial_\mu \partial^\varpi h_{\mu\nu} = \sqrt{32\pi G} \cdot \left(T_{\mu\nu} - \frac{1}{2}\eta_{\mu\nu} T^\mu_\mu\right) \tag{22}$$

When $m_{graviton} \neq 0$, the above becomes

$$\left(\partial_{\mu}\partial^{\varpi}-m_{graviton}\right)\cdot h_{\mu\nu}=\left[\sqrt{32\pi G}+\delta^{+}\right]\cdot\left(T_{\mu\nu}-\frac{1}{3}\eta_{\mu\nu}T_{\mu}^{\mu}+\frac{\partial_{\mu}\partial_{\nu}T_{\mu}^{\mu}}{3m_{graviton}}\right) \qquad (23)$$

The mismatch between these two equations, when $m_{graviton}\to 0$, is due to $m_{graviton}h_{\mu}^{\mu}\neq 0$ as $m_{graviton}\to 0$, which is due to setting a value of $m_{graviton}\cdot h_{\mu}^{\mu}=-\left[\sqrt{32\pi G}+\delta^{+}\right]\cdot T_{\mu}^{\mu}$ The semi classical method by t'Hooft[17] , using Eq. (12) is the solution. We generalize to higher dimensions the following diagram as given by Beckwith[3] . Use an instanton- anti instanton structure, and t'Hooft [17] equivalence classes along the lines of Eq. (24) below with equivalence class structure in the below wave functional to be set by a family of admissible values[3] $\phi_0(x)$

$$\Psi_{i,f}\left[\phi(\mathbf{x})\right]\Big|_{\phi=\phi_{ci,cf}}=c_{i,f}\cdot\exp\left\{-\int d\mathbf{x}\,\alpha\left[\phi_{Ci,f}(\mathbf{x})-\phi_0(\mathbf{x})\right]^2\right\} \qquad (24)$$

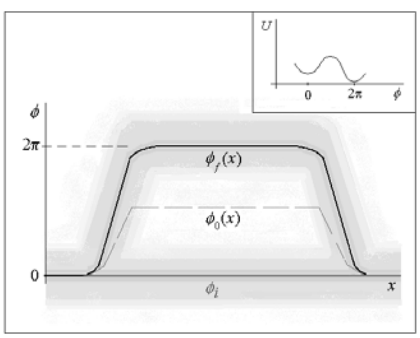

Fig. 2: The pop up effects of an intanton-anti-instanton in Euclidian space[3, 17]

6. Tie in of Eq. (16) with structural issues of low lithium in early stars

What we are doing is to have Eq. (16) and Eq. (17) form an upper bound as to initial energy , making the identification of a net energy $E\propto\hbar\omega\propto V(\phi)$ at the onset of inflation with , when doing it $\omega \sim \omega_F$ which will serve as an upper bound to the expression below as part of the inequality so discussed for the formation of neutrino mass. Our discussion closely parallels what was introduced by Beckwith, in Eric [21] Note

M. Marklund, G. Brodin, and P.K. Shukla [22] have estimated neutrino mass as $m_\nu^2 = -g_{\alpha\ \beta} p^\alpha p^\beta$ where m_ν is neutrino mass, $g_{\alpha\beta}$ is for a metric, and p^α is four momentum. If space becomes abruptly flat at the onset of inflation, for a neutrino mass, as $\bar{L} \neq 0$ approaches zero, $g_{\alpha\beta}$ approaches $g_{\alpha\alpha}$, i.e. leading to flat space, then by M. Marklund et al [22] there exits, assuming k^α is for a four space wave number, the inequality

$$\omega_F^2 > \left(g_{\alpha\alpha} / |g_{00}|\right) \cdot \left[k^\alpha\right]^2 + 2\omega_F \left(g_{00}/|g_{00}|\right) k^0 \tag{25}$$

It is suggested that neutrino-graviton interactions would allow a researcher to input values of k^α , k^0, $g_{\alpha\alpha}$, and g_{00} when Eq. (25) is true, based on that the neutrino has approximately $10^{28} - 10^{29}$ the effective mass of a graviton. As seen in Eq. (10),

$m_{graviton} \leq 4.4 \times 10^{-22} h^{-1} eV / c^2 \Leftrightarrow \lambda_{graviton} \sim 2.8 \times 10^{15}\, meters$ versus having

$$m_{neutrino-relic-condt} \leq .5 \times 10^{-1} h^{-1} eV / c^2 \Leftrightarrow \lambda_{neutrino-relic-condt.} \equiv \frac{\hbar}{m_n \cdot c} \sim 2.8 \times 10^{-8}\, meters \tag{26}$$

I.e., for non-relativistic conditions, the contribution of the neutrino is $10^{22} - 10^{23}$ times larger than that from a graviton, . So for a non-relativistic graviton $\mu / M_{Planck} \sim \bar{L} \propto \frac{c - v}{c} \Leftrightarrow \frac{p^0}{\mu} \leq 1$. Once we specify that it is likely that graviton-neutrino wave mixing took place as $\bar{L} \to 0$, we can consider entropy contributions in the time neutrinos interacted with gravitons to perturbations on DM which may influence BBN [21].

7. How DM would be influenced by gravitons

The interrelationship of structure of the profile of a DM cluster , with perturbations to DM density profile [23]

$$\delta \equiv -\left[\frac{3}{2} \cdot \Omega_m \cdot H^2\right]^{-1} \cdot \nabla^2 \Phi \tag{27}$$

As told to the author by Sabino Matarre[23] , in July , 2009, in Como Italy, the gravitational potential has , perturbatively speaking an additional term f_{NL} added to variations in the gravitational potential term which Matarre gave as[23]

$$\Phi \equiv \Phi_L + f_{NL} \cdot \left[\Phi_L^2 \mathbin{ƍ} \left\langle \Phi_L^2 \right\rangle\right] + g_{NL} \cdot \Phi_L^3 \tag{28}$$

It is suggested that the function f_{NL} is largely due to entropy variations, some of which occurred during relic GW/graviton production. Here the expression $f_{NL} =$ variations from gaussianity. Furthermore, Φ_L is a linear Gaussian potential, and the overall gravitational potential is altered by inputs from f_{NL}. Note that neutrinos flavor physics oscillations are not very important in terms of f_{NL}, as specified in conversations. Beckwith had in September 23, 2009 in Erice with Georg Raffert[24] . Which leads to emphasizing the role of entropy processes due to graviton-neutrino physics, as $\overline{L} \to 0$ as written up by Beckwith [21]

8. 1st part of .Conclusion The start to this investigation is to explain how, and why the star HE0107-5240 could form with so little lithium in the first place. As stated by Fuller et al[22], neutrinos could interact with DM potential wells in ways Beckwith thinks could influence deviations from standard galaxy hierarchy formation models which will also have a counter part in deviations in the BBN nucleosynthesis of light elements,by examining the role of temperature fluctuations modeled on Eq (29) below ,leading to fluctuations affecting BBN element rarity[23].

$$(\delta T/T) \cong (1/3) \cdot \left[\Phi_L + \tilde{f}_{NL} \cdot \left(\Phi_L^2 - \langle \Phi_L \rangle^2 \right) \right] \tag{29}$$

While Eq. (29) above would have its maximum impact for regions as of about red shift $Z \sim 1.5 - 2.0$, the impact of Eq. (29) would be as of red shifts $Z \sim 1000 - 1100$, with the corresponding $\tilde{f}_{NL}$ influenced by Bashinsky's [25] neutrino – gravition damping as stated by the coefficient of density fluctuation modified by $\left[1 - 5 \cdot (\rho_{neutrino}/\rho) + \vartheta\left([\rho_{neutrino}/\rho]^2 \right) \right]$. Note that $\tilde{f}_{NL}$ would be larger than f_{NL} of Eq. (28) and would be dominated by neutrino-graviton interactions, whereas f_{NL} would be dominated by graviton generated entropy, with neutrinos at $Z \sim 2.0$ hitting DM directly. We submit that a graviton with a small rest mass may be more amendable to such interaction with neutrinos, and that in addition Eq. (27), Eq. (28) and Eq. (29) may influence and affect structure formation as seen by the following diagram in figure 1. Note that this is assuming that early universe interactions which we are talking about eventually play out and reach, with the re acceleration of the universe, as outlined in the 1st half of our document to also be indirectly responsible for the famous "halo merging tree diagram we call Fig 3 below.At or about when $k \geq k_{equilibrium} \equiv \tau_{equilibrium}^{-1} \sim 10^{-2} Mpc^{-1}$ begins to delineate the neutrino-GW interaction becoming a significant damping impact upon each other, one would be seeing variations from the usual structure formation, as given by the following diagram.

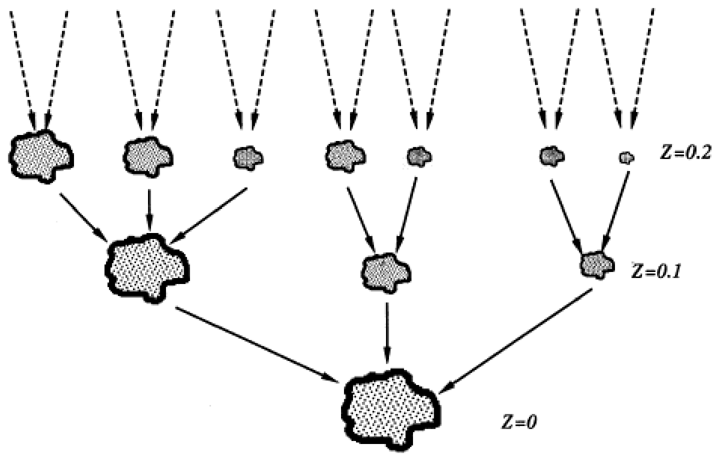

Figure 1. A schematic representation of a halo merging history 'tree'.

Figure 3 how we obtain 'bottom up' development of galactic super structure [26]

We should keep in mind that the following holds, i.e. for flat space. That one will have

Note that, M. Marklund, G. Brodin, and P.K. Shukla [22] posted their own version of not only neutrino mass, as given by $m_{\nu}^{2} = -g_{\alpha\ \beta} p^{\alpha} p^{\beta}$, where the overall mass is set by

Note, here, that the potential for where the frequency comes from is, here , is $U = \hbar \cdot \omega_F$, and , according to Eberle and Ringwald et al. [27], may have lightest relic neutrino masses of the order of

$$m_{relic-neutrino} \propto .1eV/c^2 \tag{30}$$

as opposed to, as given by D, Valev [13]

$$m_{graviton} \leq 2 \times 10^{-29} \breve{h}^{-1} eV / c^2 \tag{31}$$

Where $\breve{h} \approx .65$, is a dimensionless Hubble constant, Very roughly put, for relic early universe conditions, one may be seeing that the neutrino has $10^{28} - 10^{29}$ the effective mass than a graviton. Furthermore, for a neutrino we have [21]

$$\lambda_k \approx \frac{hc}{E_k} + \frac{hm_{\nu k}^2 c^5}{2E_k^3} \tag{32}$$

This will tie in directly with a neutrino mass limit we state as [21, 22]

$$m_\nu^2 = -g_{\alpha\ \beta} p^\alpha p^\beta \equiv \left[\hbar \cdot \sqrt{|g_{00}| \cdot \omega_F^2 - g_{\alpha\beta} k^\alpha k^\beta - 2\omega_F g_{0\alpha} k^\alpha}\right]^2 .. \qquad (33)$$

If , as if often expected in inflation, space becomes abruptly flat at the onset of inflation, then for a neutrino mass, as the $\overline{L} \xrightarrow[approach-to-standard-model-physics]{} 0$ will then lead to the following inequality [21, 22].

$$m_\nu^2 \equiv \left[\hbar \cdot \sqrt{|g_{00}| \cdot \omega_F^2 - g_{\alpha\beta} k^\alpha k^\beta - 2\omega_F g_{0\alpha} k^\alpha}\right]^2$$

$$\xrightarrow[Flat-Space]{} \left[\hbar \cdot \sqrt{|g_{00}| \cdot \omega_F^2 - g_{\alpha\alpha} \left[k^\alpha\right]^2 - 2\omega_F g_{00} k^0}\right]^2 > 0 \qquad (34)$$

$$\Leftrightarrow |g_{00}| \cdot \omega_F^2 > g_{\alpha\alpha} \left[k^\alpha\right]^2 + 2\omega_F g_{00} k^0 \Rightarrow |g_{00}| \cdot \omega_F^2 > g_{\alpha\alpha} \left[k^\alpha\right]^2 + 2\omega_F g_{00} k^0$$

Now, how would variation from the above " halo Merging history tree', partly due to the modulation , via entropy, of DM structure formation, due to GW/gravitons affecting DM profile affect the concentration for lithium in stars, and perhaps lead to the famous 'lithium problem" being resolved ? We are investigating it. But we do think that having a graviton with mass is affecting the particulars of the 'halo mixing tree' diagram[28].

9. 2nd part of Conclusion. Examining information exchange between different universes?

Beckwith[3] has concluded that the only way to give an advantage to higher dimensions as far as cosmology would be to look at if a fifth dimension may present a way of actual information exchange to give the following parameter input from a prior to a present universe, i.e. the fine structure constant, as given by [3]

$$\tilde{\alpha} \equiv e^2 / \hbar \cdot c \equiv \frac{e^2}{d} \times \frac{\lambda}{hc} \qquad (35)$$

The wave length as may be chosen to do such an information exchange would be part of a graviton as being part of an information counting algorithm as can be put below, namely: Argue that when taking the log, that the 1/N term drops out. As used by Ng [17]

$$Z_N \sim (1/N!) \cdot \left(V/\lambda^3\right)^N \qquad (36)$$

This, according to Ng,[18] leads to entropy of the limiting value of, if $S = (\log[Z_N])$ will be modified by having the following done, namely after his use of quantum infinite statistics, as commented upon by Beckwith[3]

$$S \approx N \cdot \left(\log\left[V/\lambda^3\right] + 5/2\right) \approx N \qquad (37)$$

Eventually, the author hopes to put on a sound foundation what 'tHooft[17] is doing with respect to t'Hooft [17] deterministic quantum mechanics and equivalence classes embedding quantum particle structures.. Doing so will answer the questions Kay[29] raised about particle creation, and the limitations of the particle concept in curved and flat space, i.e. the global hyperbolic space time which is flat everywhere expect in a localized "bump" of curvature. Furthermore, making a count of gravitons with $S \approx N \sim 10^{20}$ gravitons[3,17], with $I = S_{total} / k_B \ln 2 = [\#operations]^{3/4}$ ~ 10^{20} as implying at least one operation per unit graviton, with gravitons being one unit of information, per produced graviton[3]. What the author, Beckwith, sees is that since instanton- anti instanton pairs do not have to travel slowly, as has been proved by authors in the 1980s, that gravitons if nucleated in a fashion as indicated by Fig. 2, may be able to answer the following. The stretch-out of a graviton wave, greater than the size of the solar system, gives, an upper limit of a graviton mass due to wave length $\lambda_{graviton} > 300 \cdot h_0 kpc \Leftrightarrow m_{graviton} < 2\times 10^{-29} h_0^{-1} eV$. I. e. stretched graviton wave, at ultra-low frequency, may lead to a low mass limit. However, more careful limits due to experimental searches, as presented by Buonanno [30] have narrowed the upper limit to $10^{-20} h_0^{-1} eV$. An instanton – anti instanton structure to the graviton, if confirmed, plus experimental confirmation of mass, plus perhaps $n \sim 10^{20}$ gravitons $\approx 10^{20}$ entropy counts, Eq. (23) implies up to $\approx 10^{27}$ operations. If so, there is a one-to-one relationship between an operation and a bit of information, so a graviton has at least one bit of information. And that may be enough to determine the conditions needed to determine if Eq. (21) gives information and structure from a prior universe to our present cosmos. Finally, the datum referred to in Eq. (14) to Eq. (17) as combined with $S \approx N$ as referenced on pages 5 and 6 as a way to relate the graviton count with entropy may be a way to make inter connection between the inflaton picture of entropy generation and entropy connected/ generated with a numerical count of gravitons. This datum needs experimental confirmation and is important to astro physics linkage of DE with DM, in the future. Eq. (14) to Eq. (17) if confirmed for Z ~ . 423 may prove that higher dimensions are necessary for cosmology.

10. 3rd and final point to conclusions , the need to find out the border of the introduction of where Quantum gravity emerges from a prior 'analog' structure may, if tied into questions of graviton mass determine if multiple universes are possible/ feasible. As well as extending a new "atoms of space time" of GR 'thermodynamics' to the early universe.

Beckwith[31], in his FQXi document outlined a procedure where a graviton with mass may be indicative of the existence of multiple universes co existing. The details of the mapping of that multiple universe picture involve a transition from an analog physics (discrete, i.e. classical world picture) to one where octonian gravity is formed ,i.e. a quantum picture as a pre cursor to quantum gravity. The existence of a small mass may mean the extension of quantum physics to a larger embedding/ extension of quantum physics. Furthermore, keep in mind that tandem to that step of semi classical embedding of a graviton, that eventually we want to make explicit an idea by, T. Padmanabhan in DICE 2010 , as to finding "atoms of space time" permitting a thermodynamic treatment of emergent structure similar to Gibbs treatment of statistical physics[32]. I.e. for finding out if the following is possible, ie. can an ensemble of gravitons, be used to construct an 'atom' of space time congruent with relic GW. That is our ultimate end, as to our research. That would make our inquiry of the nature of gravitons most worthwhile. This idea was presented at DICE 2010, and we would like to refine it in our future research work. This would be in tandem of adapting the Kiefer, Polarski, and Starobinsky[33] presentation of the evolution of relic entropy via the evolution of phase spaces, with Γ/Γ_0 being the ratio of 'final (future)' / 'initial' phase space volume, for k modes of secondary GW background. From "atoms of space time" treatment of early universe space time geometry according to

$$S(k) = \ln \frac{\Gamma}{\Gamma_0} \tag{38}$$

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