Applications of Euclidian Snyder geometry to the foundations of space-time physics

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Abstract. A thought experiment supposition will be raised as a way to start investigations into choosing either LQG or string theory as an initial space-time template for emergent gravity. This paper will explore the applications of deformed Euclidian space to questions about the role of string theory and/or LQG: to what degree are the fundamental constants of nature preserved between different cosmological cycles, and to what degree is gravity an emergent field that is either partly/largely classical with extreme nonlinearity, or a far more quantum phenomenon?

Introduction

Recently, a big bounce has been proposed by papers on LCQ at the 12 Marcell Grossman conference (2009) as an alterative to singularity conditions that Hawkings, Ellis, and others use. In particular, Marco Valerio Batistini (2009) uses Snyder geometry to find a common basis in which to make a limiting approximation for how to derive either brane world or LQG conditions for cosmological evolution. The heart of what Batistini works with is a deformed Euclidian Snyder space, using $\hbar = c = 1$ units, obtaining then $[q,p] = i \cdot \sqrt{1-\alpha \cdot p^2} \Leftrightarrow \Delta q \Delta p \geq \frac{1}{2} \cdot \left| \left\langle \sqrt{1-\alpha \cdot p^2} \right\rangle \right|$. The LQG condition is $\alpha > 0$, and brane worlds have instead, $\alpha < 0$. As Batistini indicated, it is possible to obtain a string theory limit of $\Delta q \geq \left[(1/\Delta p) + l_s^2 \cdot \Delta p \right] \equiv (1/\Delta p) - \alpha \cdot \Delta p$. We will use this result explicitly in this paperto differentiate between criteria for information transfer from a prior to a present universe, to determine if minimum spatial uncertainty requirements for space-time can distinguish between LQG and brane world scenarios. What is at stake can be parsed as follows.

How much information is in an individual graviton? And how can one analyze normalized GW density in terms of gravitons?

Consider the following i.e., as a first principle introduction. What can be said about gravitational wave density and its detection? It is useful to note that normalized energy density of gravitational waves, as given by Maggiore (2008), is

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

Where n_f is a frequency-based count of gravitons per unit cell of phase space. In terms of early universe nucleation, the choice of n_f may also depend upon interaction of gravitons with neutrinos. The supposition is, that eventually, Eq. (1) above could be actually modified with a change of

$$n_f \propto n_f[graviton] + n_f[neutrinos] \quad (2)$$

And also a weighted average of neutrino-graviton coupled frequency $\langle f \rangle$, so that for detectors

$$h_0^2 \Omega_{gw}(f) \cong \frac{3.6}{2} \cdot \left[\frac{n_f[graviton] + n_f[neutrino]}{10^{37}} \right] \cdot \left(\frac{\langle f \rangle}{1kHz} \right)^4 \quad (3)$$

The supposition to be investigated is: What if Eq (3) were true? Among other things, the author suggests that the spread out in a spatial wave length extending to perhaps several light years in length of the neutrino, as outlined by Fuller and Kishimoto (2009), may be one of the factors leading to the graviton having in later times a small mass, perhaps on the order of $m_{graviton} \propto 10^{-65}$ grams as outlined by M Novello and R P Neves,(2003) theoretically, and Patrick J Sutton and Lee Samuel Finn (experimentally, in terms of pulsar physics) The consequences of such a small rest mass are shown in figure 1.

Consequences to be investigated

As suggeted by Beckwith (2009 gravitons may contribute to the re- acceleration of the Universe. In a revision of the Alves et al. (2009) treatment of the jerk calculation , i.e., --based on re-acceleration for the universe one billion years ago, Beckwith (2009) obtained for a brane world treatment of the Friedman equation, the following behavior. Assume X is red shift, Z. q(X) is Deceleration due to a small $m_{graviton} \propto 10^{-65}$ grams, with q(Z) defined as below

$$q = -\frac{\ddot{a}a}{\dot{a}^2} \tag{4}$$

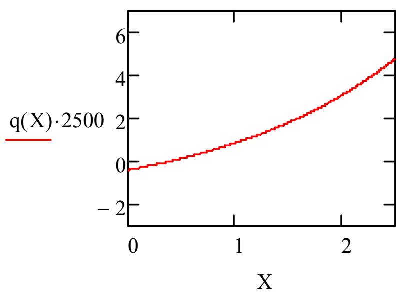

Figure 1: Basic results of Alves, et al. (2009), using their parameter values, with an additional term of C for "dark flow: added, corresponding to one KK additional dimensions.

The treatment of the jerk calculation follows what Beckwith (2009) did for a brane world plot and analysis of the jerk, q(Z), with Z set = X in the calculation above. This assumes that a small mass exists for the graviton, and that this is for a brane world treatment of the Friedman equation, with the density of a brane world,

$$\rho \equiv \rho_0 \cdot \left(\frac{a_0}{a}\right)^3 - \left[\frac{m_g c^6}{8\pi G \hbar^2}\right] \cdot \left(\frac{a^4}{14} + \frac{2a^2}{5} - \frac{1}{2}\right) \tag{5}$$

The above Eq (5) assumes use of the following inequality, for a change in the HUP

$$\Delta q \geq \left[(1/\Delta p) + l_s^2 \cdot \Delta p\right] \equiv (1/\Delta p) - \alpha \cdot \Delta p \tag{5a}$$

This assumes that the mass of the graviton is partly due to the stretching alluded to by Fuller and Kishimoto (2009), a supposition the author is investigating for a slight modification of a joint KK tower of gravitons, as given by Maartens (2005) for DM, which the author suggests is promising. I.e., what if the following actually occurred? Assume that the stretching of neutrinos that would lead to the KK tower of gravitons, for when $\alpha < 0$, and higher dimensions are used, is:

$$m_n(Graviton) = \frac{n}{L} + 10^{-65} \text{ grams,} \tag{6}$$

As well as having the following way of calculating the jerk; If the following modification of the HUP is set, $\Delta q \geq \left[(1/\Delta p) + l_s^2 \cdot \Delta p\right] \equiv (1/\Delta p) - \alpha \cdot \Delta p$, with the LQG condition is $\alpha > 0$, and brane worlds have, instead, $\alpha < 0$. When $\alpha < 0$, we effectively have higher dimensional gravity, and a representation of gravitons in KK space. This leads to the following treatment of the jerk calculation: when Brane worlds imply $\alpha < 0$ and when one has $\alpha > 0$ implying no higher dimensions are necessary.

To paraphrase a common question : What if a brane world and KK tower for representing Gravitons were used in the Friedman equation? What happens to the jerk calculation? Answer :They are already used in the Friedman equation.

If we wish to look at string theory versions of the FRW equation , in Friedman-Roberson-Walker metric space, we can do the following decomposition , with different limiting values of the mass, and other expressions, e.g., as a function of an existing cosmological constant

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{\rho_{Total}}{3M_{Planck}^2} - \frac{k}{a^2} + \frac{\Lambda}{3} \tag{6a}$$

As well as

$$\left(\frac{\ddot{a}}{a}\right) = -\frac{\left(\rho_{Total} + 3p_{Total}\right)}{6M_{Planck}^2} + \frac{\Lambda}{3} \tag{6b}$$

Not only this, if looking at the brane theory Friedman equations as presented by / for Randall Sundrum theory, it would be prudent working with

$$\dot{a}^2 = \left[\left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{\rho^2}{36M_{Planck}^2}\right)a^2 - \kappa + \frac{C}{a^2}\right] \tag{6c}$$

For the purpose of Randal Sundrum brane worlds, (6c) is what will be differentiated with respect to $d/d\tau$, and then terms from (6b) will be used, and put into a derivable equation, which will be for a RS brane world version of $q = -\frac{\ddot{a}a}{\dot{a}^2}$. Several different versions of what q should be will be offered for the time dependence of terms in (6c). Note that Roy Maartens (2004) states that KK modes (graviton) satisfy a 4 Dimensional Klein-Gordon equation, with an effective 4 dim mass, $m_n(Graviton) = \frac{n}{L}$, with $m_0(Graviton) = 0$, and L as the stated "dimensional value" of higher dimensions. The value $m_0(Graviton) \sim 10^{-65} - 10^{-60}$ gram in value picked is very small, but almost zero. Grossing (????DATE?) has shown how the Schrodinger and Klein Gordon equations can be derived from classical Lagrangians, i.e., using a version of the relativistic Hamilton-Jacobi- Bohm equation, with a wave functional $\psi \sim \exp(-iS/\hbar)$, with S the action, so as to obtain working values for a tier of purported masses of a graviton from the equation , for 4 D of $\left[g^{\alpha\beta}\partial_\alpha\partial_\beta \xrightarrow[FLAT-SPACE]{} \nabla^2 - \partial_\tau^2\right]$, and $\left[\nabla^2 - \partial_\tau^2\right]\cdot \psi_n = m_n^2(graviton)\cdot \psi_n$ If one adds instead the small mass of $m_n(Graviton) = \frac{n}{L} + 10^{-65}$ grams, with $m_0(Graviton) \approx 10^{-65}$ grams, with the supposition that the small added mass, $m_0(Graviton) \approx 10^{-65}$ is a result of a semi classical super structure containing the usual field theory/ brane world treatment of gravitons.

Creating an analysis of how graviton mass, assuming branes, can influence expansion of the universe

Following development of (6c) as mentioned above, with inputs from Friedman eqns. To do this, the following normalizations will be used, i.e., $\hbar = c = 1$, so then

$$q = A1 + A2 + A3 + A4 \tag{6d}$$

Where

$$A1 = \frac{C}{a^3}\cdot\left[1 \Big/ \sqrt{\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)}\right] \tag{6e}$$

$$A2 = -\left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\Big/\left[\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\right] \tag{6f}$$

$$A3 = -\frac{1}{2}\cdot\left[\frac{(d\rho/d\tau)}{3M_4^2} + \frac{(d\Lambda_4/d\tau)}{3} + \frac{1}{18}\cdot\frac{\rho\cdot(d\rho/d\tau)}{M_P^2}\right]\Big/\left[\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\right]^{3/2} \tag{6g}$$

$$A4 = \frac{\kappa}{a^3}\cdot\left[\frac{(da/d\tau)}{3}\right]\Big/\left[\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\right]^{3/2} \tag{6h}$$

Furthermore, if we are using density according to whether or not 4 dimensional graviton mass is used, then

$$\rho \equiv \rho_0\cdot\left(\frac{a_0}{a}\right)^3 - \left[\frac{m_g c^6}{8\pi G\hbar^2}\right]\cdot\left(\frac{a^4}{14} + \frac{2a^2}{5} - \frac{1}{2}\right) \tag{6i}$$

So, then one can look at $d\rho/d\tau$ obtaining

$$d\rho/d\tau = -\left(\frac{\dot{a}}{a}\right)\cdot\left[3\cdot\rho_0\cdot\left(\frac{a_9}{a}\right)^3 + 4\cdot\left(\frac{a^4}{14} + \frac{a^2}{5}\right)\cdot\left(\frac{m_g c^6}{8\pi G\hbar^2}\right)\right] \tag{6j}$$

Here, use, $\left(\frac{\dot{a}}{a}\right) = \sqrt{\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)}$, and assume eqn. (6i) covers ρ, then

If $\hbar \equiv c \equiv 1$,

$$d\rho/d\tau = -\sqrt{\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)}\cdot\left[3\cdot\rho_0\cdot\left(\frac{a_9}{a}\right)^3 + 4\cdot\left(\frac{a^4}{14} + \frac{a^2}{5}\right)\cdot\left(\frac{m_g}{8\pi G}\right)\right] \tag{6k}$$

Now, if, to first order, $d\Lambda_4/d\tau \sim 0$ and, also, we neglect Λ_4 as of being not a major contributor

$$d\rho/d\tau \cong -\sqrt{\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)}\cdot\left[3\cdot\rho_9\cdot\left(\frac{a_0}{a}\right)^3 + 4\cdot\left(\frac{a^4}{14} + \frac{a^2}{5}\right)\cdot\left(\frac{m_g}{8\pi G}\right)\right] \tag{6l}$$

$$A3 \cong \frac{1}{2}\left(\cdot\left[\frac{1}{3M_4^2} + \frac{1}{18}\cdot\frac{\rho\cdot}{M_P^6}\right]\Big/\left[\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\right]^{1/2}\right)\cdot \left[3\cdot\rho_0\cdot\left(\frac{a_0}{a}\right)^3 + 4\cdot\left(\frac{a^4}{14} + \frac{a^2}{5}\right)\cdot\left(\frac{m_g}{8\pi G}\right)\right]\cdot \tag{6m}$$

Also, then, set the curvature equal to zero. i.e. $\kappa = 0$. So then $A4 = 0$, and

$$A3 \cong \frac{1}{2}\left(\cdot\left[\frac{1}{3M_4^2}+\frac{1}{18}\cdot\frac{\rho\cdot}{M_P^6}\right]\Big/\left[\frac{C}{a^4}+\left(\frac{\rho}{3M_4^2}+\frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\right]^{1/2}\right)\cdot \left[3\cdot\rho_0\cdot\left(\frac{a_0}{a}\right)^3+4\cdot\left(\frac{a^4}{14}+\frac{a^2}{5}\right)\cdot\left(\frac{m_g}{8\pi G}\right)\right]\cdot \tag{6n}$$

Then

$$A2 \cong -\left(\frac{\rho}{3M_4^2}+\frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\Big/\left[\frac{C}{a^4}+\left(\frac{\rho}{3M_4^2}+\frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\right] \tag{6o}$$

$$A1 \cong \frac{C}{a^3}\cdot\left[1\Big/\sqrt{\frac{C}{a^4}+\left(\frac{\rho}{3M_4^2}+\frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)}\right] \tag{6p}$$

Pick, here, $\rho \equiv \rho_0\cdot\left(\frac{a_0}{a}\right)^3-\left[\frac{m_g}{8\pi G}\right]\cdot\left(\frac{a^4}{14}+\frac{2a^2}{5}-\frac{1}{2}\right)$, after $\hbar = c = 1$, and also set

$$\Phi(\rho,a,C)=\frac{C}{a^4}+\left(\frac{\rho}{3M_4^2}+\frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right) \tag{6q}$$

$$A3 \cong \frac{1}{2}\left(\cdot\left[\frac{1}{3M_4^2}+\frac{1}{18}\cdot\frac{\rho\cdot}{M_P^6}\right]\Big/[\Phi(\rho,a,C)]^{1/2}\right)\cdot\left[3\cdot\rho_0\cdot\left(\frac{a_0}{a}\right)^3+4\cdot\left(\frac{a^4}{14}+\frac{a^2}{5}\right)\cdot\left(\frac{m_g}{8\pi G}\right)\right] \tag{6r}$$

$$A2 \cong -\left(\frac{\rho}{3M_4^2}+\frac{1}{36}\cdot\frac{\rho^2}{M_P^6}\right)\Big/[\Phi(\rho,a,C)] \tag{6s}$$

$$A1 \cong \frac{C}{a^3}\cdot\left[1\Big/\sqrt{\Phi(\rho,a,C)}\right] \tag{6t}$$

For what it is worth, the above can have the shift to red shift put in by the following substitution. I.e., use $1+z=a_0/a$. Assume also that C is the dark radiation term which in the brane version of the Friedman equation scales as a^{-4} and has no relationship to the speed of light. a_0 Is the value of the scale factor in the present era, when red shift z =0, and $a \equiv a(\tau)$ in the past era, where τ is an interval of time after the onset of the big bang. $(a_0/a)^3=(1+z)^3$, and $a \equiv a_0/(1+z)$, Then

$$\rho(z) \equiv \rho_0\cdot(1+z)^3-\left[\frac{m_g}{8\pi G}\right]\cdot\left(\frac{a_0^4}{14\cdot(1+z)^4}+\frac{2a_0^2}{5\cdot(1+z)^2}-\frac{1}{2}\right) \tag{6u}$$

$$A1(z) \cong \frac{C\cdot(1+z)^3}{a_0^3}\cdot\left[1\Big/\sqrt{\Phi(\rho(z),a_0/(1+z),C)}\right] \tag{6v}$$

$$A2(z) \cong -\left(\frac{\rho(z)}{3M_4^2}+\frac{1}{36}\cdot\frac{\rho(z)^2}{M_P^6}\right)\Big/[\Phi(\rho(z),a_0/(1+z),C)] \tag{6w}$$

$$A3(z) \cong \frac{1}{2}\left(\cdot \left[\frac{1}{3M_4^2} + \frac{1}{18} \cdot \frac{\rho(z)\cdot}{M_P^6} \right] \Big/ \left[\Phi\left(\rho(z), a_0/(1+z), C\right)\right]^{1/2} \right) \cdot$$

$$\left[3 \cdot \rho_0 \cdot (1+z)^3 + 4 \cdot \left(\frac{a_0^4/(1+z)^4}{14} + \frac{a_0^2/(1+z)^2}{5} \right) \cdot \left(\frac{m_g}{8\pi G} \right) \right] \tag{6x}$$

$$\Phi\left(\rho(z), a_0/(1+z)), C\right) = \frac{C \cdot (1+z)^4}{a_0^4} + \left(\frac{\rho(z)}{3M_4^2} + \frac{1}{36} \cdot \frac{\rho(z)^2}{M_P^6} \right) \tag{6y}$$

So, for $4 < z \le 0$, i.e., not for the range, say $z \sim 1100$ 380 thousand years after the big bang, it would be possible to model, here

$$q(z) = A1(z) + A2(z) + A3(z) \tag{6z}$$

Easy to see though, that to first order, $q(z) = A1(z) + A2(z) + A3(z)$ would be enormous when $z \sim 1100$, and also that for Z =0, $q(0) = A1(0) + A2(0) + A3(0) > 0$ .Negative values for eqn. (6z) appear probable at about $z \sim 1.5$, when eqn. (6a1) would dominate, leading to $q(z \sim 1.5))$ with a negative expression/ value . The positive value conditions rely upon, the C dark radiation term,

Final result. The JERK calculation can be done, for the braneworld case, and KK gravitons. However, it also is a major problem as to explain exactly what may have contributed to the graviton having a slight mass which contravenes the correspondence principle. We will get to this in the last part of this article.

Now what can one expect with LQG condition with respect to the HUP, with $\alpha > 0$? What happens, is that most of the complexity drops out, and above all, the following

When using the LQG condition $\alpha > 0$, in Snyder geometry modified HUP

The claim is that almost all the complexity is removed, and what is left is a set of equations similar to the tried and true $\left(\frac{\dot{a}}{a}\right)^2 = \frac{\rho_{Total}}{3M_{Planck}^2} - \frac{k}{a^2} + \frac{\Lambda}{3}$. To get an idea of what happens with LQG versions of the Friedman equation, one can look at Taveras's (2008) treatment of the Friedman equations, and he obtains, to first order, if ρ is a scalar field DENSITY.

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{\kappa}{3} \cdot \rho \tag{7a}$$

As well as

$$\left(\frac{\ddot{a}}{a}\right) = -\frac{2 \cdot \kappa}{3} \cdot \rho \tag{7b}$$

The interpretation of ρ as a scalar field DENSITY, and if one does as Aves et al did, i.e work with flat space, with k=0, in $\left(\frac{\dot{a}}{a}\right)^2 = \frac{\rho_{Total}}{3M_{Planck}^2} - \frac{k}{a^2} + \frac{\Lambda}{3}$, as well as $\rho \equiv \rho_0 \cdot \left(\frac{a_0}{a}\right)^3 - \left[\frac{m_g c^6}{8\pi G \hbar^2}\right] \cdot \left(\frac{a^4}{14} + \frac{2a^2}{5} - \frac{1}{2}\right)$

The sticking point in all of this is to interpret the role of ρ. In the purported LQG version brought up by Taveras's (2008) article, the $\left(\frac{\dot{a}}{a}\right)^2 = \frac{\kappa}{3} \cdot \rho$ may be rewritten, as follows: If conjugate momentum is in many cases, "almost" or actually a constant, then to good effect,

$$\left(\frac{\dot{a}}{a}\right)^2 \equiv \frac{\kappa}{6} \cdot \frac{p_\phi^2}{a^6} \tag{7c}$$

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

$$\dot{\phi} = -\frac{\hbar}{i} \cdot \frac{\partial}{\partial \cdot p_\phi} \tag{7d}$$

It is appropriate to consider, to first order that Alves et al's program can probably be carried out, especially if Eq (7d) is, true, but this is a matter of subjective interpretation of Eq. (7d) above. The main point though that there should be an interpretation of what the graviton actually is, which is in common to both the LQG condition $\alpha > 0$, and the brane world case, when $\alpha < 0$.

What is in common, with both models as far as 4 dimensional representations of the Graviton, for both $\alpha < 0$ and $\alpha > 0$

Two hypotheses to consider. The first is that there is an interaction between neutrinos and gravitons. Bashinsky (2005), gave details in his article about an alleged modification of density fluctuations via neutrino-graviton interactions. A far more radical hypothesis George Fuller and Chad Kishimoto's 2009 BY WHOM? is that there are a few "stretched neutrinos" that may span many light years, and these stretched neutrinos may affect gravitons, as put forward for consideration by Bashinsky (2005) . What is being considered is that there is graviton-neutrino interactions, as proposed by Bashinsky (2005) and that Fuller and Kishimoto (2009) ask what are the natures of the neutrino-graviton interaction if a few of the neutrinos 'stretch' by many light years. , and may lend credence to George Fuller and Chad Kishimoto's 2009 supposition that as the "universe expanded, the most massive of these states slowed down in the relic neutrinos, stretching them across the universe." If there is a coupling between gravitons and neutrinos, as speculated by Bashinsky, the author suggests that this brings into question the correspondence principle, which is usually used to require gravitons to be spin 2, with zero mass. This will be explored in the latter part of this paper.

The probably effect of stretching of the neutrino on graviton wavelengths

Assume that with stretching of the neutrino, and a graviton neutrino coupling with zeroth order value of $m_0(Graviton) \approx 10^{-65}$ grams as a consequence of at least a few of the neutrino-gravitons obeying density fluctuation as modified by Neutrio-Graviton intteractions . According to Bashinsky $\left[1 - 5 \cdot (\rho_{neutrino}/\rho) + \vartheta([\rho_{neutrino}/\rho]^2)\right]$, the overall density of the evolving space time continuum has neutrino-graviton interactions which effectively damp the overall space time density.. In addition, having equivalent neutrino-graviton wavelengths becomes instead the same order of magnitude as the wavelength values of neutrinos, with, initially

$$\begin{gathered} m_{graviton}\Big|_{RELATIVISTIC} < 4.4 \times 10^{-22} h^{-1} eV / c^2 \\ \Leftrightarrow \lambda_{graviton} \equiv \frac{\hbar}{m_{graviton} \cdot c} < 2.8 \times 10^{-8} meters \end{gathered} \tag{7c}$$

A few select gravitons, coupled to almost infinite wavelength stretched neutrinos would lead to Eq(7c) , if the wavelengths were sufficiently large, as of

$$\lambda_{graviton} \equiv \frac{\hbar}{m_{graviton} \cdot c} < 10^4 meters \text{ or larger} \tag{8}$$

The author suggests that if graviton wave length becomes of the dimensions of Eq(8) or larger , as suggested perhaps up to the size of the solar system , that semi classical treatments of the Graviton may be appropriate to consider.

The correspondence principle, and t'Hooft's supposition of 'Deterministic QM' as applied to gravitons

What to look into? The author suggests that the stretch out of the graviton implied by Eq (8) above may be a sign that the correspondence principle, used by string theorists and others as a way to insist that the graviton be of zero mass, may have to be amended. After presenting why the author states this, the author will suggest a mechanism for replacement of the correspondence principle, which the author suggests is consistent with t'Hooft's deterministic quantum mechanics. The final part to this paper suggest what "information: a particle like the graviton may carry. What can be stated about the "correspondence principle" and its connections to gravitons? Rothman and Boughn wrote a well considered article (2006) arguing that it is unrealistic given current detector technology to envision gravitons ever being measured. The author asserts that their premise seems illogical, and can only be supported old style detector technology is used. The author will summarize Rothman and Bohn's findings with a statement as to what he views as a weak point in their presentation which may be amendable to investigations, and to from there to lay out as to how and why the graviton may carry physical information. Finally, upon doing this, the author will look into what a graviton "construction" with a tiny mass may entail as to instanton-anti instantons, and its relationship to t'Hooft's deterministic quantum mechanics. To recap what they are suggesting, it is useful to note the formula 2. from Rothman, and Bohn, (2006) which will be reproduced here, as , where $\tilde{n}$ is the purported numerical density of "detector particles," σ is the detector cross area, and $\tilde{\lambda}$ is the mean "distance" a graviton would have to travel, i.e., look at the following equation, as given by Rothman and Bohn(2009)

$$\tilde{n} \cdot \sigma \cdot \tilde{\lambda} \geq 1 \tag{9}$$

The author does not quarrel with the basic physics of Eq (9) above. Assume though that, for an instant, that the cross sectional area for a graviton would have to be larger "than the diameter of Jupiter, which is what. Rothman, and Bohn (2006) assume,. Note that " $\tilde{n}$ is given by Rothman and Bohn, to be $\tilde{n} \equiv M_{\det} / \lfloor m_{proton} \cdot V_{\det} \rfloor$. I.e., this is for a detector with gravitons interacting with some version of hydrogen, with $M_{\det}$ the "mass" of the detector, and with $V_{\det}$ the purported volume of the detector. Also, m_{proton} is the mass of protons in the detector which the gravitons may interact with. then the figures for the volume $V_{\det}$ being Jupiter sized may look very reasonable. The author does not understand the claim that the detector **must** be Jupiter sized , and can only assume its relevance to 2010 if one is using very old style, gas based detector technology. Rothman and Bohn go further, rewriting Eq (9) as implying the following for a numerical total of gravitons detected during the lifetime of an experiment as, when $L_{graviton-production}$ is the luminosity of graviton production, R as the purported distance the graviton would travel, while setting up the right hand side with $\frac{A_{\det} \cdot \tau_B}{\in_{graviton}} \equiv$ (detector cross sectional area* time of process for the graviton source to be operating) / graviton energy . Also, $\tau_B \leq \frac{M_{graviton-generating-source}}{L}$. Here $M_{graviton-generating-source}$ is the relative mass of the graviton producing source, and L the luminosity of the source. The bounds for τ_B effectively are invalidated if the source for the term $M_{graviton-generating-source}$ is not of the sort of graviton generator assumed by Rothman and Bohn (2006) if the graviton production "site" is relic early universe gravitons, instead of what is cited, i.e., for non zero graviton energies, $\in_{graviton}$

$$N_{graviton=\exp-lifetime} \equiv \left[\frac{L_{graviton-production}}{4\pi R^2} \right] \cdot \left[\frac{A_{\det} \cdot \tau_B}{\in_{graviton}} \right] \tag{9a}$$

Rothman and Bohn give a coherent argument that for neutron stars, black holes and the like, Eq. (9a) has an upper bound of $N_{graviton=\exp-lifetime} \approx 10^{-5}$. The author suggests that the total source luminosity L versus luminosity of graviton production process of the source $L_{graviton-production}$ may be very different from the ratio values given by Rothman, and Bohn, of $L_{graviton-production} / L = f_{graviton} \sim .01 - .02$. If the $f_{graviton}$ is over ten times larger, plus the life time $\tau_B \leq \frac{M_{graviton-generating-source}}{L} >>$ of graviton production from black holes with a larger time due to having a value of $M_{graviton-generating-source} >> 10^{15}$ grams , with 10^{15} grams ~ mass of a black hole, then $N_{graviton=\exp-lifetime} \approx 10^{-5}$ may be way too small. Furthermore, if the stretched neutrino hypothesis, with coupling to the graviton occurs, then, assuming that there is at a minimum $\lambda_{graviton} \equiv \frac{\hbar}{m_{graviton} \cdot c} < 10^4\,meters$, instead of $\lambda_{graviton} \equiv \frac{\hbar}{m_{graviton} \cdot c} < 2.8 \times 10^{-8}\,meters$, even with a non-giant planet sized detector, one would see an effective $N_{graviton=\exp-lifetime} >> N_{Rothman-calculated-graviton-\exp er-lifetime} \approx 10^{-5}$, perhaps as high as nearly unity. And this is primarily due to recalibration of the different input coefficients. This is, however, using very old gravitational wave/graviton detector technology. It will lead up to the author questioning the standard correspondence principle used to characterize gravitons, and to mention an alternative as to having Gravitons with spin 2, but perhaps masses slightly larger than zero. Eventually, this will lead to considering the correspondence principle, as well as t'Hooft's "deterministic" quantum mechanics as a way to consider the nature of gravitons.

Can the graviton have a small mass? Embedding the laws of QM regarding gravitons within a nonlinear theory.

Recently, an alternative to usual space time Gravitation theories was proposed , HoYYava gravity, and has been obtaining reviews in the Perimeter Institute, among other places. Robert Brandenberger in (2009) also modeled this new theory in terms of the early universe, with the claim that there was a matter bounce instead of standard inflation. This theory, ironically depends upon a chaotic inflationary potential $V(\phi) = (1/2) \cdot m^2 \phi^2$ for its pre bounce conditions, and uses 'dark radiation' for obtaining a 'bounce', and Shinji Mukohyama (2009) has presented what he calls "scale-invariant, super-horizon curvature perturbations" . Both Mukohyama, and Brandeberger accept scale free 'perturbations' so long as the contraction phase does use 'quantum vacuum fluctuations', and the author is waiting to see if HoYYava gravity develops or is provided with a mechanism to transfer energy to the standard model of comology predictions as to the radiation and matter eras. By way of contrast what the author will attempt to do is to with gravitons is far more modest, i.e., referencing the construction of a graviton in terms of instanton- anti instantons, and asking if a composition of a graviton as such an 'object' as a composition of such kink- anti kinks can be tied in with 'tHoofts "deterministic quantum mechanics" Beginning the analysis, the author will review, briefly what he did with CDW in $1 + \varepsilon^+$ dimensions , and then reference the chances for doing the same for 4 dimensions for gravitons,. Finally, closing with a description if the graviton can carry information, and what this says about graviton mass.

Brief review of S-S' in CDW, and its relevance to higher dimensional 'objects'

Seen below is a representation of CDW and instantons The author is briefly presenting his density wave instanton- anti instanton construction for CDW, which has classical analogies, and then making a reference to such constructions in instanton type models in cosmology. As presented in Beckwith's PhD dissertation, kink- anti kink models have a classical analogy
with

$$\phi_{\pm}(z,\tau) = 4 \cdot \arctan\left(\exp\left\{\pm \frac{z+\beta\cdot\tau}{\sqrt{1-\beta^2}}\right\}\right) \tag{9.b}$$

Which is a solution to

$$\frac{\partial^2 \phi(z,\tau)}{\partial \tau^2} - \frac{\partial^2 \phi(z,\tau)}{\partial z^2} + \sin\phi(z,\tau) = 0 \tag{9.c}$$

A tunneling Hamiltonian version of such solutions had the following formalism, namely a Gaussian wave functional with

$$\Psi_{i,f}\ \left[\phi(\mathbf{x})\right]\Big|_{\phi \equiv \phi_{ci,cf}} = c_{i,f} \cdot \exp\left\{-\int d\mathbf{x}\ \alpha \left[\phi_{C_{i,f}}(\mathbf{x}) - \phi_0(\mathbf{x})\right]^2\right\}, \tag{9.d}$$

Furthermore, this allowed us to derive, as mentioned in another publication a stunning confirmation of the fit between the false vacuum hypothesis and data obtained for current – applied electrical field values graphs (I-E) curves of experiments initiated in the mid 1980s by Dr. John Miller, et al[13]. which lead to the modulus of the tunneling Hamiltonian being proportional to a current, with E_T a threshold pinning field

$$I \propto \widetilde{C}_1 \cdot \left[\cosh\left[\sqrt{\frac{2\cdot E}{E_T \cdot c_V}} - \sqrt{\frac{E_T \cdot c_V}{E}}\right]\right] \cdot \exp\left(-\frac{E_T \cdot c_V}{E}\right) \tag{9.e}$$

The phase as put in eqn. (9.d) was such that it had the following graphical representation, and it is indicative of what instanton physics can be used for, i.e., this is not a substitute for a well thought out treatment of instantons which will be connected with appropriate metrics in GR. Figure 4 in particular , is a template as to how the author will model a pop up effect of a S-S' pair, in a quantum mode, using S and S' pairs.

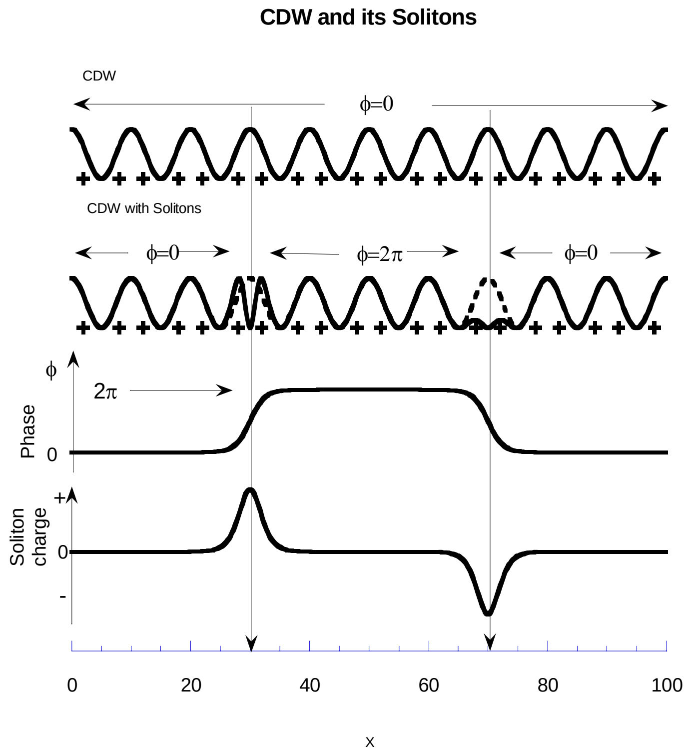

Figure 2: Typical results of density wave physics instanton-anti instanton pairs. As from Beckwith(2002), and Beckwith (2006)

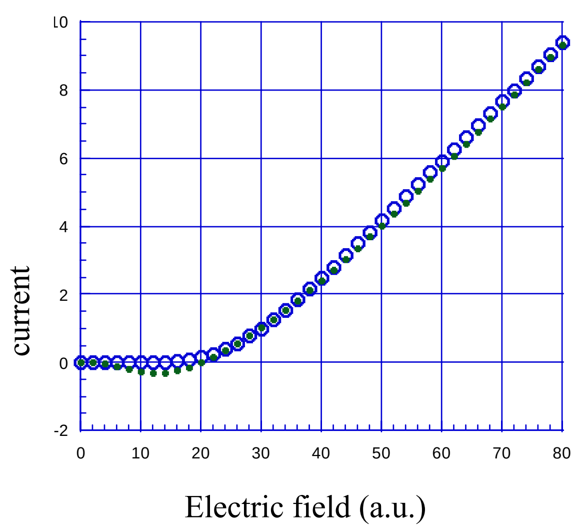

Figure 3 : Results of applying Eq (9.s) as opposed to $I \propto G_P \cdot (E - E_T) \cdot \exp\left(-\frac{E_T}{E}\right)$ if $E > E_T$, and setting $I = 0$ if $E \leq E_T$. In figure 4, the blue dots represent Eq. (9.s) whereas the black dots represent uniformly applying the non zero plot for electric fields as given by the Zenier plot approximation.

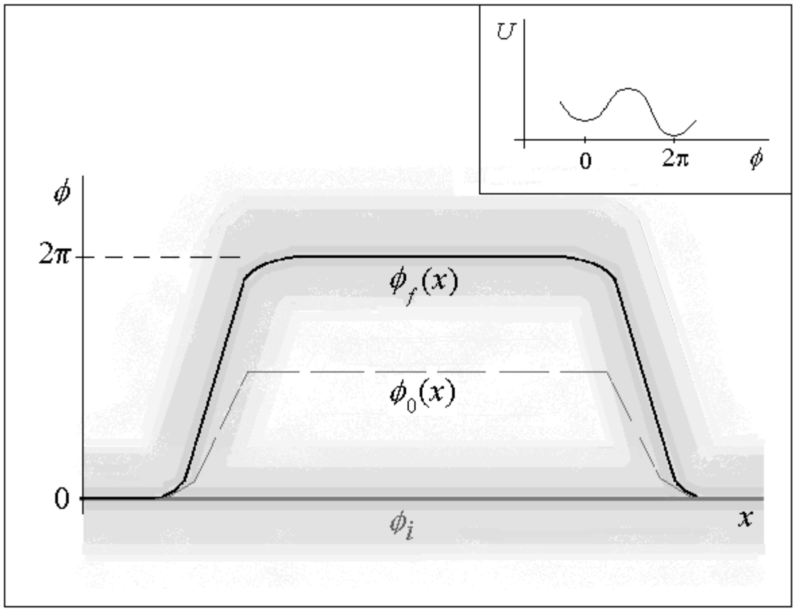

Figure 4. The pop up effects of an intanton- anti instanton in Euclidian space. Taken from Beckwith(2001)

In order to connect with GR, one needs to have a higher dimensional analog of $\phi_{\pm}(z,\tau) = 4 \cdot \arctan\left(\exp\left\{\pm \frac{z+\beta\cdot\tau}{\sqrt{1-\beta^2}}\right\}\right)$ which is consistent with regards to space time metrics, a topic which will be presented in brief, in the next section.

Brief introduction to instantons in GR, which are consistent with respect to space time metrics

The best, physically consistent models of GR admissible solitons appears to be given by Belunski, and Verdaguer, 2001, in work which ties in the instanton formulation for gravitation to specific metrics in space time physics. In addition, the author will reference done by Givannini, 2006, which gives a kink- anti kink construction, which the author says is similar to what the author was doing with CDW, in order to obtain a model of the graviton. How this graviton, as a kink- anti kink construction fits with QM, and the usual comments as to a correspondence mass zero values for the graviton will be brought up with t'Hoofs version of a Deterministic QM , i.e., a highly non linear structure embeds quantum physics, w.r.t. the graviton. Belunski, and Verdaguer, 2001, gave an example of how to match conditions of the instanton with space time metrics, and Givannini has another example of a kink- anti kink construction involving instantons which will be commented upon. The author also has a paper which claims that instantons initially travel at low velocity, and which only reach speeds up to nearly light speed in nearly infinite distance travel. Aside from the CDW example, the author is convinced that the only way to avoid such conundrums is to have a kink- anti kink construction for the graviton.. The basic idea is how to generalize figure 4, which was in the authors PhD dissertation, in 2001.Another argument as to how information can be attached to the graviton will be the closing part of this discussion., based upon a presentation which the author made in Chongquing University, November 2009. Belunski, and Verdaguer, 2001, give an example of how to generalize an instanton from the metric g, with $g \equiv diag\{t\cdot\exp(\phi), t\cdot\exp(-\phi)\}$ when put into the Einstein equations leads to obtaining a two part solution, which is further generalized on their page 198 to read, as

$$\phi \equiv d\cdot\ln t + \sum_{k=1}^{s} h_k \ln(\mu_k / t) \tag{9.g}$$

The 2nd part of this equation roughly corresponds to $\phi_{+}(z,\tau) = 4 \cdot \arctan\left(\exp\left\{\frac{z+\beta\cdot\tau}{\sqrt{1-\beta^2}}\right\}\right)$. Further work by Belunski, and Verdaguer, 2001 yields instanton- anti instanton solutions which are elaborations of Eq (9.s) above, which is in the case of instantons applied to cosmology can be justified by the warning given by J. Ibanez, and E. Verdaguer (1985) that instantons by themselves travel at speeds very much smaller at the speed of light, in cosmology and reach peak velocities only much later on, at 'infinite; distance from a source. To put it mildly, that is not going to work. Aside from other considerations, the warning by J. Ibanez, and E. Verdaguer (1985) is one of the reasons why the author is seeking higher dimensional versions of Figure 5 above, as a pop up version of when instantons can come into space time.

More on that later. It is important now to reference what was presented by Givannini, 2006 , namely from a least action version of the Einstein – Hilbert action for 'quadratic' theories of gravity involving Euler-Gauss-Bonnet, a scalar field which has the form of, when w in this case roughly corresponds to a time variable. Then.his equation 6 corresponds to

$$\phi = \tilde{v} + \arctan\left((bw)^{\nu}\right) \tag{9.h}$$

Givannini's (2006) manuscript also has a representation of Eq (9.t) as a kink, and makes references to an anti kink solution, in his figure 1. Furthermore the over lap between Eq. (9.t) and $\phi_{+}(z,\tau) = 4 \cdot \arctan\left(\exp\left\{\frac{z+\beta\cdot\tau}{\sqrt{1-\beta^2}}\right\}\right)$ is in its own way very obvious. If the two equations are similar, and if $\arctan\left((bw)^{\nu}\right)$ overlaps in behavior with $\sum_{k=1}^{s} h_k \ln\left(\mu_k / t\right)$ in certain limits, as far as the formation of an instanton, the problem is amendable to analysis. Furthermore, is considering what role a kink-anti kink model of an instanton would arise from. If a graviton is a kink-anti kink combination, arising from, in part a 5 dimensional line element

$$dS^2 = a(w) \cdot \left[\eta_{uv} dx^u dx^v - dw^2\right] \tag{9.i}$$

Then how the graviton may be nucleated in this space is important, and involves the transfer of information. How that information will be embedded and transferred to an instanton- anti instanton configuration will be the next topic of discussion of this manuscript . Before doing this, the geometry of where the instanton- anti instanton pair arises, in the beginning of inflation needs to be addressed.

Dropping in of 'information' to form an instanton- anti instanton pair, and avoiding the cosmological singularity via the 5th dimension?

As the author brought up in Chongquing, there is NO reliable way to reconcile the formation of an instanton-anti instanton pair, and to avoid having an instanton as an example disrupted by a cosmological singularity. What the author proposed, as a graphical example was to consider what if there was, in higher dimensions than just four dimensions, a transfer of region of space for when an instanton – anti instanton could pop up

This lead to the author writing up in Chonquing the region about the singularity definable via a ring of space – time about the origin, but not over lapping it, with a time dimension defined via

$$\Delta t \equiv 10^{\beta} \cdot t_{Planck} \tag{9.j}$$

The exact uncertainty principle, in five dimensions is open to discussion, but the author envisioned, as an example, a five dimensional version of $\Delta E \Delta t \geq \hbar$. IF one takes the tiny mass specified via the $m_{graviton} \propto 10^{-65}$ grams , and make energy equivalent to mass, then the small mass , times the speed of light, squared, in the case of instanton-anti instanton (kink – anti kink) would be the S-S' pair for the instanton nucleated about the cosmic singularity The classical treatment of this problem would be in assuming that the transfer of information from a prior universe, to our own went through a 5th dimension, with the cosmic singularity, a 4th dimensional artifact. I.e., that the information was dropped via a 5th dimensional conduit to a 4th dimensional space time, in order to form a small mass for the graviton, i.e., $m_{graviton} \propto 10^{-65}$ grams, with, say a top value for the graviton mass, after acceleration being $m_{graviton} \propto 10^{-61}$ grams, I.e., abrupt acceleration making the graviton mass **at least** 10^4 times heavier than initially. To understand why the author is investigating such a supposition, a brief review of typical field theories involving 'massive' gravitons and the limit $m_{graviton} \to 0$ will be presented, with a description of why these effects may lead to semi classical approximations.

Massive Graviton field theories, and the limit $m_{graviton} \to 0$

As given by M. Maggiore (2008), the massless equation of the Graviton evolution equation takes the form

$$\partial_{\mu}\partial^{\varpi} h_{\mu\nu} = \sqrt{32\pi G} \cdot \left(T_{\mu\nu} - \frac{1}{2}\eta_{\mu\nu} T^{\mu}_{\mu} \right) \tag{9.k}$$

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

$$\left(\partial_{\mu}\partial^{\varpi} - m_{graviton}\right) \cdot h_{\mu\nu} = \left[\sqrt{32\pi G} + \delta^{+}\right] \cdot \left(T_{\mu\nu} - \frac{1}{3}\eta_{\mu\nu} T^{\mu}_{\mu} + \frac{\partial_{\mu}\partial_{\nu} T^{\mu}_{\mu}}{3 m_{graviton}} \right) \tag{9.l}$$

The mis match between these two equations, when $m_{graviton} \to 0$**,** is largely due to $m_{graviton} h^{\mu}_{\mu} \neq 0$ as $m_{graviton} \to 0$ **,** which is in turn due to setting $m_{graviton} \cdot h^{\mu}_{\mu} = -\left[\sqrt{32\pi G} + \delta^{+}\right] \cdot T^{\mu}_{\mu}$. The miss match between these two expressions is one of several reasons why the author is looking at what happens for semi classical models for when $m_{graviton} \neq 0$**,** $m_{graviton} \sim 10^{-65}$ grams , noting that in QM, a spin 2 $m_{graviton} \neq 0$ has five degrees of freedom, whereas the $m_{graviton} \to 0$ gram case has two helicity states, only**.** Note that string theory treats gravitons as 'excitations' of a closed string , as given by Keifer , with a term added to a space time metric, $\bar{g}_{uv}$, such that $g_{uv} \equiv \bar{g}_{uv} + \sqrt{32\pi G} f_{\mu\nu}$ with $f_{\mu\nu}$ a linkage to coherent states of gravitons. This is partly in relation to the Venziano (1993) expression of $\Delta x \geq \frac{\hbar}{\Delta p} + \frac{l_s^2}{\hbar}\Delta p$, where $G \sim g^2 l_s^2$. Kieffer gives a correction due to quantum gravity in page 179 of the order of $\left(\frac{m}{M_{Planck}}\right)^2$ If the mass, $m_{graviton} \sim 10^{-65}$ g**,** then this is going to be hard to measure as an individual 'particle'**.** But, if $m_{graviton} \sim 10^{-65}$ g exists, as a macro effect, it may well pay a role as indicated by **Fig 1** above.

So, what about representing a graviton as a kink- anti kink ? How does this fit in with t'Hooft's deterministic QM?

T'Hooft used, in 2006 an equivalence class argument as an embedding space for simple harmonic oscillators, as given in his Figure 2, on page 8 of his 2006 article. It is also noteworthy to consider that in 2002, t'Hooft also wrote in his introduction, that "Beneath Quantum Mechanics, there may be a deterministic theory with (local) information loss. This may lead to a sufficiently complex vacuum state,". The author submits, that a kink-anti kink formulation of the graviton, when sufficiently refined, may , indeed create such a vacuum state, as a generalization of Fig 5 of this manuscript. In addition, the embedding equivalence class structure may be a consequence of a family of

$\Psi_{i,f}\left[\phi(\mathbf{x})\right]\Big|_{\phi \equiv \phi_{ci,cf}} = c_{i,f} \cdot \exp\left\{ -\int d\mathbf{x}\, \alpha \left[\phi_{C i,f}(\mathbf{x}) - \phi_0(\mathbf{x}) \right]^2 \right\}$, solutions to a graviton state, if one is

taking the $\phi(x)$ as a kink-anti kink combination. I.e., looking at a history plot of equivalent solutions to the graviton problem, in a 5 dimensional space. The point being that the above 'functional', if one takes the tack of equivalence classes of solutions may, with work be part of a deterministic embedding space for the vacuum space of space time embedding the graviton. The author is trying to re formulate the above solution in terms of different values of $\phi_0(x)$ in a wave functional representation of a graviton, and trying to look for equivalence class embedding structures. This would mean as an example, a considerable refinement of the metric in 5 dimensions, given above, $dS^2 = a(w) \cdot \left[\eta_{uv} dx^u dx^v - dw^2\right]$ While doing this, the author is also asserting that the closeness of this fit, would , if worked out in detail perhaps give an explanation of the graviton mass problem. i.e., in looking at why $m_{graviton} \sim 10^{-65}$ exists.The closeness of $m_{graviton} \sim 10^{-65}$ to a zero mass should not be seen as a failure of quantum physics, but a success story, whereas the author asserts that the hard work of establishing equivalence classes as part of a procedure to embed gravitons in space time will require generalizing t'Hoofts equations 4.3 and 4.4 of his 2006 manuscript to the wave functional the author asserts may be of use , namely looking at

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

in terms of a solution similar to the equivalence class t'Hoot is working with harmonic oscillators showing up in his 2006 manuscripts figure 2. Having said that, it is time to look at if the graviton can actually carry information and what such information would imply for the cosmological constants.

How much information needs to be maintained to preserve the cosmological constants? From cosmological cycle to cycle?

No clear answer really emerges, YET. It is useful to note, that de La Peña in 1997 proposed an order-of-magnitude estimate to derive a relation between Planck's constant (as a measure of the strength of the field fluctuations) and cosmological constants. If , as an example, the fine structure constant has input parameter variance, as was explored by Livio, et al (1998), with an explanation of why fine structure constant has $\Delta\tilde{\alpha}/\tilde{\alpha} \leq 10^{-5} - 10^{-6}$ when traveling from red shift values Z ~ 1.5 to the present era, and there is, as an example, from QED a proportional argument that $\tilde{\alpha} \equiv e^2/\hbar \cdot c$, with , in CGS units

$$\tilde{\alpha} \equiv e^2/\hbar \cdot c \equiv \frac{e^2}{d} \times \frac{\lambda}{hc} \tag{9m}$$

With a now commonly accepted version of $\dot{\tilde{\alpha}}/\tilde{\alpha} \leq (-1.6 \pm 2.3) \times 10^{-17}\ year$. The supposition which the author will be investigating, as an example, will be if the energy needed to overcome the electrostatic repulsion between two electrons when the distance between them is reduced from infinity to some finite *d*, and (ii) the energy of a single photon of wavelength λ = 2π*d* has limiting grid values as to, in earlier conditions of cosmological expansion where the limits as given by the Snyder geometery version of HUP $\Delta q \geq \left[(1/\Delta p) + l_s^2 \cdot \Delta p\right] \equiv (1/\Delta p) - \alpha \cdot \Delta p$ could be investigated, and at least given limiting values.. This is where the LQG condition is $\alpha > 0$, and Brane worlds have, instead $\alpha < 0$. The author is fully aware of the inappropriateness of extrapolating eqn. (9m) before Z ~ 1100, and is, instead, looking for an equivalent statement as to what $\tilde{\alpha} \equiv e^2/\hbar \cdot c$ would be at the onset of the big bang. Furthermore, the planck length, as given by $l_P \equiv \sqrt{\hbar G/c^3}$ would be, if followed through, a ay to make linkage between minimum length $\Delta q \geq \left[(1/\Delta p) + l_s^2 \cdot \Delta p\right] \equiv (1/\Delta p) - \alpha \cdot \Delta p$, and ways to obtain $\tilde{\alpha} \equiv e^2/\hbar \cdot c$. If minimum uncertainty could be argued so as to look at

$$\Delta q \equiv 10^{\beta} \cdot l_P \sim \left[(1/\Delta p) + l_s^2 \cdot \Delta p\right] \equiv (1/\Delta p) - \alpha \cdot \Delta p \tag{10}$$

Which was advanced by G. Veneziano , (1993), i.e., $10^{\beta} \cdot l_P \equiv l_{string}$ as a minimum length, it may be a way as to link choices of how much information could be stored in $\Delta q \equiv 10^{\beta} \cdot l_P$, with values of both the value $\widetilde{\alpha} \equiv e^2 / \hbar \cdot c$, and $l_P \equiv \sqrt{\hbar G / c^3}$. The author is looking as to different algorithms of how to pack 'information' into minimum quantum lengths, $\Delta q \equiv 10^{\beta} \cdot l_P$, with the supposition that the momentum variance Δp could come from prior universe inputs into the present cosmos.

1st Conclusion, one needs a reliable information packing algorithm!

The author is working on it. Specifically one of the main hurtles is in finding linkage between information, as one can conceive of it, and entropy. If such a parameterization can be found, and analyzed, then Seth Lloyds short hand for entropy can then possibly be utilized. Namely as given by Lloyd (2002)

$$I = S_{total} / k_B \ln 2 = [\#operations]^{3/4} = \left[\rho \cdot c^5 \cdot t^4 / \hbar\right]^{3/4} \qquad (11)$$

The author's supposition is that eqn (3) is basic, but that there could be a variance of inputs into eqn. (3) as far as inputs into the Planck's constant, $\hbar$ based upon arguments present at and after eqn (10)

Once resolution of the above ambiguities is finalized, one way or another, choices of inputs into eqn (2) and eqn. (3) will commence, with ways of trying to find how to select between the following. : the LQG condition is $\alpha > 0$, and Brane worlds have, instead $\alpha < 0$ If as an example, one is viewing gravitons according to the idea refined by Beckwith from Y.J. Ng, 2008, that a counting algorithm for entropy is de rigor according to **Appendix I**, 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, then Eq (11) above implies up to $\approx 10^{27}$ operations. If so, then there is at least a 1-1 relationship between an operation, and a bit of information, then a graviton has at least one 'bit' of information. The operation being considered is of the same form as a 2nd order phase transition. What the author thinks, is that tentatively, higher dimensional versions of gravity perhaps need to be investigated, which may allow for such a counting algorithm. Either refinements as to determinisitic kink-anti kinks $\approx 10^{20}$ in number during inflation, according to a combination of **Appendix I ,** and the arguments given in page 17 of this document, or similar developments.

2nd Conclusion : Sensitivity limits as to detectors may need to be revisited.

Note that the initial standing question posed in the beginning was if there was a mass to the graviton. The stretch out of a graviton wave, perhaps greater than the size of the solar system gives, according to Maggiore (2008) an upper limit of a graviton mass, of $\lambda_{graviton} > 300 \cdot h_0 kpc \Leftrightarrow m_{graviton} < 2 \times 10^{-29} h_0^{-1} eV$. I .e a massively stretched graviton wave, ultra low frequency, may lead to a low mass limit. I.e., though more careful limits have narrowed the upper limit to about $10^{-20} h_0^{-1} eV$. Needless to state the author finds the usual field theory treatments of graviton mass to be very difficult to maintain from a purely quantum field theoretic treatment. Note, that ultra low frequency arguments and bounds to the graviton mass converged to the supposition of a kink- anti kink argument in the spirit of Giovannini's (2006) Classical and quantum gravity letter. The author sees no way to entertain a graviton mass without looking at a stretch out of a graviton to huge distances and then a permissible upper bound to the mass which is tiny. This lead to the author entertaining a fifth dimensional conduit as to 'information' being exchanged from a prior universe, to our present universe. Having said that though, the material in appendix 1 argues in favor of perhaps a large number of gravitons having higher frequencies. The two items are not out of sync with one another. A counting algorithm, partly based upon the spirit of Appendix I with commensurate information attached to a graviton may be a way to give a minimum amount of information from a prior universe to our present universe put in Eq (9y). Note that in $\tilde{\alpha} \equiv e^2 / \hbar \cdot c \equiv \frac{e^2}{d} \times \frac{\lambda}{hc}$ that most of the information probably will be packed in the wavelength given as λ above, and that the amount of information packed into this wavelength λ may be amendable to how much information is packed into subsequent gravitons given in appendix I, below. I.e., what the author thinks is that what would be important would be, as an example for the fine structure constant, to seed a certain amount of information for its value via wavelength values from nucleated kink-anti kink gravitons nucleated in a region of space more than Planck time after the big bang. Doing so may necessitate better sensitivity limits than what was assumed via use of LIGO and the cited value given to the author , by Raymond Weiss as to $h \sim \frac{\lambda}{Lb\sqrt{N\tau}}$ as for looking at the full range of GW frequencies. Eq (12) is a, formula for HFGW of at least 1000 Hertz for GW which is a start in the right direction i.e., a strain value of, if L is the Interferometer length, and N is the number of quanta / second at a beam splitter, and τ is the integration time.

$$h \sim \frac{\lambda}{Lb\sqrt{N\tau}} \tag{12}$$

For LIGO systems, and their derivatives, the usual statistics and technologies of present lasers as bench marked by available steady laser in puts given by Eq (12) appear to limit $h \sim 10^{-23}$. If one wishes to investigate the possibility of measuring $\tilde{\alpha} \equiv e^2 / \hbar \cdot c \equiv \frac{e^2}{d} \times \frac{\lambda}{hc}$, then strain values of $h \sim 10^{-23}$ are possibly inadequate, as referenced by the author in private notes given to the author by Dr. Fangyu Li. (2009) In any case, since this is not an HFGW article, the details of why this is raised will be the subject of a future article.

Further Research questions to look into

If Eq(8) is true for a few select neutrinos and gravitons, then the author believes that it is reasonable to assume that as up to a billion years ago, $m_{graviton} \propto 10^{-65}$ grams. If so then the derivation of Figure 1 above is plausible. The problem the author is investigating is what is the consequence of Eq(8) for Eq(3). The author believes this problem is resolvable, and may imply a linkage between DE and DM in ways richer than what is done by the Chapygin gas models which are now currently a curiosity, Note that the proof of perhaps a kink- anti kink model as a bound for graviton mass is, initially a low frequency phenomenon

Appendix I : Entropy generation via Ng's Infinite Quantum Statistics

How relic gravitational waves relate to relic gravitons"?. Graviton space V for nucleation is tiny, well inside inflation. Therefore, the log factor drops OUT of entropy S if V chosen properly for both eqn (0.1) and eqn (0.2).Ng's result begins with a modification of the entropy/ partition function Ng used the following approximation of temperature and its variation with respect to a spatial parameter, starting with temperature $T \approx R_H^{-1}$ (R_H can be thought of as a representation of the region of space where we take statistics of the particles in question). Furthermore, assume that the volume of space to be analyzed is of the form $V \approx R_H^3$ and look at a preliminary numerical factor we shall call $N \sim (R_H / l_P)^2$, where the denominator is Planck's length (on the order of 10^{-35} centimeters). We also specify a "wavelength" parameter $\lambda \approx T^{-1}$. So the value of $\lambda \approx T^{-1}$ and of R_H are approximately the same order of magnitude. Now this is how Jack Ng changes conventional statistics: he outlines how to get $S \approx N$, which with additional arguments we refine to be $S \approx < n >$ (where <n> is graviton density). Begin with a partition function

$$Z_N \sim \left(\frac{1}{N!}\right) \cdot \left(\frac{V}{\lambda^3}\right)^N \tag{0.1}$$

This, according to Ng, leads to entropy of the limiting value of, if $S = \left(\log\left[Z_N\right]\right)$

$$S \approx N \cdot \left(\log\left[V/N\lambda^3\right] + 5/2\right) \xrightarrow[Ng-\inf inite-Quantum-Statistics]{} N \cdot \left(\log\left[V/\lambda^3\right] + 5/2\right) \approx N \tag{0.2}$$

But $V \approx R_H^3 \approx \lambda^3$, so unless N in eqn (0.2) above is about 1, S (entropy) would be < 0, which is a contradiction. Now this is where Jack Ng introduces removing the N! term in eqn (1) above , i.e., inside the Log expression we remove the expression of N in eqn. (0.2) above.

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