Inquiry as to if higher dimensions can be used to unify DM and DE if Massive gravitons are stable.

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Abstract. . The following questions are raised in this document. First, can there be a stable (massive) graviton? If so, does this massive graviton, as modeled by KK DM, with a modification of slight 4 dimensional space mass, contribute to DE, at least in terms of re acceleration ? The answer, if one assumes that the square of a frequency for graviton mass is real valued and greater than zero appears to be affirmative. The author, when considering a joint DM – DE model finds evidence that re acceleration of the universe one billion years ago in a higher dimensional setting can be justified in terms of a slight modification of standard KK DM models, if one considers how an information exchange between present to prior universes occurs, which the author thinks mandates more than four dimensional space time geometry

1.**Introduction**

As presented in the introduction the article asks first for criteria for massive graviton stability, and then applies stable massive (4 D) gravitons in terms of a KK DM model, with small 4 D graviton mass to obtain re acceleration of the universe a billion years ago. The re acceleration, is a way to obtain DE, at least in terms of a macro effect in cosmological structure. To look at the problem of massive graviton stability, the author applies a modification of KK representation of DM, with small mass in 4 D, and then using Visser's [1] treatment of a stress energy tensor, comes up with a criteria as to obtaining the square of frequency, of a massive graviton, which is both positive and real valued. Deviation from this last criteria would imply that the frequency is imaginary, which would signify unstable behavior for a massive graviton. If the graviton is, with small mass, stable, then its macro effects show up in de celebration parameter behavior, indicating re acceleration a billion years ago. We look at work presented by Maggiorie [2],which specifically delineated for non zero graviton mass, where we write $h \equiv \eta^{uv} h_{uv} = Trace \cdot (h_{uv})$ and $T = Trace \cdot \left(T^{uv}\right)$ that

$$- 3 m_{graviton}^{2} h = \frac{\kappa}{2} \cdot T \qquad (1)$$

Our work uses Visser's [1]1998 analysis of non zero graviton mass for both T and h. We will use the above equation with a use of particle count n_f for a way to present initial GW relic inflation density using the definition given by Maggiore[2] as a way to state that a particle count

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

where n_f is the frequency-based numerical count of gravitons per unit phase space. To do so, let us give the reasons for using Visser's [5] values [1] for T and h above, in Eqn. (1). While Maggiore's explanation ,[2] and his treatment of gravitational wave density is very good, the problem we have is that any relic conditions for GW involve stochastic back ground, and also that many theorists have relied upon either turbulence/ and or other forms of plasma induced generation of shock waves, as stated by Duerrer, et. al. [3] and others looking at the electro weak transition as a GW generator. The n_f value Beckwith obtained, was used to make a relationship , using Y. J. Ng's entropy[4]counting algorithm of roughly $S_{entropy} \sim n_f$. We assert that in order to obtain $S_{entropy} \sim n_f$ from initial graviton production, as a way to quantify n_f , that a small mass of the graviton can be assumed.

We begin our inquiry by initially looking at a modification of what was presented by Maartens [5] , as done by Beckwith [6]

$$m_n(Graviton) = \sqrt{\left(\frac{n}{L}\right)^2 + (10^{-65} grams)^2} \sim \frac{n}{L} + 10^{-65} \ grams \qquad (3)$$

On the face of it, this assignment of a mass of about 10^{-65} grams for a 4 dimensional graviton, allowing for $m_0(Graviton - 4D) \sim 10^{-65}$ grams violates all known quantum mechanics, and is to be avoided. Numerous authors, including Maggiore [2] have demonstrated how adding a term to the Fiertz Lagrangian for gravitons, and assuming massive gravitons leads to results which appear to violate field theory, as we can call it . Turning to the problem, we can examine what inputs to the Eq. (1) above can tell us about if there are grounds for $m_0(Graviton - 4D) \sim 10^{-65}$ grams [6]Visser [1] came up with inputs into the GR stress tensor and also , for the perturbing term h_{uv}. We will use them in conjunction with Eq (1) to perform a stability analysis of the consequences of setting the value of $m_0(Graviton - 4D) \sim 10^{-65}$ grams , and from there discuss a conditions for stability of $m_0(Graviton - 4D) \sim 10^{-65}$ grams [6]

2. Visser's treatment of the stress energy tensor of GR, and its applications-Stability criteria

Visser in [1], stated a stress energy treatment of gravitons along the lines of

$$T_{uv}\Big|_{m\neq 0} = \left[\left(\frac{\hbar}{l_P^2 \lambda_g^2} \right) \cdot \left(\frac{GM}{r} \right) \cdot \exp\left(\frac{r}{\lambda_g} \right) + \left(\frac{GM}{r} \right)^2 \right] \times \begin{bmatrix} 4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \qquad (4)$$

Furthermore, his version of $g_{uv} = \eta_{uv} + h_{uv}$ can be written as setting , via inclusion of a expression of $h_{uv} \equiv 2\frac{GM}{r} \cdot \left[\exp\left(\frac{-m_g r}{\hbar} \right) \right] \cdot \left(2 \cdot V_\mu V_\nu + \eta_{uv} \right)$ into modeling of gravitons which are traveling at speeds

$$v_g = c \cdot \sqrt{1 - \frac{m_g^2 \cdot c^4}{\hbar^2 \omega_g^2}} \qquad (5)$$

One can insert all this into Eq. (1) to obtain a real value for the square of frequency > 0, i.e.

$$\hbar^2 \omega^2 \cong m_g^2 c^4 \cdot \left[1 / \left(1 - \breve{A}\right)\right] > 0 \qquad (6)$$

$$\breve{A} = \left\{ 1 - \frac{1}{6 m_g c^2} \left(\frac{\hbar^2}{l_P^2 \lambda_g^2} \cdot \exp\left[-\frac{r}{\lambda_g} + \frac{m_g \cdot r}{\hbar} \right] + \left(\frac{MG}{r} \right) \cdot \exp\left(\frac{m_g r}{\hbar} \right) \right) \right\}^2 \qquad (7)$$

According to Kim , [7] if the square of the frequency of a graviton, with mass, is >0, and real valued, it is likely that the graviton is stable, at least with regards to perturbations. Kim's article[7] is with regards to Gravitons in brane / string theory, but it is likely that the same dynamic for semi classical representations of a graviton with mass. Furthermore we have the following stability criteria for stability,

$$0 < \frac{1}{6 m_g c^2} \left(\frac{\hbar^2}{l_P^2 \lambda_g^2} \cdot \exp\left[-\frac{r}{\lambda_g} + \frac{m_g \cdot r}{\hbar} \right] + \left(\frac{MG}{r} \right) \cdot \exp\left(\frac{m_g r}{\hbar} \right) \right) < 1 \qquad (8)$$

Note that Visser [1] writes $m_g < 2 \times 10^{-29} eV \sim 2 \times 10^{-38} m_{nucleon}$, and a wave length $\lambda_g \sim 6 \times 10^{22}$meters. The two values, as well as ascertaining when one can use $\frac{MG}{r} \sim 1/5$, with r the usual distance from a graviton generating source, and M the mass' of an object which would be a graviton emitter put severe restrictions as to the volume of space time values for which r could be ascertained.

3. Applying a stable massive graviton (4D) to the problem of re acceleration of the Universe (DE)?

Beckwith [6]used a version of the Friedman equations as inputs into the deceleration parameter using Maarten's [2] expression for the time derivative of a scale factor, and also used what Maartens used in a 2nd Friedman equation. 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. (12)**,** and use $a \equiv \left[a_0 = 1\right] / (1 + z)$. As given by Beckwith[6]

$$q = -\frac{\ddot{a} a}{\dot{a}^2} \equiv -1 - \frac{\dot{H}}{H^2} = -1 + \frac{2}{1 + \tilde{\kappa}^2 [\rho / m] \cdot (1+z)^4 \cdot (1 + \rho \ / 2\lambda)} \approx -1 + \frac{2}{2 + \delta(z)} \qquad (9)$$

Eq. (13) 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

4. Consequences of small graviton mass for reacceleration of the universe

In a revision of Alves *et. al,* [8] Beckwith[6] used a higher-dimensional model of the brane world and Marsden[10] KK graviton towers. The density ρ of the brane world in the Friedman equation as used by Alves *et. al*[9] is [8] is used in [6] for a non-zero graviton

$$\rho \equiv \rho_0 \cdot (1+z)^3 - \left[\frac{m_g \cdot (c=1)^6}{8\pi G(\hbar = 1)^2}\right] \cdot \left(\frac{1}{14 \cdot (1+z)^3} + \frac{2}{5 \cdot (1+z)^2} - \frac{1}{2}\right) \qquad (10)$$

I.e. Eq. (10) above is making a joint DM and DE model, with all of Eq. (3) being for KK gravitons and DM, and 10^{-65} grams being a 4 dimensional DE. Eq. (10) is part of a KK graviton presentation of DM/ DE dynamics. Beckwith [6] found at $z \sim$ **.4**, a billion years ago, that acceleration of the universe increased, as shown in Fig. 1.

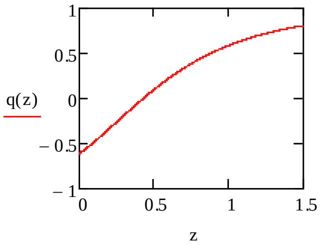

FIGURE 1 : Reacceleration of the universe based on Beckwith [6] (note that q < 0 if z< .423). Figure 1 assumes 5 dimensions

5. Conclusion : Next stage will be in terms of making a count of gravitons , initially.

Furthermore, we make an initial count of gravitons with $S \approx N \sim 10^7$ gravitons' with

$$I = S_{total} / k_B \ln 2 = [\#operations]^{3/4} \sim 10^7 \qquad (11)$$

as implying at least one operation per unit graviton, with gravitons being one unit of information, per produced graviton[7]. **Note,** Smoot [9] gave initial values of the operations as $[\#operations]_{initially} \sim 10^{10}$

If, indeed, there is a case to be made that gravitons are connected to information exchange, the next step would be to determine if there is seeding of the present universe with prior universe information.

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