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.

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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, so presented, 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 Maartens KK representation of DM, with small mass in 4 D, and then using Visser's 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,[4] 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

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

Our work uses Visser's[5] 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[4] as a way to state that a particle count

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

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 for T and h above, in Eqn. (1). While Maggiore's explanation [4], 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. [6] 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[7] 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.

DEFINING THE GRAVITON PROBLEM AND USING VISSER'S (1998) T_{uv}

We begin our inquiry by initially looking at a modification of what was presented by R. Maartens [9] , as done by Beckwith [1,2]

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

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[1,2] violates all known quantum mechanics, and is to be avoided. Numerous authors, including Maggiore[4] have richly 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 Eqn. (1) above can tell us about if there are grounds for $m_0(Graviton - 4D) \sim 10^{-65}$ grams [1,2]. Visser[5], in 1998 came up with inputs into the GR stress tensor and also , for the perturbing term h_{uv} which will be given below. We will use them in conjunction with Eqn (1) to perform a stability analysis of the consequences of setting the value of $m_0(Graviton - 4D) \sim 10^{-65}$ grams [1,2,5], and from there discuss how T'Hooft's [1,2,8] supposition of deterministic QM, as an embedding of QFT, and more could play a role if there are conditions for stability of $m_0(Graviton - 4D) \sim 10^{-65}$ grams[1,2,5].

Visser's treatment of the stress energy tensor of GR, and its applications

Visser[5] in 1998, stated a stress energy treatment of gravitons along the lines of

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

Furthermore, his version of $g_{uv} = \eta_{uv} + h_{uv}$ can be written as setting

$$h_{uv} \equiv 2\frac{GM}{r}\cdot\left[\exp\left(\frac{-m_g r}{\hbar}\right)\right]\cdot\left(2\cdot V_\mu V_\nu + \eta_{uv}\right) \tag{5}$$

If one adds in velocity 'reduction' put in with regards to speed propagation of gravitons[5]

$$v_g = c \cdot \sqrt{1 - \frac{m_g^2 \cdot c^4}{\hbar^2 \omega_g^2}} \tag{6}$$

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

$$\hbar^2\omega^2 \cong m_g^2 c^4 \cdot \left[1 \big/ \left(1-\breve{A}\right)\right] > 0 \qquad (7)$$

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

According to Jin Young Kim [11], 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 [11] 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.

Conditions permitting Eqn. (7) to have positive values

Looking at Eqn. (7) is the same as looking at the following, analyzing how

$$0 < \frac{1}{6m_g c^2}\left(\frac{\hbar^2}{l_P^2\lambda_g^2}\cdot \exp\left[-\frac{r}{\lambda_g} + \frac{m_g \cdot r}{\hbar}\right] + \left(\frac{MG}{r}\right)\cdot \exp\left(\frac{m_g r}{\hbar}\right)\right) < 1 \qquad (9)$$

Note that Visser [5] (1998) 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

The author believes that such a configuration would be occurring in most generation of gravitons at, or before the Electro Weak transition point in early cosmology evolution.

APPLYING A STABLE MASSIVE GRAVITON (4 D) TO THE PROBLEM OF RE ACCELERATION OF THE UNIVERSE (DE ?)

Beckwith[1,2] used a version of the Friedman equations as inputs into the deceleration parameter using Maarten's[10]

$$\dot{a}^2 = \left[\left(\frac{\tilde{\kappa}^2}{3}\left[\rho + \frac{\rho^2}{2\lambda}\right]\right)a^2 + \frac{\Lambda\cdot a^2}{3} + \frac{m}{a^2} - K\right] \qquad (10)$$

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

$$\dot{H}^2 = \left[-\left(\frac{\tilde{\kappa}^2}{2}\cdot\left[p+\rho\right]\cdot\left[1+\frac{\rho^2}{\lambda}\right]\right) + \frac{\Lambda\cdot a^2}{3} - 2\frac{m}{a^4} + \frac{K}{a^2}\right] \qquad (11)$$

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 $a \equiv \left[a_0 = 1\right] \big/ (1+z)$. As given by Beckwith[3]

$$q = -\frac{\ddot{a}a}{\dot{a}^2} \equiv -1 - \frac{\dot{H}}{H^2} = -1 + \frac{2}{1+\tilde{\kappa}^2\left[\rho/m\right]\cdot(1+z)^4\cdot\left(1+\rho\ \ /2\lambda\right)} \approx -1 + \frac{2}{2+\delta(z)} \qquad (12)$$

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

Consequences of small graviton mass for reacceleration of the universe

In a revision of Alves *et. al,* [9] Beckwith[1,2] 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 use by Beckwith[3] for a non-zero graviton

$$\rho \equiv \rho_0 \cdot (1+z)^3 - \left[\frac{m_g \cdot (c=1)^6}{8\pi G (\hbar = 1)^2} \right] \cdot \left(\frac{1}{14 \cdot (1+z)^3} + \frac{2}{5 \cdot (1+z)^2} - \frac{1}{2} \right) \quad (13)$$

I.e. Eq. (13) 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. (3) is part of a KK graviton presentation of DM/ DE dynamics. Beckwith[1,2] found at z ~ **. 4**, a billion years ago, that acceleration of the universe increased, as shown in Fig. 1.

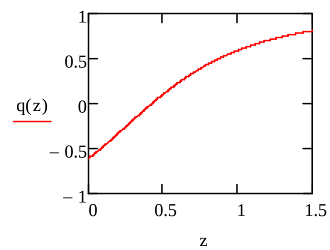

FIGURE 1 : Reacceleration of the universe based on Beckwith [1,2] (note that q < 0 if z< .423). Figure 1 assumes 5 dimensions

CONCLUSION

The end result of a massive graviton may also lead to information exchange between a prior to our present universe as has commented upon by Beckwith[1,2.] . Note that Beckwith[1,2] has used Y. Ng's counting algorithm[7] with regards to entropy, and non zero mass (massive) gravitons , where

$$S \approx N \cdot \left(\log\left[V / \lambda^3 \right] + 5/2 \right) \approx N \quad (14)$$

Furthermore, making an initial count of gravitons with $S \approx N \sim 10^7$ gravitons[7,] with Seth Lloyd's [2,12]

$$I = S_{total} / k_B \ln 2 = [\# operations]^{3/4} \sim 10^7 \quad (15)$$

as implying at least one operation per unit graviton, with gravitons being one unit of information, per produced graviton[7]. **Note,** Smoot [3] gave initial values of the operations as

$$[\# operations]_{initially} \sim 10^{10} \quad (16)$$

It would be useful to determine if there were inter connections between the parameter space defined by Eqn. (9) above , in terms of input variables, and optimal conditions as well for both Eqn (15) and Eqn. (16) to be confirmed experimentally. In addition, the author hopes for understanding optimal space time geometric conditions for the development of KK particle physics allowing for implementation of Eqn (12) above, which assumes stable giant gravitons are possible. The number of operations , if tied into bits of 'information' may allow for space time linkages of the following value of the fine structure constant, as given in Eqn. (17) from a prior to a present universe, once initial conditions of inflation may be examined experimentally, i.e. looking at inputs into [1,2]

$$\tilde{\alpha} \equiv e^2 / \hbar \cdot c \equiv \frac{e^2}{d} \times \frac{\lambda}{hc} \tag{17}$$

After this is done, then the next step would be to look at inputs into the near the present time value for a Friedman equation, leading to fuller understanding of Eqn (12) above. All this is possible if a non brane theory version of stability of the graviton, is obtained, if an extension of Kim's[12] frequency based criteria as to giant graviton stability is confirmed, experimentally. It would also confirm M. Alcubierre's[13] energy flux expression for GW, which the author used

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