Cosmic deceleration parameter q(Z) dependence upon gravitons? Implications for DM models, DE, and the search for gravitons as measured via E and M interactions in detectors

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Abstract In this paper the author asks if DM and gravitons could also impact the cosmic acceleration of the universe, leading to an increase of acceleration one billion years ago, in a manner usually attributed to DE. Following Alves, et al. (2009) the author will high light what KK style gravitons, with a slightly different mass profile could mean in terms of DM The consequences are from assuming that axions are CDM, and KK gravitons are for WDM, then up to a point, $\rho_{Warm-Dark-Matter}$ would dominate not only structure formation in early universe formation , Further efforts in obtaining data for such suppositions would lie in electro magnetic-graviton interactions contributing toward $h_0^2 \Omega_{gw}(f)$ being appropriately measured.

Key words: Graviton, DM, E &M interactions with GW/Gravitons
PACs: 98.80.Cq, 95.35.+d, 95.30.Sf, 65.40.gd, 11.25.Uv

Introduction

When at the 12 Marcell Grossman meeting, July 2009 17th , the author talked with Roszkowski, at the Paris Observatory as to what would happen to DM if hot and cold DM models were mixed together.., Dr. Roszkowsk stated there would be no structural changes which would occur in galaxy formation, if two cold DM candidates would be partially mixed. .. For the sake of investigating Roszkowski's research views, the author decided to investigate the probability of DM as a KK graviton. Next, the author looked to find a different setting for joint DM and DE models. Having settled upon looking at the KK graviton as a dark matter candidate, which could influence different forms of galaxy formation, at or before red shift Z~ 1.0 to 1.5, the author decided to find a higher dimensional setting to re duplicate what Marcio E. S. Alves et al, (2009) accomplished in having a non zero graviton act in promoting a re acceleration of the universe, the author is considering what happens if there is a tiny mass, $m_{graviton} \propto 10^{-65}$ grams , as the first KK mode, in contrast to the zero mass predicted as to the zeroth mode of the KK graviton.. I.e. a slight modification of the usual KK graviton mass equation $m_n(Graviton) = \dfrac{n}{L} + 10^{-65}$ grams, It so happens that this red shift pre dates the Z~.55 point of inflection With the zeroth mode of the KK graviton , if with a tiny mass, influencing DE type cosmological expansions.

How DM would be influenced by gravitons, in 4 dimensions

, This can be conflated with Marcio E. S. Alves, Oswaldo D. Miranda, Jose C. N. de Araujo's results arguing that non zero graviton mass may lead to acceleration of our present universe, in a manner usually conflated with DE , i.e. their graviton mass

$$q = -\frac{\ddot{a}a}{\dot{a}^2} \tag{1}$$

. This leads to eqn.. (1) having increasingly positive acceleration values as would be definitely be given for masses of $m_{graviton}(4 - Dim \quad GR) \sim 10^{-48} \times 10^{-5} eV \sim 10^{65}$ grams for red shift values $z \sim .3$ for eqn. (1) just becoming > 0 to maximum values of (1) today, with $z = 0$, all at mass of the order of 10^{-65} grams. This increase of (1) then leads us to consider how to configure the Friedman equations if using and for RS brane world values. As can be related to, if we wish to look at string theory versions of the FRW equation , in FRW metrics, we can do the following decomposition ,

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

As well as

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

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

$$\dot{a}^2 = \left[\left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{\rho^2}{36M_{Planck}^2}\right)a^2 - \kappa + \frac{C}{a^2}\right] \tag{4}$$

For the purpose of Randall Sundrum brane worlds, eqn. (21) is differentiated with respect to $d/d\tau$, and then terms from eqn. (20) Will be used, and put into a derivable equation version of $q = -\frac{\ddot{a}a}{\dot{a}^2}$. Note that Roy Maartens has written as of 2004 that $m_n(Graviton) = \frac{n}{L}$, 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, ALMOST zero.

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

Following presenting of eqn. (1) above with $\hbar = c = 1$, so then when writing

$$q = A1 + A2 + A3 \tag{5}$$

Then, assume that the density has a small graviton mass component added in, as follows:

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

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

$$d\rho/d\tau = -\left(\frac{\dot{a}}{a}\right) \cdot \left[3 \cdot \rho_0 \cdot \left(\frac{a_9}{a}\right)^3 + 4 \cdot \left(\frac{a^4}{14} + \frac{a^2}{5}\right) \cdot \left(\frac{m_g c^6}{8\pi G \hbar^2}\right)\right] \tag{7}$$

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. (28) covers ρ . Now, if $\hbar \equiv c \equiv 1$ and $d\Lambda_4/d\tau \sim 0$, and , also, we neglect Λ_4 as of being not a major contributor.

With such assumptions put in,

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

afterward, the following function should be used as a way of collecting terms

$$\Phi(\rho, a, C) = \frac{C}{a^4} + \left(\frac{\rho}{3M_4^2} + \frac{1}{36} \cdot \frac{\rho^2}{M_P^6}\right) \tag{9}$$

For what it is worth, 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, the following representation of the density function, in terms of r ed shift should be acceptable. Furthermore , q(z) has the following forms of de composition

$$\rho(z) \equiv \rho_0 \cdot (1+z)^3 - \left[\frac{m_g}{8\pi G}\right] \cdot \left(\frac{a_0^4}{14 \cdot (1+z)^4} + \frac{2a_0^2}{5 \cdot (1+z)^2} - \frac{1}{2}\right) \tag{10}$$

$$A1(z) \cong \frac{C \cdot (1+z)^3}{a_0^3} \cdot \left[1 \Big/ \sqrt{\Phi(\rho(z), a_0/(1+z), C)}\right] \tag{11}$$

$$A2(z) \cong -\left(\frac{\rho(z)}{3M_4^2} + \frac{1}{36} \cdot \frac{\rho(z)^2}{M_P^6}\right) \Big/ \left[\Phi(\rho(z), a_0/(1+z), C)\right] \tag{12}$$

$$A3(z) \cong \frac{1}{2}\left(\cdot \left[\frac{1}{3M_4^2} + \frac{1}{18} \cdot \frac{\rho(z)\cdot}{M_P^6}\right] \Big/ \left[\Phi(\rho(z), a_0/(1+z), C)\right]^{1/2}\right) \cdot$$
$$\left[3 \cdot \rho_0 \cdot (1+z)^3 + 4 \cdot \left(\frac{a_0^4/(1+z)^4}{14} + \frac{a_0^2/(1+z)^2}{5}\right) \cdot \left(\frac{m_g}{8\pi G}\right)\right] \tag{13}$$

$$\Phi(\rho(z), a_0/(1+z)), C) = \frac{C \cdot (1+z)^4}{a_0^4} + \left(\frac{\rho(z)}{3M_4^2} + \frac{1}{36} \cdot \frac{\rho(z)^2}{M_P^6}\right) \tag{14}$$

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

$$q(z) = A1(z) + A2(z) + A3(z) \tag{15}$$

And here are the results! Assume X is red shift, Z. q(X) is De - Celeration . Here we have a graph of De celeration parameter due to small $m_{graviton} \propto 10^{-65}$ grams, with one additional dimension added

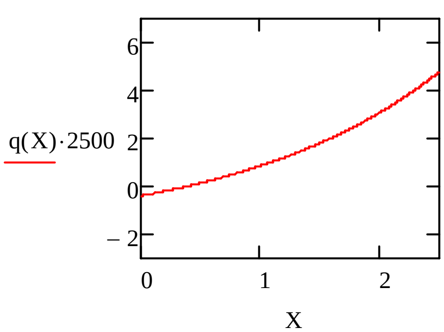

Figure 1 : re duplication of basic results of Alves, et al. (2009), using their parameter values, with an additional term of C for 'Dark flow' added, corresponding to one KK additional dimensions.Figure **1** suggest that additional dimensions are permissible. It does not mean that the initial states of GW/ initial vaccum states have to form due to either quantum or semi classical processes.

Unanswered questions, and suggestions for future research endeavors

First of all, what can researchers expect if KK gravitons exist, and exist in inter stellar space with axions ? Cembranos, ; Feng, ; and Strigari. (2007) give a partial answer. It is not just the gamma ray spectrum which may be altered. I.e. Boyarsky, Lesgourgues, Ruchayskiy and Viel (2009) have strict Baysian statistical limits as to what sort of warm to cold dark matter mixes are allowed. One of their basic result, which is put here, $\rho_{Baryons}, \rho_{Cold-Dark-Matter}, \rho_{Warm-Dark-Matter}$ refer to density profiles, of the respective baryons, CDM, and WDM candidates, whereas, the density fluctuations $\delta_{Baryons}, \delta_{Cold-Dark-Matter}, \delta_{Warm-Dark-Matter}$ are with regards to the fluctuations of these density values. So

$$\left(\frac{\delta\rho}{\rho}\right) \equiv \frac{\rho_{Baryons}\delta_{Baryons} + \rho_{Cold-Dark-Matter}\delta_{Cold-Dark-Matter} + \rho_{Warm-Dark-Matter}\delta_{Warm-Dark-Matter}}{\rho_{Baryons} + \rho_{Cold-Dark-Matter} + \rho_{Warm-Dark-Matter}} \quad (16)$$

If axions are CDM, and KK gravitons are for WDM, then up to a point, $\rho_{Warm-Dark-Matter}$ would dominate Eqn. (40) in earlier times, ie. Up to Z~1000. However, Boyarsky, et al (2009) also stress that as of the recent era, i.e. probably for Z~.55 to Z~0 today , they would expect to see the following limiting behavior

$$\begin{aligned} &\delta_{Baryons} \equiv \delta_{CDM}, \\ &\delta_{WDM} << \delta_{CDM} \end{aligned} \quad (17)$$

In earlier times, what is put in, with regards to eqn. (17) would be probably far different . However, up in the present era, the denominator of Eqn (16) would be dominated by KK DM, whereas there would be rough equality in the contributions $\rho_{Cold-Dark-Matter}\delta_{Cold-Dark-Matter}, \rho_{Warm-Dark-Matter}\delta_{Warm-Dark-Matter}$, with the baryon contribution to the numerator being ignorable, due to how small baryon values would be for Z~.55 to Z~0 today. Somehow, contributions as to eqn (40) should be compared with.

$$\left(\frac{\delta\rho}{\rho}\right)_{Horizon} \cong \frac{k^{3/2}|\delta_k|}{\sqrt{2}\pi} \propto \frac{k^{(3/2)+3\alpha-3/2}}{\sqrt{2}\pi} \approx \left(1/\sqrt{2}\pi\right)\cdot k^{3\alpha} \quad (18)$$

where $-.1<\alpha<0.2$, and $\alpha \equiv 0 \Leftrightarrow n_s \equiv 1$ and to first order, $k \cong Ha$. The values, typically of $n_s \neq 1$ If working with $H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \left[\left(\frac{\rho}{3M_4^2} + \frac{\rho^2}{36M_{Planck}^2}\right) + \frac{C}{a^4}\right]$, and with a density value $\rho \equiv \rho_0 \cdot \left(\frac{a_0}{a}\right)^3 - \left[\frac{m_g c^6}{8\pi G\hbar^2}\right]\cdot\left(\frac{a^4}{14} + \frac{2a^2}{5} - \frac{1}{2}\right)$ where $m_g \approx 10^{-65}$ grams, and $\alpha < 0.2$ is usually picked to avoid over production of black holes, a complex picture emerges. Furthermore, $\alpha < 0.2$ and $\alpha \neq 0$. The following limits as of eqn. (18) in early and later times should be reconciled with.

$$\left(\frac{\delta\rho}{\rho}\right)_{Horizon} \cong \left(1/\sqrt{2}\pi\right)\cdot k^{3\alpha} \sim \frac{H^2}{\dot{\phi}} \propto 10^{-4} - 10^{-5} \quad (19)$$

The above equation gives inter relationships between the time evolution of a pop up inflaton field ϕ, and a Hubble expansion parameter H , and a wave length parameter $\lambda = (2\pi/k)\cdot a(t)$ for a mode given as δ_k. What should be considered is the inter relation ship of eqn (19) and $\lambda \leq H^{-1}$ in order to explain deviations of galaxy formation from the standard ‘tree model’ of Z~2 to today in increasing complexity of structure..

Conclusion

It is useful to note that normalized energy density of gravitational waves, as given by Michele Maggiore (2008)

$$\Omega_{gw} \equiv \frac{\rho_{gw}}{\rho_c} \equiv \int_{f=0}^{f=\infty} d(\log f)\cdot\Omega_{gw}(f) \Rightarrow h_0^2\Omega_{gw}(f) \cong 3.6\cdot\left[\frac{n_f}{10^{37}}\right]\cdot\left(\frac{f}{1kHz}\right)^4 \qquad (20)$$

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 or may not depend upon semi classical representations of the graviton. What is to be brought up in consideration would be if there is a slight mass to the graviton, as given by $m_{graviton} \sim 10^{-65}\, grams, m_{photon} \sim 10^{-51} grams,$ leading to a new numerical count per phase space to consider

$$n_f \propto n_f[graviton] + n_f[photon] \qquad (21)$$

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

$$h_0^2\Omega_{gw}(f) \cong \frac{3.6}{2}\cdot\left[\frac{n_f[graviton]+n_f[photon]}{10^{37}}\right]\cdot\left(\frac{\langle f\rangle}{1kHz}\right)^4 \qquad (22)$$

The author believes that finding proper values of n_f in experiment will go a long way toward proving eqn (21) and (22) above. The slight difference from zero for spin two gravitons, if due to semi classical processes may not only give proof of eqn (20) and (22) above, but may give foundational clues as to how gravitons formed in the first place, and the relative stability of their states as they move toward the conditions reflected in figure 2 above. In future work, the author intends to present an inatanton-anti instanton model for gravitons , and their relative stability which the author believes will be important not only in confirming predictions given in figure 2, and eqn (22) but which will be important to the question of if a graviton can actually carry information. The instanton – anti instanton coupling for gravitons would have to fit in with appropriate space time metrics, as outlined by Belunski, and Verdaguer (2001), and may confirm t’Hoofts (2006) treatment of quantum mechanics as being part of a larger theoretical construction

BIBLIOGRAPHY

Allen, B., Flanagan, E. and Papa, M. Is the squeezing of relic gravitational waves produced by inflation detectable?, Phys.Rev.D61:024024,2000., http://arxiv.org/PS_cache/gr-qc/pdf/9906/9906054v2.pdf ...

Alves, M. Miranda. O. and de Araujo, J. ,” Can Massive Gravitons be an Alternative to Dark Energy?”, arXiv:0907.5190 (July 2009)

Belunski, V. and Verdaguer, E., *Gravitational Solitons*, in series: Cambridge Monographs on Mathematical physics, Cambridge, UK, (2001)

Bischoff-Kim, M. H. Montgomery and D. E. Winget, “Strong Limits on the DFSZ Axion Mass with G117-B15A”,

Jedamzik, K., Lemoine M., and Moultaka, G,.” Gravitino, axino, and Kaluza–Klein graviton warm and mixed dark matter and reionization”, JCAP 0607 (2006) 010; http://arxiv.org/abs/astro-ph/0508141

Kahniashvili ,.T. ”Relic Gravitational Waves as a Test of the Early Universe”,arXiv:0705.1733 [astro-ph], (2007)

Jean-Luc Lehners, Paul J. Steinhardt, ‘Non-Gaussian Density Fluctuations from Entropically Generated Curvature Perturbations in Ekpyrotic Models’, Phys.Rev.D77:063533,2008; http://arxiv.org/abs/0712.3779

Maggiore, M.,”Gravitational Waves, Volume 1: Theory and Experiment”, Oxford University press, Oxford, UK, 2008

Maartens, R., , “Brane-World Gravity (2004)”, http://www.livingreviews.org/lrr-2004-7

Roszkowski, Leszek discussions with A.Beckwith at 12 Marcel Grossman meeting, July 17th, 2009, in Paris observatory, during the Dark matter section of the conference, in Parallel section run by Dr. Chardin.

t’Hooft, G., “The mathematical basis for Deterministic Quantum Mechanics,” http://arxiv.org/PS_cache/quant-ph/pdf/0604/0604008v2.pdf, (2006).