# Cosmic deceleration parameter q(Z) dependence upon gravitons? Implications for the DM rocket/ram jet model


## Andrew Walcott Beckwith

*American Institute of Beam Energy propulsion ( life member)*
abeckwith@uh.edu, beckwith@aibep.org



**Abstract** In this paper Beckwith 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 Marcio E. S. Alves, Oswaldo D. Miranda, Jose C. N. de Araujo, 2009 Beckwith will high light what KK style gravitons, with a slightly different mass profile could mean in terms of his DM rocket proposal brought up in both Christ Church, Dark 2009, and in SPESIF, 2009. I.e. value of up to 5 TeV, as opposed to 400 GeV for DM, which may mean more convertible power for a dark matter ram jet. 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 , but would also influence the viability of the DM ram jet applications for interstellar travel



**Key words:** Graviton, DM, ram jet
**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 Leszek 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. Conversely, Roszkowsk referred to significant formation and density fluctuation changes if warm and cold DM candidates were mixed together. Having heard Roszkowsk say this, Beckwith tried to find what would happen if warm and cold dark matter was mixed together. Beckwith read that Karsten Jedamzik, Martin Lemoine and Gilbert Moultaka (2006), have written "Stable particle dark matter may well originate during the decay… ( of particles such as the ) higher-dimensional Kaluza-Klein (KK) graviton" I.e. the axion is a cold DM candidate, whereas the KK graviton is warm DM.. For the sake of investigating Leszek Roszkowski's research views, Beckwith decided to investigate the probability of DM as a KK graviton.

Next, Beckwith 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, Beckwith 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 , in the manner associated with DE. In what is a departure from usual models of the graviton, 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 $m_n(Graviton) = \frac{n}{L} + 10^{-65}$ grams, It so happens that this red shift pre dates the Z~.55 point of inflection where cosmological speed up of expansion occurs, Joining the above, for higher dimensions than what Alves et al (2009) considered may be a way to show DM as due to higher dimensional representations of the gravition, via a KK tower, of energy values while having a modification of the KK tower for gravitons . With the zeroth mode of the KK graviton , if with a tiny mass, influencing DE type cosmological expansions. The implications may be that there is a joining of DM and DE, and sharply higher masses for the non axion versions of DM which may be relevant to the DM ram jet problem.

## Linkage of DM to gravitons and gravitational waves?

L Durrer, Massimiliano Rinaldi (2009), state that there would be negligible graviton production in cosmological eras after the big bang.. In fact, they state. “We calculate in detail the generation of gravitons during the transition to a matter dominated era. We show that the resulting gravitons generated in the standard radiation/matter transition are negligible”. One of the way to delineating the evolution of GW is the super adiabatic approximation, done for when $k^2 << |a''/a|$ as given by M. Giovannini (page 138), when $\mu_k \equiv a \cdot h_k$ is a solution to

$$\mu_k'' + \left[k^2 - \frac{a''}{a}\right]\mu_k = 0 \,. \tag{1}$$

Which to first order when $k^2 << |a''/a|$ leads to a GW solution

$$h_k(\tau) \cong A_k + B_K \cdot \int_0^\tau \frac{dx}{a(x)} \tag{2}$$

Eqn (0.1) will be contrasted with an evolution equation for gravitons, of ( i.e. KK gravitons )

$$h'' - \left[4k^2 + \frac{m^2}{a^2(z)}\right]h \equiv 0 \tag{3}$$

One of the models of linkage between gravitons, and DM is the KK graviton as a DM candidate.. Note that usual Randall Sundrum brane theory has a production rate $\Gamma \sim T^6 / M_{Planck}^2$ as the number of Kaluza Klein gravitons per unit time per unit volume Note this production rate is assuming a mass for which $T_* > M_X$ , and temperature $T \sim T_*$ . Furthermore, we assume a total production rate of KK gravitons of

$$\frac{dn}{dt} \sim \frac{T^6}{M_{Planck}^2} \cdot (T \cdot R)^d \sim T^4 \cdot \left(\frac{T}{M_X}\right)^{2+d} \tag{4}$$

Where R is the assumed higher dimension ‘size’ and , d is the number of dimensions above 4, and we obtain T >>1/R. I.e. we can assume tiny higher dimensional ‘dimensions’, very high temperatures, and also a wave length for the resulting KK graviton for a DM candidate looking like

$$\lambda_{KK-Graviton} \sim T^{-1} \tag{5}$$

If KK gravitons have the same wavelength as DM, this will support Jack Ng’s treatment of DM. All that needs to put this on firmer ground will be to make a de facto linkage of KK Gravitons, as a DM candidate , and more traditional treatments of gravitons, which would assume a steady drop in temperature from $T \sim T^*$, to eventually much lower temperature scales. . Note that in a time interval based as proportional to the inverse of the Hubble parameter, we have the total numerical density of KK gravitons ( on a brane? ) as $n(T) \sim T^2 M^{*}_{Planck} \cdot (T/M)^{2+d}$ , where $M^{*}_{Planck} \sim 10^{18} GeV$ give or take an order of magnitude. This number density $n(T)$ needs to be fully reconciled to $\lambda_{KK-Graviton} \sim T^{-1}$ and can be conflated with the dimensionality 'radius' value $R \sim 10^{\frac{32}{d}} \cdot 10^{-17}$ centimeters for dimensions above 4 space time GR values, with this value of R being unmanageable for d < 2 . V.A. Rubakov , and others also (2009) claim

$$V(r) = -\frac{G_4}{r} \cdot \left(1 + \frac{const}{k^2 r^2}\right) \tag{6}$$

As well as being related to an overall wave functional which can be derived from a line element

$$dS^2 \equiv \left[a^2(z) \cdot \eta_{uv} + h_{uv}(x,z)\right] \cdot dx^u dx^v + dz^2 \tag{7}$$

With $h'' - \left[4k^2 + \frac{m^2}{a^2(z)}\right] h \equiv 0$ (suppressing the u,v coefficients) . This evolution equation for the KK gravitons is very similar to work done by Baumann, Daniel, Ichiki, Kiyotomo, Steinhardt, Paul J. Takahashi , Keitaro (2007) with similar assumptions, with the result that KK gravitons are a linear combination of Bessel functions. Note that one has for gravitons.

$$h \equiv h_m(z \to 0) = const \cdot \sqrt{\frac{m}{k}} \tag{8}$$

Ruth Gregory, Valery A. Rubakov and Sergei M. Sibiryakov (2000) make the additional claim that for large z (the higher dimensions get significant) that there are marked oscillatory behaviors

$$h \equiv h_m(z \neq 0) \approx const \cdot \sqrt{a(z)} \cdot \sin\left(\frac{m}{k} \cdot esp(kz) + \varphi_m\right) \tag{9}$$

This is similar to what Baumann, Daniel, Ichiki, Kiyotomo, Steinhardt, Paul J. Takahashi , Keitaro (2007) for GW, in a relic setting, with the one difference being that the representation for a graviton is in the z ( additional dimension) space, as opposed to what Bauman et al did for their evolution of GW, with an emphasis upon generation in over all GR space time.. Furthermore, the equation given in $h'' - \left[4k^2 + \frac{m^2}{a^2(z)}\right] h \equiv 0$ for massive graviton evolution as KK gravitons along dS branes is similar to evolution of GW in standard cosmology. Let us , now look at if higher dimensions are relevant to GR

## How DM would be influenced by gravitons, in 4 dimensions

We will also discuss the inter relationship of structure of DM, with challenges to Gaussianity. The formula as given by

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

(10)

The variation, will link to a statement about the relative contribution of Gaussianity, via

$$\Phi \equiv \Phi_L + f_{NL} \cdot \left[ \Phi_L^2 - \left\langle \Phi_L^2 \right\rangle \right] + g_{NL} \cdot \Phi_L^3 \tag{11}$$

Here the expression $f_{NL} =$ variations from Gaussianity, while the statements as to what contributes, or does not contribute will be stated in our presentation. Furthermore, $\Phi_L \equiv$ is a linear Gaussian potential, and the over all gravitational potential is altered by inputs from the term, presented, $f_{NL}$ . The author discussed inputs into variations from Gaussianity, which were admittedly done from a highly theoretical perspective with Sabino Matarre, on July 10, with his contributions to non Gaussianity being constricted to a reported range of $-4 < f_{NL} < 80$ , as given to Matarre, by Senatore, et al, 2009.. What is ascertained as far as DM, via a density profile variation needs to have it reconciled with DM detection values

$$\sigma_{DM-dectecion} \leq 3 \times 10^{-8} \quad \text{pb (pico barns)} \tag{12}$$

To whit, \ KK gravitons would have a combined sum of Bessel equations as a wave functional representation. In fact V. A Rubasov (2009) writes that KK graviton representation as, after using the following normalization $\int \frac{dz}{a(z)} \cdot [h_m(z) \cdot h_{\tilde{m}}(z)] \equiv \delta(m - \tilde{m})$, where $J_1, J_2, N_1, N_2$ are different forms of Bessel functions, to obtain the KK graviton/ DM candidate representation along RS dS brane world

$$h_m(z) = \sqrt{m/k} \cdot \frac{J_1(m/k) \cdot N_2([m/k] \cdot \exp(k \cdot z)) - N_1(m/k) \cdot J_2([m/k] \cdot \exp(k \cdot z))}{\sqrt{[J_1(m/k)]^2 + [N_1(m/k)]^2}} \tag{13}$$

This allegedly is for KK gravitons having an order of TeV magnitude mass $M_Z \sim k$ (i.e. for mass values at .5 TeV to above a TeV in value) on a negative tension RS brane. What would be useful would be managing to relate this KK graviton, which is moving with a speed proportional to $H^{-1}$ with regards to the negative tension brane with $h \equiv h_m(z \to 0) = const \cdot \sqrt{\frac{m}{k}}$ as a possible initial starting value for the KK graviton mass, before the KK graviton, as a 'massive' graviton moves with velocity $H^{-1}$ along the RS dS brane. If so, and if $h \equiv h_m(z \to 0) = const \cdot \sqrt{\frac{m}{k}}$ represents an initial state, then one may relate the mass of the KK gravition, moving at high speed, with the initial rest mass of the graviton, which in four space in a rest mass configuration would have a mass many times lower in value, i.e. of at least $m_{graviton}(4 - Dim \quad GR) \sim 10^{-48} eV$ , as opposed to $M_X \sim M_{KK-Graviton} \sim .5 \times 10^9 eV$ . 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 would be about $m_{graviton}(4 - Dim \quad GR) \sim 10^{-48} \times 10^{-5} eV \sim 10^{65}$ grams, leading to a possible explanation for when the universe accelerated, i.e. the de-acceleration parameter

$$q = -\frac{\ddot{a}a}{\dot{a}^2} \quad (14)$$

In the case of working with a simpler version of the Friedman equation with no graviton mass, but with pressure and density factored in, we can obtain

$$\frac{\ddot{a}}{a} = \frac{4\pi G}{3} \cdot \left[\left(-3p/c^2\right) - \rho\right] \quad (15)$$

This above Friedman equation will lead to a very simple de celebration parameter value of

$$q = -\frac{\ddot{a}a}{\dot{a}^2} = \left(\frac{4\pi G}{3c^2 H^2}\right) \cdot \left[3p + \rho\right] \quad (16)$$

The article will see what happens to insure what happens if t the sign of 16 goes from positive to negative. .If one has a graviton mass $m_{graviton} \neq 0$, then (16) changes, and there will be a way forward to consider whether or not there is a linkage between DM, DE, and structure formation. Using

$$\left(\frac{\dot{a}}{a}\right)^2 + \frac{m_g^2 c^4}{2\hbar^2} \cdot \left(1 - a^2\right) \equiv \frac{8\pi G}{3c^2} \cdot \rho \quad (17)$$

And

$$\frac{\ddot{a}}{a} + .5 \cdot \left(\frac{\dot{a}^2}{a^2}\right) + \frac{m_g^2 c^4}{4\hbar^2} a^2 \cdot \left(a^2 - 1\right) = \frac{8\pi G}{3c^2} \cdot p\,. \quad (18)$$

For the matter dominated era, it is important to note that the R.H.S. of eqn. (18) is zero. This leads to eqn.. (15) 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 (1.4) just becoming $> 0$ to maximum values of (1.4) today, with $z = 0$, all at mass of the order of $10^{65}$ grams. This increase of (1.4) then leads us to consider how to configure eqn. (17) and eqn. (18) 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 ,

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{\rho_{Total}}{3M_{Planck}^2} - \frac{k}{a^2} + \frac{\Lambda}{3} \quad (19)$$

As well as

$$\left(\frac{\ddot{a}}{a}\right) = -\frac{\left(\rho_{Total} + 3p_{Total}\right)}{6M_{Planck}^2} + \frac{\Lambda}{3} \qquad (20)$$

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

$$\dot{a}^2 = \left[\left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{\rho^2}{36M_{Planck}^2}\right)a^2 - \kappa + \frac{C}{a^2}\right] \qquad (21)$$

For the purpose of Randall Sundrum brane worlds, eqn. (21) is differentiated with respect to $d/d\tau$, and then terms from (1.5) 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. Grossing 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 of 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 is adding , instead the small mass of $m_n(Graviton) = \frac{n}{L} + 10^{-65}$ grams, with $m_0(Graviton) \approx 10^{-65}$ grams, then the problem being worked with is a source term problem of the form given by Peskins as of the type

$$\psi_n(x) \equiv \int d^3p \cdot \frac{1}{(2\pi)^3}\cdot\frac{1}{\sqrt{2E_P}}\cdot\left\{\left(a_P + \frac{i}{\sqrt{2E_P}}\cdot FT(m_0(graviton))\right)\exp(-ipx) + H.C.\right\} \qquad (22)$$

This eqn (22) is, using the language V.A. Rubakob (2009) put up equivalent to writing

$$\psi_m(x) \approx h_m(x) + \int d^3p \cdot \frac{1}{(2\pi)^3}\cdot\left(\frac{1}{\sqrt{2E_P}}\right)^2 \cdot \left\{\left(i\cdot FT(m_0(graviton))\right)\exp(-ipx) + H.C.\right\} \qquad (23)$$

I.e. how to interpret the quantity $FT(m_0(graviton)$ being the issue If $m_0(graviton)$ is a constant, then eqn. (23) has delta functions. We will do a time differentiation of eqn (21), and compare it term by term with what arises if there is a suitable graviton mass, and comment as to what would be needed to have graviton mass in a brane version of (1.7) , and its time derivative, and do a similar analysis as to what was done to recover the positive acceleration , for (1.4) using brane equivalents to (1.5) as well as imputs from (1.6) . This may show up about modification of the galaxy models, as follows.

## Controversies of DM/ DE applications to cosmology. How HFGW may help resolve them

What to consider is the'cosmic void hypothesis'. See Timothy Clifton, Pedro G. Ferreira and Kate Land . I.e. Clifton raises the following question- can HFGW and detectors permit cosmologist to get to the bottom of this ? "Solving Einstein's equations for an averaged matter distribution is NOT the same as solving for the real matter distribution and then averaging the resultant geometry"("We average, then solve when in effect we should solve, then average") .Next, let us look at a recently emerging conundrum of DM feeding into the structure of new galaxies and their far earlier than expected development, i.e. 5 billion years after the big bang. What could cause the earlier clumping? . First of all, note the formula of variation of DM density which exists has a Hubble parameter $H$, and also the 2nd derivative of the gravitational potential $\nabla^2\Phi$ , where $\rho_0, a_0$ are today's values for density and 'distance.' Note that if $H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \left[\left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{\rho^2}{36M_{Planck}^2}\right) - \frac{\kappa}{a^2} + \frac{C}{a^4}\right] \xrightarrow[\Lambda_4 \to 0]{\kappa \to 0,} \left[\frac{\rho}{3M_4^2} + \frac{\rho^2}{36M_{Planck}^2} + \frac{C}{a^4}\right]$, as well as $\rho \to \rho(z) \equiv \rho_0 \cdot (1+z)^3 - \left[\frac{m_g}{8\pi G}\right] \cdot \left(\frac{a_0^4}{14\cdot(1+z)^4} + \frac{2a_0^2}{5\cdot(1+z)^2} - \frac{1}{2}\right)$ , and $1+z = a_0/a$ , then the contribution of large $z$ , i.e. large contributions from red shift, that a significant early contributions will be for non zero contributions from $1/\rho^\beta$ terms, for [ **large number ]** $> \beta \geq 1$ in the DM density variation parameters. So long as $m_{graviton} \neq 0$, even if $m_{graviton}$ is very small. In addition, if the following is true

$\Phi \equiv \Phi_L + f_{NL} \cdot \left[\Phi_L^2 - \left\langle \Phi_L^2 \right\rangle\right] + g_{NL} \cdot \Phi_L^3$ then. when using the formula, $\nabla^2\Phi$ consider the contributions to the expression $f_{NL}$ . To do this consider what Licia Verde (2000) put up about $\Phi$ considered to be the gravitational potential, and $\Phi_L$ its linear Gaussian contribution. P. Chingabam, C. Park (2009)) used $-4 < f_{NL} < 80$ at a confidence level of 95%. Now for some sort of bounds as to what may be acceptable bounds in error, based upon CMB data

$$\left| f_{NL} \cdot \left[\Phi_L^2 - \left\langle \Phi_L^2 \right\rangle\right] \right| \leq 10^{-5} \cdot \left| f_{NL} \right| < ?up \quad to \quad 10^{-3} \tag{24}$$

Depending upon which model is used for describing $\Phi_L$ i.e. as a perturbation of a gravitational potential, this eqn. (24) may allow us to obtain a good guess as to what dimensions are crucial for the formation of a graviton, i.e. how much spread may be permitted. Also, White and Hu (1996), also have a way to link the gravitational potential $\Phi$ to temperature fluctuations, and do it as

$$\left.\frac{\Delta T}{T}\right|_{Final} - \left.\frac{\Delta T}{T}\right|_{Initial} = -\Phi_{Initial} \tag{25}$$

A simple way to understand eqn (25) is to consider if it is linkable to the Sach-Wolfe effect. Here, the Sachs–Wolfe effect (ISW) occurs when the Universe is dominated in density by something other than matter. If the Universe is dominated by matter, then large-scale gravitational potential wells and hills do not evolve significantly. If the Universe is dominated by radiation, or by dark energy, , those potentials do evolve, subtly changing the energy of photons passing through them. If so is there a difference in the initial and final ratios $\Delta T/T$ of temperature variations are for different red shift values ? Look at then

$$(\delta T/T) \cong (1/3) \cdot \left[\Phi_L + f_{NL} \cdot \left(\Phi_L^2 - \left\langle \Phi_L \right\rangle^2\right)\right] \tag{26}$$

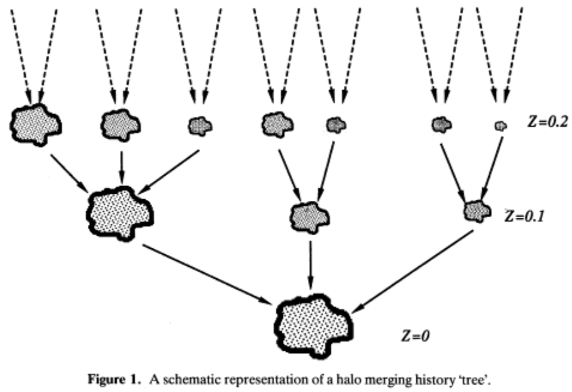


**Figure 1.** *How we obtain from the 'bottom up' development of galactic super structure.*

What is actually observed, contradicts this halo emerging history 'tree', i.e. Just ONE little problem: DM appears to be fattening up young galaxies, allowing for far-earlier-than-expected creation of early galaxies. "A clutch of massive galaxies that seem to be almost fully-formed just 5 billion years after the big bang challenge models that suggest galaxies can only form slowly. Tendrils of dark matter that fed the young galaxies on gas could be to blame (NASA/CXC/ESO/P Rosati et al)"

The following figure 2 is a KK tower for gravitons, with the zeroth KK mode being the 4 dimensional graviton. **The modified KK tower for gravitons will be our candidate for DM which may explain Figure 1s result**

**Kaluza Klein modes in detector simulations for / as a DM candidate.**

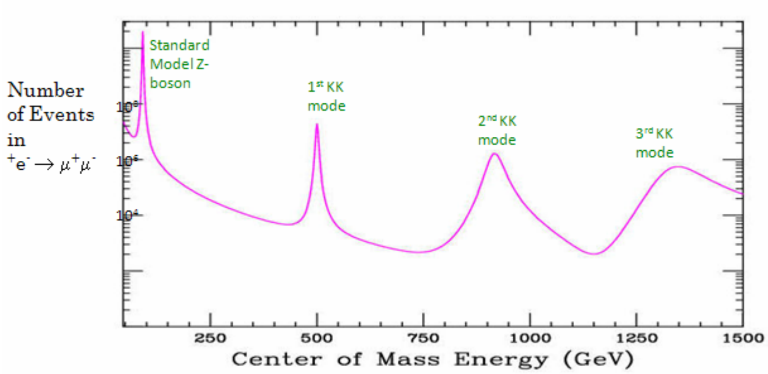


**Figure 2**: *Number of Events in e+e- $\rightarrow \mu+\mu$- For a conventional braneworld model with a single curved extra dimension of size ~ 10-17 cm Numbers range from* $10^4$ *to about* $10^8$ *for the number of events in scattering. First peak is for KK zero mode, a.k.a. the standard Z boson, ending with the 4th peak for the 3rd KK mode,*

Having presented figure 2 and making the case of a KK gravition being important for the structure formation of galaxies, the next matter to consider is if a tiny gravition mass, attached to the zeroth KK tower, can influence/ substitute for the dynamics of DE enabling of a speed up of cosmological expansion a billion years ago.

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

Following presenting of eqn. (23) above with . $\hbar = c = 1$, so then when writing

$$q = A1 + A2 + A3 \tag{27}$$

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

$$\rho \equiv \rho_0 \cdot \left(\frac{a_0}{a}\right)^3 - \left[\frac{m_g c^6}{8\pi G \hbar^2}\right] \cdot \left(\frac{a^4}{14} + \frac{2a^2}{5} - \frac{1}{2}\right) \tag{28}$$

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

$$d\rho/d\tau = -\left(\frac{\dot{a}}{a}\right) \cdot \left[3 \cdot \rho_0 \cdot \left(\frac{a_9}{a}\right)^3 + 4 \cdot \left(\frac{a^4}{14} + \frac{a^2}{5}\right) \cdot \left(\frac{m_g c^6}{8\pi G \hbar^2}\right)\right] \tag{29}$$

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 $\rho$. Now, if $\hbar \equiv c \equiv 1$ and $d\Lambda_4/d\tau \sim 0$, and , also, we neglect $\Lambda_4$ as of being not a major contributor. And set the curvature equal to zero. i.e. $\kappa = 0$, the density will be evolving as

$$d\rho/d\tau \cong -\sqrt{\frac{C}{a^4} - \frac{\kappa}{a^2} + \left(\frac{\rho}{3M_4^2} + \frac{1}{36} \cdot \frac{\rho^2}{M_P^6}\right)} \cdot \left[3 \cdot \rho_9 \cdot \left(\frac{a_0}{a}\right)^3 + 4 \cdot \left(\frac{a^4}{14} + \frac{a^2}{5}\right) \cdot \left(\frac{m_g}{8\pi G}\right)\right] \tag{30}$$

With such assumptions put in,

$$\rho \equiv \rho_0 \cdot \left(\frac{a_0}{a}\right)^3 - \left[\frac{m_g}{8\pi G}\right] \cdot \left(\frac{a^4}{14} + \frac{2a^2}{5} - \frac{1}{2}\right), \tag{31}$$

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

$$\Phi(\rho, a, C) = \frac{C}{a^4} + \left(\frac{\rho}{3M_4^2} + \frac{1}{36} \cdot \frac{\rho^2}{M_P^6}\right) \tag{32}$$

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

$$\rho(z) \equiv \rho_0 \cdot (1+z)^3 - \left[\frac{m_g}{8\pi G}\right] \cdot \left(\frac{a_0^4}{14 \cdot (1+z)^4} + \frac{2a_0^2}{5 \cdot (1+z)^2} - \frac{1}{2}\right) \tag{33}$$

$$A1(z) \cong \frac{C \cdot (1+z)^3}{a_0^3} \cdot \left[1 \Big/ \sqrt{\Phi(\rho(z), a_0/(1+z), C)}\right] \tag{34}$$

$$A2(z) \cong -\left(\frac{\rho(z)}{3M_4^2} + \frac{1}{36} \cdot \frac{\rho(z)^2}{M_P^6}\right) \Big/ \left[\Phi(\rho(z), a_0/(1+z), C)\right] \tag{35}$$

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

$$\Phi(\rho(z), a_0/(1+z)), C) = \frac{C \cdot (1+z)^4}{a_0^4} + \left(\frac{\rho(z)}{3M_4^2} + \frac{1}{36} \cdot \frac{\rho(z)^2}{M_P^6}\right) \tag{37}$$

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

$$q(z) = A1(z) + A2(z) + A3(z) \tag{38}$$

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

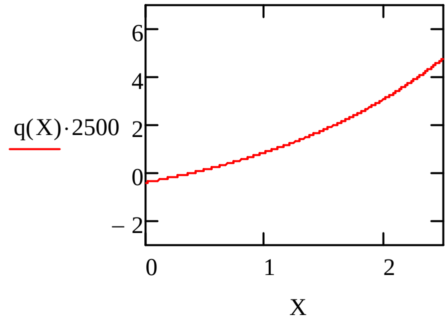

**Figure 3 : re duplication of basic results of** Marcio E. S. Alves, Oswaldo D. Miranda, Jose C. N. de Araujo, 2009, using their parameter values, with an additional term of C for 'Dark flow' added, corresponding to one KK additional dimensions.

Figure **3** 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, Jose A. R.; Feng, Jonathan L.; Strigari, Louis E. (2007) give a partial answer. It is not just the gamma ray spectrum which may be altered. I.e. Alexey Boyarsky, Julien Lesgourgues, Oleg Ruchayskiy and Matteo Viel (2009) have strict Baysian s tatistical 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

$$\left(\frac{\delta\rho}{\rho}\right) \equiv \frac{\rho_{Baryons}\delta_{Baryons} + \rho_{Cold-Dark-Matter}\delta_{Cold-Dark-Matter} + \rho_{Warm-Dark-Matter}\delta_{Warm-Dark-Matter}}{\rho_{Baryons} + \rho_{Cold-Dark-Matter} + \rho_{Warm-Dark-Matter}} \quad (40)$$

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

$$\begin{aligned} &\delta_{Baryons} \equiv \delta_{CDM}, \\ &\delta_{WDM} << \delta_{CDM} \end{aligned} \quad (41)$$

In earlier times, what is put in, with regards to eqn. (41) would be probably far different . However, up in the present era, the denominator of Eqn (40) 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.

$$\left(\frac{\delta\rho}{\rho}\right)_{Horizon} \cong \frac{k^{3/2}\left|\delta_k\right|}{\sqrt{2}\pi} \propto \frac{k^{(3/2)+3\alpha-3/2}}{\sqrt{2}\pi} \approx \left(1/\sqrt{2}\pi\right)\cdot k^{3\alpha} \quad (4.2)$$

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. (40) in early and later times should be reconciled with.

$$\left(\frac{\delta\rho}{\rho}\right)_{Horizon} \cong \left(1/\sqrt{2}\pi\right)\cdot k^{3\alpha} \sim \frac{H^2}{\dot{\phi}} \propto 10^{-4} - 10^{-5} \tag{43}$$

The above equation gives inter relationships between the time evolution of a pop up inflaton field $\phi$, and a Hubble expansion parameter H , and a wave length parameter $\lambda = (2\pi/k)\cdot a(t)$ for a mode given as $\delta_k$. What should be considered is the inter relation ship of eqn (43) and $\lambda \leq H^{-1}$. What Beckwith thinks is

$$\left(\frac{\delta\rho}{\rho}\right) \cong Ak^{\left(\frac{n_S - 1}{2}\right)} \propto 10^{-4} - 10^{-5} \tag{44}$$

Understanding eqn.(40) to Eqn. (44) may ,explain the break down of figure 1 via earlier than expected galaxy formation.

## 4. Now for the DM rocket / ram jet problem, as proposed a year ago, a brief review. As put in , in a discussion by Beckwith, 2009, as referenced for SPESIF, 2009

Quoting from the 2009 conference paper by A.W. Beckwith (2009) : ". So, we can only talk about perhaps a ram jet engineering construction, I.e., scooping up Axions /DM from the interstellar void and using that as a fuel source. So how do we get around this ?

As can be inferred from P. Sikivie (1983), "Every axion which is converted to a photon with the same total energy and going in the same direction produces a momentum kick of

$$\Delta p = mc \times \gamma \cdot (1 - \beta) \tag{45}$$

where m is the axion rest mass." What is the rest mass of a KK DM graviton candidate ? It is up to a mass of 5 TeV. The conversion factor to be considered is 5 TeV versus the upper limit of 13.5 MeV , tops, for an axion ( it is usually a lot LESS) as reported by A. Bischoff-Kim, M. H. Montgomery and D. E. Winget (2008) wrote, "our analysis yields strong limits on the DFSZ axion mass. Our thin hydrogen solutions place an upper limit of 13.5 meV on the axion, while our thick hydrogen solutions relaxes that limit to 26.5 meV". For this result, I am picking the 13.5 meV as the upper limit for axion mass analysis. I.e. values as low as 1 eV have been figured as to axion mass, 5 TeV corresponds to 5.0 × $10^{12}$ electron volts, Whereas 13.5 MeV is = 13 500 000 electron volts At the high of the energy scale for axions, there is still roughly $10^5 - 10^6$ times more energy in a DM from KK gravitons, as opposed to axions,. Contrasting this with the 400 GeV value for WIMPS specified as of being 400 000 000 000 eV, then it is that the KK graviton would yield a far higher amount of energy ~ mass value than the WIMP**.** The implication may be that Eqn (4) has a stronger change in momentum contribution as to the DM ram jet / rocket problem, than expected.

# Conclusion

Looking at the KK graviton as a enabler to adding more momentum kick to eqn (45) seems to be a reasonable thought experiment. Of greater concern is the relative distribution of mass/ DM distributions as presented in Eqns (3.1) and (3.5). That has huge implications as to what concentration of DM/ energy scoop up could be configured as to an interstellar probe. Left unsaid here is the necessary datum of a suitable power boost of a ram net, to sufficient speed to work at all. Ultimately, that involves lasers In addition, the density profile of DM and of fuel to the rocket engine has to be mapped out. WMAP techniques will not get that for us. Unfortunately, like many scientific endeavors, it will require test flights in the solar system itself, and not just theory to obtain realistic data as to what to expect.

## NOMENCLATURE

| | |
|---|---|
| $M_P \approx 2.176 \times 10^{-8}\left[kg\right]$ | $t_P = \sqrt{\hbar \cdot G / c^5}$ |
| $G = 6.67300 \times 10^{-11}\ m^3 /\ kg\ s^2$ | $g = \det(g_{ab})$ |
| $r_s = 2Gm/c^2$ | $\bar{\bar{R}}$ – Ricci scalar |
| $\lambda_C = 2 \cdot \pi \cdot \hbar / m \cdot c$ | |

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