If A MACHIAN RELATIONSHIP BETWEEN GRAVITONS AND GRAVITINOS EXIST, WHAT DOES SUCH A RELATIONSHIP IMPLY AS TO SCALE FACTOR, AND QUINESSENCE EVOLUTION?

Andrew Beckwith
Chongqing University Department of Physics;
e mail: abeckwith@uh.edu
Chongqing, PRC, 400044

Abstract

The Machs principle as unveiled in this paper is really a statement as to information conservation, with Gravitons and Gravitinos being information carriers. What we wish to know is are there measurable consequences as far as scale factor evolution, spatial distance expansion and cosmological density proportional to a quinessent variant of the cosmological 'constant' parameter ?

1. Introduction

We first of all review an earlier proposed Machs principle for the Gravitinos in the electro weak era, and then the 2nd modern day Mach's principle, as organized by the author are as seen in [1]. This construction was used in an earlier article to argue in favor of a constant value of h bar, i.e. Planck's constant. For the sake of review, we will state that the values in

$$\frac{GM_{electro-weak}\Big|_{S\,\mathrm{up}er-partner}}{R_{electro-weak}c^2} \approx \frac{G\,M_{today}\Big|_{Not-Super-Partner}}{R_0 c^2} \tag{1}$$

are really a statement of information conservationI.ethe amount of information stored in the left hand side of (1) is the same as the information as in the right hand side of (1) above Here, M as in the electro weak era refers to M = N times m, where M is the total ' mass' of the gravitinos, N the number of Gravitinos, and R for the electro weak as an infinitely small spatial radiusWhere as the Right hand side is for M for gravitons (not super partner objects) = N as the (number of gravitons) and m (the ulltra low mass of the graviton) in the right hand side of (1) This should be compared with a change in entropy formula given by Lee [2] about the inter relationship between energy, entropy and temperature as given by

$$m \cdot c^2 = \Delta E = T_U \cdot \Delta S = \frac{\hbar \cdot a}{2\pi \cdot c \cdot k_B} \cdot \Delta S \tag{2}$$

If the mass m, i.efor gravitons is set by acceleration (of the net universe) and a change in enthropy $\Delta S \sim 10^{38}$ between the electroweak regime and the final entropy value of, if $a \cong \frac{c^2}{\Delta x}$ for acceleration is used, so then we obtain

$$S_{Today} \sim 10^{88} \tag{3}$$

Then we are really forced to look at (1) as a paring between gravitons (today) and gravitinos (electro weak) in the sense of preservation of information.

Having said this, the next step will be to see if this pairing of information as to earlier era, and today, as the present era, also influences quintessence, i.e. the idea that there could be a variation of background cosmological energy, which may be one of the drivers of the speed up of expansion of the universe as of a billion years ago. We will next start to look at a construction offered by Mitra [3] as to the Roberson Friedman Lematrie Walker universe which may tell us about the quinessence behavior of the vacuum energy.

2. Examination of Mitra's[3] formation of mass, energy and its possible effects on the cosmological 'contant' vacuum energy.

The prior result[1] was to state that Avession's [4] time varing $\hbar(t)$ in fact is a constant value, with no variation as due to alleged behavior represented by Mach's principle as represented by (1) above. What will be done next will be to look at the role of energy of the universe, and what it says about quintessence. The construction comes from Mistra[3] and is adapted to what Beckwith did with the Machian universe relations [1] as given in (1) to (3) above.

Mistra [3] in Lieu of working with a FRLW universe, wrote

$$\begin{aligned} E &= M(r,t) = \frac{4\pi}{3}\cdot R^3 \rho_{\bullet} \\ R &= a(t)\cdot r(t) \\ E &= -\frac{M}{a\cdot r} + \frac{1}{2}\cdot\left(\dot{a}\cdot r + \dot{r}\cdot a\right)^2 \end{aligned} \tag{4}$$

The density factor so parlayed in this treatment in the 1st equation in (4) was cited to have the relationship

$$\rho_{\bullet}\cdot a(t) = const \tag{5}$$

And

$$\begin{aligned} a(t) &= a_0 \exp(H\cdot t) \\ r(t) &= r_0 \exp(\beta\cdot t) \\ \rho_{\bullet} &= \frac{\Lambda}{8\pi} \end{aligned} \tag{6}$$

In addition is the $\dot{a} = H\cdot a$ *associated with the Hubble parameter and all that*

This leads to the energy value of the last equation of (4) to be written as

$$(a\cdot r)^3 - \frac{E}{(\beta+H)^2}\cdot(a\cdot r) - \frac{M}{(\beta+H)^2} = 0 \tag{7}$$

Using a typical cubic solution for real valued roots, this comes out to be

If we say that E=M, in the sense of the speed of light being set =1, then

$$(a \cdot r) \sim \left[\frac{M}{(\beta + H)} \right]^{1/3} + H.O.T. \tag{8}$$

This M though is for the total mass of the universe. But still we have

$$a(t) \propto \frac{const}{\rho_{\bullet}} \approx \exp(H \cdot t) \Rightarrow \rho_{\bullet} \propto \Lambda \sim \exp(-H \cdot t) \tag{9}$$

In so many words, the parameter for quintessence goes to almost zero today, i.e.

$$\Lambda \sim \exp(-H \cdot t) \xrightarrow[t \to \infty]{} 0^{+} \tag{10}$$

Question to ask is as follows. I.e. look at

$$(a \cdot r) \sim \left[\frac{M}{(\beta + H)} \right]^{1/3} \Leftrightarrow M \sim (\beta + H) \cdot (a \cdot r)^{3} \tag{11}$$

Can we in any sense scale the value of mass, as given in the left hand side of (11) with what is seen in (1)? Arguments on this issue will be presented next. The general scaling we will be remarking upon goes as follows.

$$\left. \frac{M}{r} \right|_{era} \sim \left(\beta|_{era} + H|_{era} \right) \cdot \left(a|_{era}{}^{3} \cdot r|_{era}{}^{2} \right)$$
$$era = either \quad EW \quad or \quad Today \tag{12}$$

3. Dynamical scaling of (12) with quintessene issues

We can now look at (12) and try to make sense out of the value of (9) and (10) . The main thing to keep in mind

$$\rho_{\bullet} = \frac{\Lambda}{8\pi} \sim \Lambda \sim \exp(-H \cdot t) \tag{13}$$

So that

$$\rho_{\bullet}|_{Today} \sim \frac{\Lambda_{EW}}{8\pi} \exp(-H_{EW} \cdot t|_{Today}) \Leftrightarrow \Lambda_{Today} \sim \Lambda_{EW} \exp(-H_{EW} \cdot t|_{Today}) \tag{14}$$

I.e. the Hubble parameter would be fixed as of the value it had in the electro weak, as extremely large, whereas the time would be 13.6 billion years after the big bang.

This value of scaling of the cosmological parameter associated with vacuum energy is tied in, directly, with (12) which is a by product of (1).

The fact that the value of $\Lambda_{Today} \sim \Lambda_{EW} \exp(-H_{EW} \cdot t|_{Today})$ is so small compared to Λ_{EW} is in part due to the same sort of scaling where the value of the Graviton mass is so much smaller than the value of the Gravitino.

I.e. the mass of the Gravitino in the electro weak era is such that by (1)

$$\begin{aligned} M_{electro-weak} &= N_{electro-weak} \cdot m_{3/2} = N_{electro-weak} \times 10^{38} \cdot m_{graviton} \\ &= N_{today} \cdot m_{graviton} \approx 10^{88} \cdot m_{graviton} \end{aligned} \tag{15}$$

Then the electro weak regime would have

$$N_{electro-weak} \sim 10^{50} \tag{16}$$

Using quantum infinite stastics [5], [6], [7] , this is a way of fixing the early electro weak entropy as $\sim 10^{50}$ vs 10^{88} today. The drop off of the vacuum energy as given by $\Lambda_{Today} \sim \Lambda_{EW} \exp(-H_{EW} \cdot t|_{Today})$ is at least 10^{-38} the value of Λ_{EW}

I.e. the Machian relationship which is specifying gravitinos as 10^{38} or greater in mass than the present day 'massive' graviton would specify a decrease in the value of Λ_{EW} $10^{-38} - 10^{-40}$ or more to the tiny present Λ_{Today}.

Main point, Quintessence is linked via a Machian relationship between the mass of a Gravitino, electro weak era, with the mass of a present day tiny mass graviton. This is a by product of (12) above. It independently re enforces what Beckwith came up in the Journal of cosmology[8] about gravitions and their contribution to the speeding up of acceleration of the universe a billion years ago, which is in part related to the problem of quinessence.

4. **Conclusion, what to do next, i.e. application of** FJORTOFT'S THEOREM and its implications as to Λ_{EW}, and initial Hubbles parameter values when the initial time step is indeterminate in cosmological evolution.

Note that in terms of the Hubble parameter,

$$H = \frac{1}{a} \cdot \frac{da}{dt} \tag{17}$$

The scale factor of expansion of the universe so brought up, a, which is 1 in the present era, and infinitesimal in the actual beginning of space time expansion, is such that $\frac{da}{dt}$ gets smaller when a increases, leading to the rate of expansion slowing . This is well defined in the later part of evolution, but it does not get about the fact in the beginning that the g_{00} metric initially if pressure equals the negative of density is not well defined. As stated in [3]

$$\begin{gathered} g_{00} = \exp\left[\frac{-2p(t)}{p(t)+\rho(t)}\right] \\ s.t.\left(g_{00} = \exp\left[\frac{-2}{1+\left(\rho(t)/p(t)\right)}\right]\right) \xrightarrow[\rho+p=0]{} 0 \end{gathered} \tag{18}$$

The initial starting point for the Hubble parameter is going to have a time step pretty much arbitrarily put in, and that will lead to [3]

$$\dot{M} = 4\pi\rho R^2 \dot{R} \tag{19}$$

If E is equal to M, due to setting the speed of light equal to 1, then this means that the initial energy will be related to a change in the amount of energy put inside the system. It seems reasonable to do, however, if the initial time parameter g_{00} is unidefined that the first iteration of (19) is not due to instability, i.e. the non application of Fjororotofs theorem indicates that matter is injected into the present universe possibly from a larger meta structure,

Fjortoft theorem:

A **necessary condition for instability** is that if z_* is a point in spacetime for which $\frac{d^2U}{dz^2} = 0$ for any given potential U, then there must be some value z_0 in the range $z_1 < z_0 < z_2$ such that

$$\left.\frac{d^2U}{dz^2}\right|_{z_0} \cdot \left[U(z_0) - U(z_*)\right] < 0 \tag{20}$$

For the proof, see [8] and also consider that the main discussion is to find instability in a physical system which will be described by a given potential U. Next, we will construct in the boundary of the EW era, a way to come up with an optimal description for U.

Note that [8]'s situation is way before the re accleration of the universe, as given in [9]

To do this, we will look at T. Padamanabhan [10] and his construction of in Dice 2010 of thermodynamic potentials he used to have another construction of the Einstein GR equations. To start, T. Padamanabhan [10] wrote

If P_{cd}^{ab} is a so called Lovelock entropy tensor, and T_{ab} a stress energy tensor

$$\begin{aligned}
&U(\eta^a) = -4\cdot P_{ab}^{cd}\nabla_c\eta^a\nabla_d\eta^b + T_{ab}\eta^a\eta^b + \lambda(x)\,g_{ab}\eta^a\eta^b \\
&= U_{gravity}(\eta^a) + U_{matter}(\eta^a) + \lambda(x)\,g_{ab}\eta^a\eta^b \\
&\Leftrightarrow U_{matter}(\eta^a) = T_{ab}\eta^a\eta^b; U_{gravity}(\eta^a) = -4\cdot P_{ab}^{cd}\nabla_c\eta^a\nabla_d\eta^b
\end{aligned} \tag{21}$$

We now will look at

$$\begin{aligned}
&U_{matter}(\eta^a) = T_{ab}\eta^a\eta^b \quad ; \\
&U_{gravity}(\eta^a) = -4\cdot P_{ab}^{cd}\nabla_c\eta^a\nabla_d\eta^b
\end{aligned} \tag{22}$$

So happens that in terms of looking at the partial derivative of the top (21) equation, we are looking at

$$\frac{\partial^2 U}{\partial\left(\eta^a\right)^2} = T_{aa} + \lambda(x)\,g_{aa} \tag{23}$$

Thus, we then will be looking at if there is a specified η_*^a for which the following holds.

$$\frac{\left[\dfrac{\partial^2 U}{\partial\left(\eta^a\right)^2} = T_{aa} + \lambda(x)\,g_{aa}\right]_{\eta_0^a} *}{\left[\begin{array}{l} -4\cdot P_{ab}^{cd}\left(\nabla_c\eta_0^a\nabla_d\eta_0^b - \nabla_c\eta_*^a\nabla_d\eta_*^b\right) + \\ T_{ab}\cdot\left[\eta_0^a\eta_0^b - \eta_*^a\eta_*^b\right] + \lambda(x)\,g_{ab}\cdot\left[\eta_0^a\eta_0^b - \eta_*^a\eta_*^b\right]\end{array}\right]} < 0 \tag{24}$$

What this is saying is that there is no unique point, using this η_*^a for which (24) holds. Therefore, we say there is no official point of **instability of** η_*^a due to (23). The Lagrangian structure of what can be built up by the potentials given in (23) with respect to η_*^a mean that we cannot expect an inflection point with respect to a 2nd derivative of a potential system. Such an inflection point designating a speed up of acceleration due to DE exists a billion years ago [3]. Also note that the reason for the failure for (23) to be congruent to (20) is due to

$$\left[\frac{\partial^2 U}{\partial\left(\eta^a\right)^2} = T_{aa} + \lambda\left(x\right) g_{aa}\right] \neq 0,\ for \forall\, \eta_*^a choices \qquad (25)$$

The upshot is that the energy / matter expression has to be injected from a prior universe. This is in tandem with re interpreting the expression [3]

$$dM + \frac{pdV}{\sqrt{1-kr^2}} = 0 \qquad (26)$$

The interpretation of (26) in [3] was given as to p=0 and its implications as to the big bang. We will consider a different prospectus, i.e. that trivially, when we have k=0, that the above will give the expected density related to the mass relationship, but that at that point of configuration , one has a collapse of the time step, as seen in (27) below. I.e.

If

$$\begin{aligned} &p = -\rho \\ &g_{00} \xrightarrow[p=-\rho]{} 0 \end{aligned} \qquad (27)$$

It will mean a very different prospectus as far as identifying, i.e. Λ_{EW} and where it came from. We hope that the research protocols are up to making this determination.

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