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

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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 ? Secondly is an investigation as to what happens if we also add in that the cosmological density times a scale factor is a constant? We come up with physical behavior of scale factor times spatial evolution, based upon Mitra's recent work, proportional to the general mass to the 1/3rd power . If there is quintessence behavior, what does this say about Mach's princple as applied to Gravitons and Gravitinos?

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

$$\frac{GM_{electro-weak}\Big|_{Super-partner}}{R_{electro-weak}c^2} \approx \frac{G\,M_{today}\Big|_{Not-Super-Partner}}{R_0 c^2} \qquad (1)$$

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

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

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

$$S_{Today} \sim 10^{88} \qquad (3)$$

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 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

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

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

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

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.

$$\left. \frac{M}{r} \right|_{EW,today} \sim \left(\beta|_{EW,today} + H|_{EW,today} \right) \cdot \left(a|_{EW,today}{}^{3} \cdot r|_{EW,today}{}^{2} \right) \tag{12}$$

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

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

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, 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.

4. Conclusion, what to do next

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 downWhen one is looking at a speed up of acceleration of the universe, $\frac{da}{dt}$ gets larger as a increases.

The given (17) above, the Hubble parameter is a known experimental 'candle' of astronomyThe point in which (17) denotes a slowing down of acceleration of the universe, then quantity so H must get smaller than $\frac{1}{a}$ In fact, as is frequently stated in Astronomy text books the net energy density of the universe is proportional to H^2 which is stating then that the energy density of the universe must get smaller faster than $\frac{1}{a^2}$ in the situation where the rate of expansion of the universe is slowing down.In fact, this is what happens as long as you have a universe that is made of nothing but matter and radiation.Normal matter, as the universe expands, just gets further apart.We have the same amount of mass in a larger volumeSo normal matter dilutes as $\frac{1}{a^3}$ I.e. with normal matter we observe deceleration.With radiation, we get even more deceleration, because radiation not only dilutes in number, it also gets red-shifted, so that radiation dilutes as $\frac{1}{a^4}$.

So basically the very early universe, when most of the energy was in radiation, was decelerating. But the radiation's energy dropped more rapidly than the normal matter, and so later on the normal matter ended up dominating the energy in the universe.The universe continued to decelerate, but more slowly.As time moved on, the normal matter continued to get more and more dilute, its energy dropping more and more, until the originally much smaller (but not decreasing!) energy density in dark energy came to dominate.When the dark energy became to dominate, as it did one billion years ago, the rate of deceleration slowed down dramatically,then reversed.

What needs to be done next is to understand Machs principle and also (12) to (17) above more throughly to get more detail as to what is verbally sketched in above. Doing so will be a start as to turning to the creation of gravitational wave astronomy into a through investigation as to the evolution of the present day universe, in greater detail and with complete data sets. This also may be a way to confirm or falsify Hogans [5] speculations as to holographic treatment of perturbations, as well, which would sharpen our understanding of instrumentation physics and gravitational wave astronomy.

Acknowledgements

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