IF INITIAL LENGTH OF SPACE-TIME GOES TO A NON PATHOLOGICAL BIG BANG SINGULARITY INITIALLY, WHAT HAPPENS TO VACCUUM ENERGY EVOLUTION?

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Abstract

When initial radii $R_{initial} \to 0$ if Stoica actually derived Einstein equations in a formalism which remove the big bang singularity pathology, then the reason for Planck length no longer holds. We find that energy fluctuation $\Delta E_{initial}$ goes to zero if $R_{initial} \to 0$ which happens if there is no minimum distance mandated to avoid the pathology of singularity behavior at the heart of the Einstein equations. Then information exchange as given by Machs relationship picked by the author to preserve Planck's constant in space-time evolution has a very different meaning than in cyclical universe constructions. Without $R_{initial} \to 0$ 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}. We conclude as to what may happen to such relations if $R_{initial} \to 0$ is permitted without a Planck grid minimum size of $10^{-33} cm$. The answer apears to depend on if a 4 dimensional space-time is embedded in a higher dimensional super structure, i.e. an embedding space. The final question as seen by the author is, first of all, is Planck length actually necessary? If not, is $R_{initial} \to 0$ occuring in 4 dimensions which maybe in a braneword setting? How these questions are answered will affect the survival of vacuum energy in a cosmology model

Keywords: *Fjortoft theorem, thermodynamic potential, matter creation, vacuum energy Mach's theorem, non pathological singularity affecting Einstein equations,planck length. Braneworlds.*

1. Introduction

This article is to investigate what happens physically if there is a non pathological singularity at the start of space-time, i.e. no reason to have a minimium nonzero length. The reasons for such a proposal come from [1] by Stoica who may have removed the reason for the development of Planck's length as a minimum safety net to remove what appears to be unadvoidable pathologies at the start of applying the Einstein equations at a space-time singularity. We bring this question up, since the question affects our construction of Machian information exchange between initial and final space-time constant of nature values. I.e. we will review what was done earlier, and to use it to obtain a different frame of reference as to what is meant by information in preservation of Planck's constant, if $R_{initial} \to 0$. Note we endeavored initially to keep Planck's constant uniform to avoid changes in the dynamics of phyics equations.

2. Outline of the paper. Its underlying assumptions

a. The document begins with a statement as of Mach's principle. This is assuming, initially that an initial radius $R_{initial} \to 0$ does not occur. Tied in with perserving the uniformity of Planck's constant. Pages 2-3
b. Examination of Mitra's [4] formation of mass, energy and its possible effects on the cosmological 'contant' vacuum energy. Pages 3-5
c. Dynamical scaling of (12) with Vacuum energy changing over time. Pages 5-6
d. Application of Fjortoft's theorem and its implications / Need an embedding super structure. Pages 6-8
e. Change in energy mandated by equation (25) . What if initial energy does not go to zero and one does not have initial radius $R_{initial} \to 0$? Pages 8-9
f. If one sets initial radius $R_{initial} \to 0$, a rethinking of assumptions is needed. Pages 9- 12
g. Conclusion. Does it make sense to talk of vacuum energy if $R_{initial} \neq 0$ is changed to $R_{initial} \to 0$? Only answerable if an embedding super structure is assigned. Pages 12-13
h. Bibliography, Pages 13-14

The summary to this document is that if an embedding structure beyond 4 dimensions is assumed for the universe, then vacuum energy may be retrievable. Otherwise, there is a huge problem.

3. Mach's Principle as initially stated, in EW to present day era. Preserving Planck's constant

We first of all review an earlier proposed Mach's 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 [2]. 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 conservation. I.e. the amount of information stored in the left hand side of (1) is the same as 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 radius.Where as the Right hand side is for M for gravitons (not super partner objects) = N as the (number of gravitons) and m (the ultra low mass of the graviton) in the right hand side of (1) This formular (1) should be compared with a change in entropy formula given by Lee [3] about the inter relationship between energy, entropy and temperature as given by

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

Lee’s formula is crucial for what we will bring up in the latter part of this document. Namely that changes in initial energy could effectively vanish if [1] is right, i.e. Stoica removing the non pathological nature of a big bang singularity.

If the mass m, i.e. for 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 [4] as to the Roberson Friedman Lematrie Walker universe which may tell us about the quinessence behavior of the vacuum energy. What will determine the answer to this question is if $\Delta E_{initial}$ goes to zero if $R_{initial} \to 0$ which happens if there is no minimum distance mandated to avoid the pathology of singularity behavior at the heart of the Einstein equations.

4. Examination of Mitra’s [4] formation of mass, energy and its possible effects on the cosmological ‘contant’ vacuum energy.

The prior result was to state that Avession’s [5] 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 Mitra [4] and is adapted to what Beckwith did with the Machian universe relations [1] as given in (1) to (3) above. Mitra [4] in Lieu of working with a FRLW universe, wrote

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

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

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

and the author put in, subsequently the following scaling factors

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

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

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

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

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

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

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

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

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

Question to ask is as follows. I.e. look at what the author derived

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

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)? Note that $M \sim (\beta + H) \cdot (a \cdot r)^3$ will be used in the latter part of the manuscript to argue for some critical re thinking if the initial space-time radius can be safely set as $R_{initial} \to 0$

Arguments on this issue will be presented next. The general scaling we will be remarking upon goes as follows.

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

Keep in mind that this formula (12) is an adoption of Mitra's formalism in his article [4] based upon $R = a(t) \cdot r(t)$, whereas $R_{initial} \to 0$ refers to a general collapse of space-time at the heart of the singularity in a non pathological fashion as given by [1]. The coefficents β and H are the author' adoptation as to dynamical scaling as given by

$$\begin{aligned} a(t) &= a_0 \exp(H \cdot t) \\ r(t) &= r_0 \exp(\beta \cdot t) \end{aligned} \tag{13}$$

The coefficients denoted by a_0 and r_0 are for initial very tiny values at the start of inflation. Note that in the choice of a_0 and r_0 we are not adopting the initial radius $R_{initial} \to 0$ convention initially, but are assuming the standard Planck radii convention of a grid of ~ $10^{-33} cm$

5. Dynamical scaling of (12) with Vacuum energy changing over time.

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 another Mitra definition as to density due to a vacuum energy [4]

$$\rho_{\bullet} = \frac{\Lambda}{8\pi} \tag{13a}$$

We then make the assumption that

$$\Lambda_{Today} \sim \Lambda_{EW} \exp(-H_{EW} \cdot t|_{Today}) \tag{13b}$$

Also, we define, for the sake of convention a starting point for (13a) as an adoptation of [4]

$$\rho_{\bullet}|_{initial} = \frac{\Lambda_{EW}}{8\pi} \tag{13c}$$

(13c) is chosen as being the value for energy density at the start of the electroweak regime, when quarks first form so 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}

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 electroweak, 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] by Ng, (15) and (16) are a way of fixing the early electroweak entropy as $\sim 10^{50} \mathrm{vs} 10^{88}$ today. As stated before, 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, electroweak era, with the mass of a present day tiny mass graviton. This is a by product of (12) above. As stated before, 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}

6. Application of Fjortoft's theorem and its implications / Need an embedding super structure.

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 [4]

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

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 [4]

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

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, so we state it below:

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 [7] 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

To do this, we will look at Padamanabhan [8] and his construction of (in Dice 2010) of thermodynamic potentials he used to have another construction of the Einstein GR equations. To start, Padamanabhan [8] 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

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

So happens that in terms of looking at the partial derivative of the top (22) 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 [9]. Also note that the reason for the failure for (24) to be congruent to (20) is due to

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

What (25) tells us is that there is an embedding structure for early universe geometry, some of which may take the form of the following diagram.

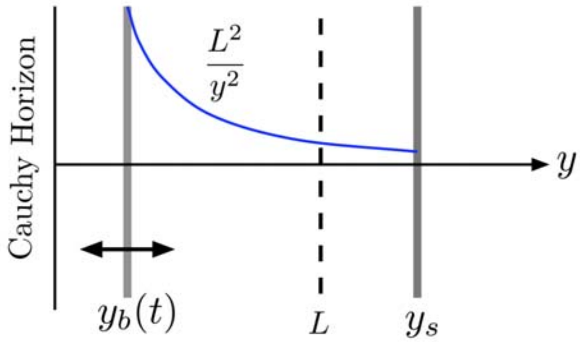

Figure 1, from [10], [11]

7. Change in energy mandated by equation (25) . What if initial energy does not go to zero and one does not have initial radius $R_{initial} \to 0$?

A rough approximation as to using at the start of time evolution is to have (25) as re set to

$$\left[\frac{\partial^2 U}{\partial\left(\eta^a\right)^2} = T_{aa} + \lambda\left(x\right) g_{aa}\right] \neq 0,\ for \forall\, \eta^a_* choices \tag{26}$$

$$T_{aa}\big|_{a=0} \sim E$$

The term in the initial time step is a way of specifying an input energy which is not zero. i.e.

$$T_{aa}\big|_{a=0} \sim E \neq 0 \tag{27}$$

If E goes to M with the speed of light c set as unity, then by adaptation of what was given by Mitra [4] we find that

$$\dot{M} = 4\pi\rho R^2 \dot{R}\big|_{c=1 \Leftrightarrow E=M} \propto \frac{\Delta E_{initial}}{\Delta t} \approx 4\pi\rho\left(R_{initial}\right)^2 \frac{\Delta R_{initial}}{\Delta t} \tag{28}$$

i.e. looking at a beginning situation with a crucial parameter $R_{initial}$ even if the initial time step is “put in by hand”.

$$\Delta E_{initial} \approx 4\pi\rho\left(R_{initial}\right)^2 \Delta R_{initial} \tag{29}$$

8. If one sets initial *radius* $R_{initial} \to 0$, a rethinking of assumptions is needed

Everything depends upon the parameter $R_{initial}$ which can go to zero. The choice as to $R_{initial}$ going to zero, or not going to zero will be conclusion of our article. $R_{initial}$ set as zero leads to no initial energy fluctuation., and likely also, but as yet to be proved

$$\begin{aligned}&\Delta E_{initial} \approx 4\pi\rho\left(R_{initial}\right)^{2}\Delta R_{initial} \Leftrightarrow E_{initial} \approx 0\\ &if \quad R_{initial} \equiv 0\end{aligned} \tag{30}$$

We have to look at what (29) tells us, even if we have an initial time step for which time is initially indeterminate, as given by a redoing of Mitra's g_{00} formula [4] which we put in to establish the indeterminacy of the initial time step if quantum processes hold.

$$\left(g_{00} = \exp\left[\frac{-2}{1+\left(\rho(t)/p(t)\right)}\right]\right) \xrightarrow[\rho+p=0]{} 0 \tag{31}$$

Stoica [1] recently came up with work which eliminates the pathology of the big bang sinularity. I.e. there is, if [1] is right no reason to stop the initial radisu $R_{initial} \to 0$ if there is no singularity castastrophe at the source of the big bang itself. Furthermore, if Stoica is correct, then one has

$$\Delta E = T_U \cdot \Delta S = \frac{\hbar \cdot a}{2\pi \cdot c \cdot k_B} \cdot \Delta S \xrightarrow[\Delta E \quad initial \to 0]{} 0 \tag{32}$$

i.e. no change in initial entropy, which is a matter of information which may have been transferred from a prior era to today.

More importantly, we could have yet another strange situation $if \quad R_{initial} \equiv 0 \Leftrightarrow E = 0$

$$\begin{aligned}&\left[\frac{\partial^2 U}{\partial\left(\eta^a\right)^2} = T_{aa} + \lambda(x)\, g_{aa}\right] = 0, if\\ &T_{aa}\big|_{a=0} \sim E \xrightarrow[R\to 0]{} 0\end{aligned} \tag{33}$$

i.e. in the beginning there would always be a zero 2nd derivative value for the U , but this would mean no change in the rate of change of the thermodynamic state for U, i.e. no inflection point , and other pathologies. If

$$\left[\frac{\partial^2 U}{\partial\left(\eta^a\right)^2} = T_{aa} + \lambda\left(x\right) g_{aa}\right] \neq 0, if \qquad (34)$$
$$T_{aa}\Big|_{a=0} \sim E \xrightarrow[R\to 0]{} const.$$

Then we have no change in entropy.i.e. if one believes the Ng infinite quantum statistic treatment [12], (34) seems to indicate there would be no particle production, since $S \sim n$, i.e. the situation would be unphysical sicne [12] sets entropy as proportional to a particle count. .

More importantly, [13] as in space-time lattice construction would completely break down. The Planck minimum length is essential for lattice guage theory to work.

Also in another parallel development at the origin of a singuarity in the big bang in terms of quantum measures, one has the odd situation for which the sum rule in particular which in its creation uses disjoint sets, in an interval [13]

$$\mu_V\left(\bigcup_{i=1}^{n}\alpha_i\right) = \sum_{i=1}^{n}\mu_V\left(\alpha_i\right) \qquad (33)$$

Eq. (33) will break down if there is no length, or specified interval. The reason for that break down is that there is nothing to measure, at a perfect point of space-time. And if there is a break down in (33) then what was said for (12) becomes a statement of no initial mass / matter-energy in the beginning.

More to the point, we should look at the nonphysical situation developing if there is a nonpathological singularity in Einstein's equation [1]. This problem becomes acute if one has an initial radius vanishing and also zero intial matter-energy states in space-time.

$$(a\cdot r) \sim \left[\frac{M}{\left(\beta + H\right)}\right]^{1/3} \Leftrightarrow M \sim \left(\beta + H\right)\cdot\left(a\cdot r\right)^3 \qquad (34)$$
$$\Leftrightarrow M_{initial} \sim \left(\beta + H\right)\cdot\left(a\cdot r\right)^3 \xrightarrow[r\to 0]{} 0$$

This is a contradiction in all sorts of levels. The foundations of information exchange, changes in the vacuum energy and creation of information which may be at the heart of appear to be held hostage by if we pick an initial radius $R_{initial} \to 0$. If [1] is correct, and the initial radius due to [1] so that $R_{initial} \to 0$ has no physical pathology created , then the entire program of quinessence, and of how matter can be built up from initial space-time may have to be singnificantly be redone. However, if $R_{initial} \neq 0$ then the entire loop quantum gravity community, and also [14] are not affected, i.e. the Planck minimum length proposal goes without saying.

Note, also, if $R_{initial} \equiv 0 \Leftrightarrow E \neq 0, but\, \Delta E = 0$

$$M_{\ initial} \neq (\beta + H)\cdot(a\cdot r)^3, M_{\ initial} \xrightarrow[r\to 0]{} const \tag{35}$$

It would mean that then, if [1] were correct one would have an infinite mass at a singular point. This equation (35) result seems to be impossible. Also, (35) means that there would be no change in entropy, which is contradicted by experimental cosmology.

Safest then to work with $R_{initial} \neq 0$ but that may not be how nature works.

9. Conclusion. Does it make sense to talk of vacuum energy if $R_{initial} \neq 0$ is changed to $R_{initial} \to 0$? Only answerable if an embedding superstructure is assigned. Otherwise no.

The adaptation of the Mitra [4] relation for mass as given by (19) presupposes that there is a well defined nonzero initial radius for cosmological evolution, and that section 8 above outlines the pathologies which may ensue if the initial radius $R_{initial} \neq 0$ is changed to $R_{initial} \to 0$. We summarize what may be the high lights of this inquiry leading to the present paper as follows.

a. One could have the situation if $R_{initial} \to 0$ of an infinite point mass, if there is an initial nonzero energy in the case of just four dimensions and no higher dimensional embedding even if [1] goes through verbatim. The author sees this as unlikely. But is prepared to be wrong. The infinite point mass construction is verbatim if one assumes a closed universe, with no embedding superstructure. Note this appears to nullify the parallel brane world construction as given by Figure 1. The author, in lieu of the manuscript sees no reason as to what would perturb this infinite point structure, so as to be able to enter in a big bang era. In such a situation, one would not have vacuum energy.

b. The most problematic scenario. $R_{initial} \to 0$ and no initial cosmological energy. I.e. this in a 4 dimensional closed universe. Then there would be no vacuum energy at all.initially. A literal completely empty initial state, which is not held to be viable by Volovik [17].

c. One could have the situation if $R_{initial} \to 0$ of a four dimensional structure, embedded in nonzero valued higher dimensions. The embedding may then allow for a nonzero vacuum energy in line with (13c) .I.e. then vacuum energy in the form of an enbedding of energy after $R_{initial} \to 0$ as given by (13c) could commence. The question then would be though, what perturbed the initial system? I.e. one would have a non closed 4 dimensional universe, perturbed by a larger structure, maybe akin to figure 1 above.

d. To answer this question as to the nature of vacuum energy if $R_{initial} \to 0$ in four dimensions leads to asking if the universe is embedded in a higher dimensional structure. If it is **not** embedded in a higher dimensional structure, as given by Figure 1, then $R_{initial} \to 0$ may mean no vacuum energy at all. If it is embedded in a higher dimensional structure, and not just a four space continuum, then a formulation like (13c) may still hold.

e. Our conclusion is that if Figure 1 above, and a higher dimensional embedding of 4 dimensional space-time exists then $R_{initial} \to 0$ would not preclude vacuum energy being formed as given by (13c). **The final question as seen by the author is, first of all, is Planck length actually necessary? If not, is $R_{initial} \to 0$ occuring in 4 dimensions which maybe embedded in higher dimensions in Figure 1's setting?**

f. <u>How these questions are answered will affect the survival of vacuum energy in a cosmology model.</u>

The rest of the remarks in this section should be thought of as consequences of the first six conclusions written above.

g. We should note that the brane-antibrane picture in figure 1 is actually more in tune with [15], [16] but that relic gravitational waves produced in such a model are extremely weak, but presumably still detectable in the advent of further advances in detector technology. This presence of weak but nonzero relic gravitational waves as opposed to where there may be no relic GW (gravity waves) at all. if one is wishing to make a linkage between DE (dark energy) and vacuum energy as [17] proposes, and then further make the connection between DE and gravitons, as was done in [18].

h. Finding that additional dimensions are involved, than just 4 dimensions may give credence to the authors speculation as to initial degrees of freedom reaching up to 1000, and the nature of a phase transition from essentially very low degrees of freedom, to over 1000 maybe in fact a chaotic mapping as speculated by the author in 2010 [19].

i. What the author would be particularly interested in knowing would be if actual semiclassical reasoning could be used to get to an initial prequantum cosmological state. This would be akin to using [20], but even more to the point, using [21] and [22] , with both these last references relevant to forming Planck's constant from electromagnetic wave equations. The author points to the enormous Electromagnetic fields in the electroweak era as perhaps being part of the background necessary for such a semiclassical derivation, plus a possible Octonionic space-time regime, as before inflation flattens space-time, as forming a boundary condition for such constructions to occur[23]

The relevant template for examinging such questions is given in the following table 1 as printed below.

TABLE 1

.Time Interval	Dynamical consequences	Does QM/WdW apply?
Just before Electroweak era	Form $\hbar$ from early E & M fields, and use Maxwell's Equations with necessary to implement boundary conditions created from change from Octonionic geometry to flat space	NO
Electro-Weak Era	$\hbar$ kept constant due to Machian relations	YES Use (1) as linkage
Post Electro-Weak Era to today	$\hbar$ kept constant due to Machian relations	YES Wave function of Universe

In so may words, the formation period for $\hbar$ is our prequantum regime. This table 1 could even hold if $R_{initial} \to 0$ but that the 4 dimensional space-time exhibiting such behavior is embedded in a higher dimensional template as given in Figure 1.

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