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Adiabaticity Violated Not Enough: Presume Primordial Black Holes to Generate Gravitons for Cosmological Constant, as Candidate for DE Initially

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Abstract

Instant preheating as given in terms of window where adiabaticity is violated is a completely inefficient form of particle production if we use Padmandabhan scalar potentials. This necessitates using a very different mechanism for early universe gravition production as an example which is to break up the initial "mass" formed about 10^{60} times Planck mass into graviton emitting 10^5 gram sized micro black holes. The mechanism is to assume that we have a different condition than the usual adiabaticity idea which is connected with reheating of the universe. Hence, we will be looking at an earlier primordial black hole generation for generation of gravitons.

Keywords

Black Holes, Cosmological Constant, Universe Gravition

1. Start off with the Following from [1] [2] with an Assumed Value as Stated

$$\begin{aligned}
&a(t) = a_{\text{initial}} t^{\nu} \\
&\Rightarrow \phi = \ln\left(\sqrt{\frac{8\pi G V_0}{\nu \cdot (3\nu - 1)}} \cdot t\right)^{\sqrt{\frac{\nu}{16\pi G}}} \\
&\Rightarrow \dot{\phi} = \sqrt{\frac{\nu}{4\pi G}} \cdot t^{-1} \\
&\Rightarrow \frac{H^2}{\dot{\phi}} \approx \sqrt{\frac{4\pi G}{\nu}} \cdot t \cdot T^4 \cdot \frac{1.66^2 \cdot g_*}{m_P^2} \approx 10^{-5}
\end{aligned} \tag{1}$$

This of course makes uses of

$$H = 1.66\sqrt{g_*} \cdot \frac{T_{\text{temperature}}^2}{m_P} \tag{2}$$

We will make the following calculation [3] [4] where we start off with [3], page 19 that:

Whereas

$$V_0 = \left(\frac{0.022}{\sqrt{qN_{\text{efolds}}}}\right)^4 = \frac{\nu(\nu-1)\lambda^2}{8\pi G m_P^2} \tag{3}$$

We can then set the coefficient λ as a dimensionless parameter which can be calculated by Equation (3).

Whereas we will look at from [4] how to obtain a bound on the inflaton via what is in page 125

$$\begin{aligned} &-\sqrt{\frac{\dot{\phi}}{\breve{g}}} \le \phi \le \sqrt{\frac{\dot{\phi}}{\breve{g}}} \\ &\Rightarrow -\sqrt[4]{\frac{\nu}{4\pi\breve{g}^2 G t^2}} \le \sqrt{\frac{\nu}{4\pi G}} \cdot \left[\ln\left(\sqrt{\frac{4\pi G V_0}{\nu\cdot(3\nu-1)}} \cdot t\right)\right] \le \sqrt[4]{\frac{\nu}{4\pi\breve{g}^2 G t^2}} \end{aligned} \tag{4}$$

Whereas from [4] and its page 125 there is a number, per unit volume a production of χ particles

$$n_\chi \approx \left(\breve{g}\left|\dot{\phi}\right|\right)^2 \equiv \breve{g}^2 \cdot \frac{\nu}{4\pi G} \cdot \frac{1}{t^2} \tag{5}$$

2. Start off $\breve{g}^2$ and Time *t* Values Picked for Equation (5) for pre Heating Particle Production? We See Almost No Particle Production This Way via the Mechanism of "Particle Density"

$$\sqrt{\frac{4\pi G V_0}{\nu\cdot(3\nu-1)}} \cdot t \equiv e^1 \Leftrightarrow t \equiv \sqrt{\frac{\nu\cdot(3\nu-1)}{4\pi G V_0}} \approx \frac{qN_{\text{efold}}}{0.022^2}\sqrt{\frac{\nu\cdot(3\nu-1)}{4\pi G}} \tag{6}$$

$$n_\chi \approx \left(\breve{g}\left|\dot{\phi}\right|\right)^2 \equiv \breve{g}^2 \cdot \frac{\nu}{4\pi G} \cdot \frac{1}{t^2} \approx \breve{g}^2 \cdot \frac{\nu}{4\pi G} \cdot \frac{0.022^4 \times 4\pi G}{\left(qN_{\text{efold}}\right)^2 \times \nu\cdot(3\nu-1)} \tag{7}$$

The smaller time is, the more the value of the initial particle generation is, per volume. *i.e.* if this means that we have a large N(effective) value, it means that there are almost no particles generated. The N(eff) refers to the number of e folds for inflation. Meaning that there would be almost NO particles generated per unit time INITIALLY by the mechanism of Pre Heating.

3. What Would Be a Way to Generate Particles? Decay of the Inflaton?

Again going to [4], if we look at the decay product for inflaton by use of a formula given in page 118

$$\Gamma \approx \left(\frac{\tilde{m}}{m_p}\right)^2 \cdot \tilde{m} \approx \left(\frac{10^2}{10^{-5}}\right)^2 \cdot 10^2 \approx 10^{16} \tag{8}$$

Here, we would be interpreting m as being the mass of the inflaton. In this case, the Corda value given in [5] The normalization of mass, would be in terms of the Planck units, with the mass of Planck's mass normalized to 1 and the value of m in Equation (8) would then be in terms of a number times Planck mass, meaning that Equation (8) would then be a numerical value

The value would then be if we are looking at Planck units, as given in [5] for $\tilde{m}$ a value of about 10^2 grams, for the presumed mass of an inflaton field whereas Planck mass would be about 10^{-5} grams

Meaning per unit time a value of 10^{16}

This is an ENORMOUS decay rate, and it presumes an inflaton mass of about 10^2 grams, as given in [5]. Since we do not know WHAT m is exactly, we would have to look at a different mechanism for a value of m which would perhaps tie in with other mechanisms for decay and primordial mass than the inflaton

4. Use of Primordial Black Holes Assumed to Be of Greater than or Equal to Planck Mass in Initial Configuration

This is from [6] and we quote it exactly.

quote

Why we consider BECs and Equation (10), *i.e.* if there is a break up of massive black holes into say Planck mass sized black holes, as or about the Planck era, very likely will not have a surviving signal which has a chance of being measurable in the CMBR data. *I.e.* the discussion of Equation (2) below uses the device of having BEC condensation in gravitons for masses up to about 10 grams or so, and in doing so a dodge as to getting entropy counts per black hole.

That is after the black hole masses, as given in Equation (10) are likely built up by the consolidation of two mini black holes going through an inspiral collapse, as has been modeled in GW

$$\begin{aligned}
m &\approx \frac{M_P}{\sqrt{N_{\text{gravitons}}}} \\
M_{BH} &\approx \sqrt{N_{\text{gravitons}}} \cdot M_P \\
R_{BH} &\approx \sqrt{N_{\text{gravitons}}} \cdot l_P \\
S_{BH} &\approx k_B \cdot N_{\text{gravitons}} \\
T_{BH} &\approx \frac{T_P}{\sqrt{N_{\text{gravitons}}}}
\end{aligned} \tag{9}$$

Here, the first term, m, is in the effective mass of a graviton. This is my take as to how to make all this commensurate as to special relativity.

$$m \approx \frac{m_g}{\sqrt{1-\left(\frac{v_g}{c}\right)^2}} \approx \frac{M_P}{\sqrt{N_{\text{gravitons}}}} \approx 10^{-10}\ \text{grams} \tag{10}$$

The effective mass of a graviton so discussed is due to the huge acceleration of the massive graviton. Mainly the effective mass would be 10^{55} times greater than the rest mass, of 10^{-65} grams and this is using [7] [8]

$$\therefore N_{\text{gravitons}} \approx 10^{10} \tag{11}$$

With this, if say one has a 1 gram black hole, about 10^5 times larger than a Planck mass, one would be having say an entropy generated this way of about 10^{10}, assuming Planck normalization and we are counting massive acceleration of a heavy graviton mass.

This is assuming massive acceleration of heavy gravity, as to have 10^{10} gravitons for a 10^5 gram mini black hole. According to the ideas presented it would then entail 10^6 mini black holes formed.

Equation (11) above would be for a single black hole, and if we take into account, 10^6 initial primordial black holes, we would be seeing

$$N_{\text{net}} \approx (\text{number black holes}) \times N_{\text{graviton}} \approx 10^6 \times N_{\text{graviton}} \approx 10^{16} \tag{12}$$

Doing so would mean that we would have say Equation (12) commensurate with Equation (8).

How could we interpret this? Easiest way would be that the decay rate as in Equation (8) is over a specified time interval and that the production of gravitons would be the decay rate leading to particle production of gravitons *i.e.* the effective mass would be about 10^{60} times Planck mass, according to [9] whereas we would be forming 10^6 black holes, of micro sized 10^5 grams, for black holes which could then release gravitons.

5. Reconciling What We Did with [9]

The value of the initial effective mass is about 10^{55} times larger than the mass of a mini black hole of about 10^5 grams. What we did in [9] is to specify an initial effective mass roughly commensurate with the mass of the universe and what is done in this paper as to Equation (12) is to consider a much smaller mass associated with primordial black holes, say of 10^{11} grams, a shrinkage of 10^{-49} in the initial effective black hole mass generated.

The huge drop off of mass would be commensurate with the radiation of the effective mass of [9] dwarfing the primordial black hole creation regime of space-time.

6. Relationship to Energy Values, and Also the Degrees of Freedom Initially with Questions to Be Asked and Investigated

In an earlier paper, we have the following value for initial mass [9]

$$\begin{aligned} M &= \sqrt{\sqrt{g_*} \cdot \frac{1.66\hbar}{64\pi^2 m_P G^2 k_B^2}} \cdot \sqrt{\frac{t}{\gamma}} \sqrt{N_{\text{Gravitons}}} \cdot m_{\text{Planck}} \\ &\xrightarrow[\text{Planck Units}]{} \approx \sqrt[4]{g_*} \cdot \sqrt{\frac{1.66}{64\pi^2}} \cdot m_{\text{Planck}} \approx \sqrt{N_{\text{Gravitons}}} \cdot m_{\text{Planck}} \approx 10^{60} \cdot m_{\text{Planck}} \end{aligned} \tag{13}$$

The N gravitons in this calculation have Not been accelerated at nearly the speed of light and are of the effective mass for an initial configuration. This is a toy calculation in order to ascertain what the effective mass M would be potentially capable in terms of initial space time entropy. And we would be considering the mass of massive gravitons NOT accelerated at the speed of light.

The value of Equation (11) refers to the production of massive gravitons, each of which would be accelerated so drastically that we would be employing Equation (10)

What we would be doing would be in future research to confirm these details as well as giving more tie in if possible with [5] and see what could be done to give further confirmation in Planck time to this calculation in [9] with [5] as a back up

If so recall from [9]

$$\sqrt[4]{g_*} \cdot \sqrt{\frac{1.66}{64\pi^2}} \approx 10^{60} \tag{14}$$

How could this be reconciled with [5]? I would look at that one. In addition if we are looking at rest mass calcultions can make the bridge done by Novello [10] as to rest mass of a graviton, and the cosmological constant not in contradiction to [5] [9]. And this paper?

If so, by Novello [10] we then have a bridge to the cosmological constant as given by

$$m_g = \frac{\hbar \cdot \sqrt{\Lambda}}{c} \tag{15}$$

All these steps need to be combined and rationalized three different pieces.

7. Comparison with the Idea of Vacuum Energy as Brought Up by [11] Cheng

In a [11] Cheng on page 272-273

$$\begin{aligned} \rho_\Lambda c^2 &= \frac{E_\Lambda}{V} \approx \frac{1}{2} \cdot \int_0^{E/c} \sqrt{p^2c^2 + m^2} \cdot \frac{4\pi p \mathrm{d}p}{(2\pi\hbar)^3} \approx \frac{E^4}{16\pi^2 \cdot (\hbar c)^3} \\ &\xrightarrow[E=E_P]{} \frac{\left(3\times 10^{27}\ \mathrm{eV}\right)^4}{(\hbar c)^3} \end{aligned} \tag{16}$$

Whereas if we scale the actual vacuum energy value, the numerator is so

$$\rho_\Lambda c^2 \approx \frac{\left(3\times 10^{27}\ \mathrm{eV}\right)^4}{(\hbar c)^3} \xrightarrow{\text{Critical density}} \frac{\left(2.5\times 10^{-3}\ \mathrm{eV}\right)^4}{(\hbar c)^3} \tag{17}$$

In other words, we see energy of about 10^{-30} smaller so then we have to look at what would cause it.

To do this consider say what if we had graviton production so that

$$\begin{aligned} &E(\text{field theory}) \approx m_p \approx 10^{-5}\ \mathrm{g} \approx 10^{27}\ \mathrm{eV} \\ &E(\text{vacuum meas}) \approx 10^{-35}\ \mathrm{g} \approx 10^{-5}\ g \approx 10^{-3}\ \mathrm{eV} \\ &E(\text{gravion rest}) \approx 10^{-65}\ \mathrm{g} \approx 10^{-33}\ \mathrm{eV} \end{aligned} \tag{18}$$

Assume then that what is involved is say 10^{10} gravitons, and then when we do the acceleration of gravitons to nearly the speed of light, we have say a generated relativistic increase due to relativistic mass of about 10^{10} from the rest mass initially for a massive graviton.

We could say presume that we have 10^4 small black holes, meaning a release of about a million gravitons being released per black hole. In primordial space time in order to form DE/Cosmological constant.

The idea is that the 10^4 number of small initial black holes may be enough to give initial formation of DE via a cosmological constant.

Keep in mind that in Equation (8) we were thinking of a much larger number of black holes, namely 10^{16} for the total decay of the inflaton.

The difference between 10^4, in terms of essential black holes needed to form a cosmological constant, and DE, and the figure 10^{16} number of black holes being generated by the TOTAL decay of the inflaton means that DE would be generated after 10^4 black holes, WELL before 10^{16} black holes created by the decay of the inflaton *i.e.* this would be similar in effect to the value of a large number of primordial black holes being released as given by the Starobinsky model [12] [13].

Our model is a bit different but we agree to a point with the start of their hypothesis. Keep in mind that this is in tandem with [8] for a rapid dissemination of gravitons as given in [8] from extremely small micro black holes.

8. Conclusions: An Open Question Here. Can the Holographic Model of DE Provide Additional Insight?

In [14] we have that as given on page 201 that we have a holographic DE model given by [15] with $\hat{c}$ defined in [15]

$$\rho_{de} \equiv 3\hat{c}^2 m_p^2 L^{-2} \tag{19}$$

Where the variable L is defined by

$$L = 1/R_b \tag{20}$$

And R_b is the so called future event horizon defined by

$$R_b = a \cdot \int_a^{\infty} \frac{\mathrm{d}a}{Ha^2} \tag{21}$$

This would yield an equation of state given by

$$\omega_{de} = -\frac{1}{3} - \frac{2}{3} \cdot \frac{\sqrt{\Omega_{de}}}{\hat{c}} \leq -\frac{1}{3} \tag{22}$$

The author, myself, would take some variant of this argument, *i.e.* an application, with suitable modifications of the Holographic model, in order to ascertain the reasons for the formation of DE say with 10^4 micro black holes as suggested in the above discussion for the formation of a cosmological constant, and use that to reconcile the figure of 10^4 black holes in order to form DE via the cosmological constant as separate from the figure of 10^{16} done for black hole production created by the decay of the inflaton in a complete sense.

Doing that would allow for making sense of early universe conditions and also tie in with additional review and checks upon the Corda hypothesis given in [5].

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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