Adiabaticity being violated as a condition for generation of primordial particles not enough: We presume afterwards primordial black holes to generate gravitons for detection

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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

I. Start off with the following from [1] [2] with an assumed value as stated

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

This of course makes uses of

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

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

Whereas

$$
V_0 = \left(\frac{.022}{\sqrt{q N_{efolds}}}\right)^4 = \frac{\nu(\nu - 1)\lambda^2}{8\pi G m_P^2} \tag{3}
$$

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

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

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

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

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

II. Start off $\breve{g}^2$ and time t values picked for Eq. (5) for pre heating particle production? We see almost NO particle production this way via the mechanism of “particle density”

$$\sqrt{\frac{4\pi G V_0}{\nu \cdot (3\nu - 1)}} \cdot t \equiv e^1$$
$$\Leftrightarrow t \equiv \sqrt{\frac{\nu \cdot (3\nu - 1)}{4\pi G V_0}} \approx \frac{q N_{efold}}{(.022)^2} \sqrt{\frac{\nu \cdot (3\nu - 1)}{4\pi G}} \qquad (6)$$

$$n_\chi \approx \left(\breve{g} \left| \dot{\phi} \right| \right)^2 \equiv \breve{g}^2 \cdot \frac{\nu}{4\pi G} \cdot \frac{1}{t^2} \approx \breve{g}^2 \cdot \frac{\nu}{4\pi G} \cdot \frac{(.022)^4 \times 4\pi G}{\left(q N_{efold} \right)^2 \times \nu \cdot (3\nu - 1)} \qquad (7)$$

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.

III. 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

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

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 Eq. (8) would then be in terms of a number times Planck mass, meaning that Eq., (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

IV. 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 Eq. (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 Eq. (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 Eq. (10) are likely built up by the consolidation of two mini black holes going through an inspiral collapse, as has been modeled in GW

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

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.

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

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]

$$\therefore N_{gravitons} \approx 10^{10} \quad (11)$$

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

Eq (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

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

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

How could we interpret this ? Easiest way would be that the decay rate as in Eq. (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

V. 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 Eq. (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

VI. 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]

$$M = \sqrt{\sqrt{g_*} \cdot \frac{1.66\hbar}{64\pi^2 m_P G^2 k_B^2}} \cdot \sqrt{\frac{t}{\gamma}} \sqrt{N_{Gravitons}} \cdot m_{Planck}$$

$$\xrightarrow[Planck-Units]{} \approx \sqrt[4]{g_*} \cdot \sqrt{\frac{1.66}{64\pi^2}} \cdot m_{Planck} \approx \sqrt{N_{Gravitons}} \cdot m_{Planck} \quad (13)$$

$$\approx 10^{60} \cdot m_{Planck}$$

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 Eq. (11) refers to the production of massive gravitons, each of which would be accelerated so drastically that we would be employing Eq. (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]

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

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 [11] we then have a bridge to the cosmological constant as given by

$$m_g = \frac{\hbar \cdot \sqrt{\Lambda}}{c} \qquad (15)$$

All these steps need to be combined and rationalized Three different pieces

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Bibliography

[1] Sarkar, Uptal, " Particle and Astroparticle Physics", Taylor and Francis, 2008, New York City, New York, USA

[2] Padmanabhan, Thanu, "An Invitation to Astrophysics", World Press Scientific, World Scientific Series in Astronomy and Astrophysics: Volume 8, Singapore, Republic of Singapore, 2006

[3] Li Baojiu, Koyamja Kazuya, "Modified Gravity" , World Scientific, Hakensack New Jersey, USA, 2020

[4] Dimopoulos , Konstrantinous, " Introduction to Cosmic inflation and Dark Energy" , CRC press, Boca Raton, Florida, USA, 2021

[5] Corda, Christian, "**Primordial gravity's breath", https://arxiv.org/abs/1110.1772**

[6] Beckwith, A.W. (2021) Does the Penrose Suggestion as to Black Holes from a Prior Universe Showing Up in Today's Universe Have Credibility? Examined from a Singular, and Nonsingular Beginning of Cosmological Expansion. Journal of High Energy Physics, Gravitation and Cosmology, 7, 149-171

[7] P.H. Chavanis, " Self Gravitating Bose-Einstein Condensates", pp 151-194, of Quantum Aspects of Black Holes, with Xavier Calmet, Editor, of Fundamental Theories of Physics, 178, Springer Nature, Cham, Switzerland, 2012

[8]Calmet, Xavier, Carr, Bernard, Wityhstanley, Elizabeth, "Quantum black holes", Springer briefs in physics Springer Verlag, New York City, New York, 2014

[9] Beckwith, Andrew ," How Initial Degrees of Freedom May Contribute to Initial Effective Mass", https://vixra.org/abs/2209.0144

[10] Novello, M. ; "The mass of the graviton and the cosmological constant puzzle", **https://arxiv.org/abs/astro-ph/0504505**