"Graviton Gas", at start of Pre Planckian to just before Planckian regimes, suggesting gravitational quantum pressure

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Abstract

Using particle density' of a 'graviton gas. For volume in space time for showing pressure formation. The radius would be, r(t) approximately Planck length, whereas the change in ΔM would be a decrease from the mass, M of the black holes, Pre Planck (very large), to the tiny micro sized black holes of the order of Planck mass, i.e. a down grading of mass from about 10^60 grams to say 10^5 grams with millions of micro black holes, Plank mass or above

Keywords: *graviton gas, entropy*

I. Intechopen article by Beckwith pre supposes a Pre Planckian space-time regime. We will use this as a starting point for our analysis

In [1] the author in use of degrees of freedom offers a background as to how one could have pre Planckian space-time. We refer to this instinctively as a start to the issue of how to consider the generation of entropy,. Next , [2] refers to what we will be examining, mainly what if our starting point to expansion of the Universe presumed a NEGATIVE energy. Why is this important ? Rosen obtained a miniuniverse commensurate with this idea, and how we examine entropy will largely draw upon this idea.Third, the work horse of our ideal depends upon Bose Einstein condensation, as in [3] where we could have Gravitons as Bose "particles".

, What we are doing is to use what is called BEC , Bose Einstein condensation, in the onset of inflation far before the creation of "monopole fields".

II. Going to using Bose Einstein condensation link

Finally we use [3] page 157 for pressure

$$P = \frac{2\pi a\hbar^2 \rho}{m^3} \quad (1)$$

If [4][5] used for mass of a graviton, as 10^-60 Planck mass,

$$m = 10^{-60} m_P \quad (2)$$

And we set

$$P = P_0 \cdot \exp\left[-r / \beta\ell_P\right] \quad (3)$$

It now leads to

III. USING BEC again due to [3]

Here we go to using the scaling used for BEC for primordial black holes[3] page 181

And use only

$$\begin{aligned} M_{BH} &\approx \sqrt{N_{gravitons}} \cdot m_P \\ S_{BH} &\approx k_B \cdot N_{gravitons} \end{aligned} \quad (4)$$

IV. And this! Conclusion !

Table 1 from[6] assuming Penrose recycling of the Universe as stated in that document

End of Prior Universe time frame	Mass (black hole) : super massive end of time BH 1.98910^+41 to about 10^44 grams	Number (black holes) 10^6 to 10^9 of them usually from center of galaxies
Planck era Black hole formation Assuming start of merging of micro black hole pairs	Mass (black hole) 10^-5 to 10^-4 grams (an order of magnitude of the Planck mass value)	Number (black holes) 10^40 to about 10^45, assuming that there was not too much destruction of matter-energy from the Pre Planck conditions to Planck conditions
Post Planck era black holes with the possibility of using Eq. (1) to have say 10^10 gravitons/second released per black hole	Mass (black hole) 10 grams to say 10^6 grams per black hole	Number (black holes) Due to repeated Black hole pair forming a single black hole multiple time. 10^20 to at most 10^25

V. MY SIMPLE QUANTUM PRESSURE MODEL which will be heavily amended

[7] on page 109 has a simple model based on GR for a change in "mass" leading to pressure It is

$$\dot{M}(t)c^2 = -4\pi p_v(t)\left[r(t)\right]^2 \dot{r}(t) \qquad (5)$$

Here we are assuming as a simplification that $p_v(t) \xrightarrow[INITIAL-CONDITIONS]{} P_0$ for pressure. This is going to lead us to re interpret the mass term $\dot{M}$ Now using [7] we can assume if the surviving effective "mass " is represented in Table 1, with surviving mass in the Pre Planckian to Planckian regime massive gravitons that according to [7] , there would be an effective velocity of if $\hbar = c = 1$ on page 89 of[7]

$$v(\omega) = \sqrt{1 - \frac{m^2}{\omega^2}} \qquad (6)$$

In terms of gravitons if they have a mass of 10^-65 grams, and a frequency of say 10^9 GhZ this means we can write

$$v(\omega) = \sqrt{1 - \frac{m^2}{\omega^2}} \approx 1 - \xi^+$$

Now make the following substitution

$$\dot{M} = \frac{\Delta M}{\Delta t} \qquad (7)$$

Use a minimum uncertainty principle of

$$\Delta E \Delta t = \hbar \xrightarrow[\hbar \to 1]{} 1 \approx \omega \cdot \Delta t \qquad (8)$$

Then

$$\dot{M}(t) = \frac{\Delta M}{\Delta t} \equiv \Delta M \cdot \omega \approx -4\pi p_v(t)\left[r(t)\right]^2 \left(1 - \xi^+\right) \qquad (9)$$

Then to first order we can write a minimum uncertainty (QM) as

$$p_v = P_0 \equiv \frac{\left(1 + \xi^+\right)}{4\pi \cdot \left[r(t)\right]^2} \cdot \left[-\Delta M \cdot \omega\right] \qquad (10)$$

The radius would be, r(t) approximately Planck length, whereas the change in ΔM would be a decrease from the mass, M of the black holes, Pre Planck (very large) as seen in Table 1, to the tiny micro sized black holes of the order of Planck mass, i.e. a down grading of mass from about 10^60 grams to say 10^5 grams with millions of micro black holes, Plank mass or above

The details of the change in ΔM would be a decrease from the mass, M of the black holes, Pre Planck (very large) as seen in Table 1, to the tiny micro sized black holes of the order of Planck mass, await further investigation. We should before ending state that we do not expect r in Eq. (10) to ever go to zero, partly due to the arguments as to the definition of a removable singularity in [8]. Point of fact, if there is, due to [3] no conservation of energy due to table 1 and [1] and [3] I then do not see a Penrose singularity [9][10]. Also

$$U(\phi) \sim -m^2\phi^2 + \lambda\phi^4 \qquad (11)$$

Whereas there is an inflaton mass m

$$m \sim \left(\frac{\lambda}{\sqrt{2\pi^3}} T^{3/2} t^{\sqrt{2\tilde{n}}} \right)^{2/5} \qquad (12)$$

Dolgov, in [11] has an emergent value of the vacuum energy density which he gives as follows with our subsequent valuation.

Our next idea will reference the inspiration given in [12]. I.e. of a "quantum pressure"

Here we will NOT make a linkage between pressure P_0 and temperature T via applying treatment of a "graviton gas" as an ideal gas law

$$P_0 = \frac{\breve{n}\Re T}{V} \qquad (13)$$

But in doing this, we first of all need to consider how to obtain the VACCUM energy which is of the order of 10^-30. We will derive arguments for an ENORMOUS pressure value, but this is commensurate if we wish to isolate out a vaccum energy scaled to a value of about 10^-30 or so, to isolate out the value of the cosmological constant which is of the order of 10^-120 or so, which is fine tuning on steroids. Doing this means looking at:

$$\rho_{Vacuum} \sim \left({m^4}\big/{2\lambda} \right) \sim \frac{\lambda^{8/5}}{2\lambda \cdot \left(\sqrt{2\pi^3}\right)^{8/5}} \cdot \left(T^{3/2} \cdot t^{\sqrt{2\tilde{n}}} \right)^{8/5} \qquad (14)$$

And [11]

$$\begin{aligned} Z &= \iint \wp\, \phi \exp\left(-S(\phi)\right) \\ &= \iint \wp\, \phi \exp\left(-\frac{1}{T_{eff}} \int d^3x \left[\frac{(\nabla\phi)^2 - 2\mu^2 \exp\left(\phi(x)\right)}{2} \right] \right) \end{aligned} \qquad (15)$$

Then, if T is a temperature, and z is the fugacity, and m is the inflaton mass, which we will decompose:

$$T_{eff} = 4\pi G m^2 T^{-1}; \mu^2 = \sqrt{2\pi^{-1}} \cdot z \cdot G \cdot m^{7/2} \cdot \sqrt{T} \qquad (16)$$

The key element which we will be working with is, a particle density expression of [11] as

$$\left\langle \rho(r) \right\rangle = \mu^2 T_{eff}^{-1} \cdot \left\langle \exp\left(\phi(r)\right) \right\rangle \qquad (17)$$

If we use the following from Padmanabhan, [13], using the approximation of $a(t) \sim t^{\tilde{n}}$, then

$$\phi\left(r(t)\right) \sim \phi(t) \approx \sqrt{2\tilde{n} \cdot m_{Pl}} \cdot \ln(t) \simeq \ln\left(t^{\sqrt{2\tilde{n} \cdot m_{Pl}} \cdot} \right) \qquad (18)$$

$$\left\langle \rho(r) \right\rangle = \mu^2 T_{eff}^{-1} \cdot t^{\sqrt{2\tilde{n} \cdot m_{Pl}}} \propto \mu^2 T_{eff}^{-1} \cdot t^{\sqrt{2\tilde{n}}} \qquad (19)$$

We will be utilizing these first five equations, with Eq.(5) compared against results from [3] , next.

And use only the following for the production of initial black holes[3]

$$M_{BH} \approx \sqrt{N_{gravitons}} \cdot m_P$$
$$S_{BH} \approx k_B \cdot N_{gravitons} \qquad (20)$$

We shall next come up with a value for the number of Gravitons initially where we set T in our initial configuration as set equal to Planck temperature

V1. Existence of Graviton Gas? Non zero initial entropy?

We acknowledge that Glinka, in [14] pursued this idea in 2007. Our approach is fundamentally different from his, and we make use of using Eq. (13) to set the λ. As well as specify the mass of a graviton as 10^-62 grams as given in [5]. Following up upon the Ng 'infinite quantum statistics' as given by [6] so we then write, S (entropy) as ~ N (counting number), and we specify N, via

$$m \sim \left(\frac{\lambda}{\sqrt{2\pi^3}} T_{Planck}{}^{3/2} t_{Planck}{}^{\sqrt{50/32}} \right)^{2/5} \sim N_{graviton} \cdot m_{graviton}$$
$$\Rightarrow N_{graviton} \sim S(Initial - entropy) \sim \left(\frac{\lambda}{\sqrt{2\pi^3}} T_{Planck}{}^{3/2} t_{Planck}{}^{\sqrt{50/32}} \right)^{2/5} \Big/ m_{graviton} \qquad (21)$$

The value of the initial graviton mass is specified as of being 10^-62 grams, meaning that this puts a premium upon the fine tuning of the initial parameters in the numerator of Eq. (14). We hope that, if this is conclusively non zero, that it will enable CMBR style studies as as well as looking at non zero vacuum energy as given by non linear electrodynamics as in [15] and also the issue of the nature of gravity as up by Corda [16] , as far as future studies and investigations, See Appendix A as to further elaborations as to the Infinite Quantum statistics [6]brought up in this document. further developments should specifically investigate the symmetry breaking potential as written up as enabling the metric tensor approach given in .

$$N_{graviton} m_{graviton} \approx \left(\frac{\lambda}{\sqrt{2\pi^3}} T_{Planck}{}^{3/2} t_{Planck}{}^{\sqrt{50/32}} \right)^{2/5} \qquad (22)$$

For black holes, we would write

$$M_{BH} \approx \sqrt{N_{graviton}}\, m_{Planck} \qquad (23)$$

Assume for the sake of argument we restrict the number of Gravitons, as for micro sized black holes,. We then get if we write

$$N_{graviton}\Big|_{Black-hole} \approx \left(\frac{\lambda}{\sqrt{2\pi^3}} T_{Planck}{}^{3/2} t_{Planck}{}^{\sqrt{50/32}} \right)^{2/5} / \, m_{graviton} \qquad (24)$$

Then

$$
\begin{aligned}
M_{BH}\big|_{Planck} &\approx \sqrt{N_{graviton}\big|_{Black-hole}}\, m_{Planck} \\
&\approx \left(\left(\frac{\lambda}{\sqrt{2\pi^3}} T_{Planck}{}^{3/2} t_{Planck}{}^{\sqrt{50/32}} \right)^{1/5} / \sqrt{m_{graviton}} \right) \cdot m_{Planck} \\
&\equiv \left(\frac{\lambda}{\sqrt{2\pi^3}} T_{Planck}{}^{3/2} t_{Planck}{}^{\sqrt{50/32}} \right)^{1/5} 10^{65/2} \cdot \sqrt{m_{Planck}}
\end{aligned}
\tag{25}
$$

Using Planck units where we have [18][19][20]

$$
\begin{aligned}
&\ell_{Planck} = \sqrt{\frac{\hbar G}{c^3}} \\
&t_{Planck} = \sqrt{\frac{\hbar G}{c^5}} \\
&T_{Planck} = \sqrt{\frac{\hbar c^5}{G k_B}} \\
&\Rightarrow N_{graviton} m_{graviton}
\end{aligned}
\tag{26}
$$

We also write

$$
m_{Planck} = \sqrt{\frac{\hbar c}{G}} \tag{27}
$$

We can normalize all these to be 1 for which then we have

$$
\begin{aligned}
&M_{BH}\big|_{Planck} \approx \sqrt{N_{graviton}\big|_{Black-hole}}\, m_{Planck} \\
&\equiv \left(\frac{\lambda}{\sqrt{2\pi^3}} T_{Planck}{}^{3/2} t_{Planck}{}^{\sqrt{50/32}} \right)^{1/5} 10^{65/2} \cdot \sqrt{m_{Planck}} \\
&\approx \left(\frac{\lambda}{\sqrt{2\pi^3}} \right)^{1/5} 10^{65/2}
\end{aligned}
\tag{28}
$$

If this is for in the Planck regime where we have Eq. (28) equal to 10^2 times Planck mass, then this sets the λ to be then

$$
\begin{aligned}
&M_{BH}\big|_{Planck} \approx \left(\frac{\lambda}{\sqrt{2\pi^3}} \right)^{1/5} 10^{65/2} \approx 10^2 \\
&\Rightarrow \lambda \approx \sqrt{2\pi^3} \times 10^{-305/2}
\end{aligned}
\tag{29}
$$

This is an incredibly small value, and bespeaks of an almost insane level of fine tuning for the effective potential in Eq. 12 which is the symmetry breaking value. I.e. it is almost chaotic potential

Meanwhile if the following holds for vacuum density which is to the ¼ power of the Cosmological constant

$$\frac{\lambda^{8/5}}{2\lambda\cdot\left(\sqrt{2\pi^{3}}\right)^{8/5}}\cdot\left(T^{3/2}\cdot t^{\sqrt{2\tilde{n}}}\right)^{8/5}\xrightarrow{Planck-normalization}\frac{\lambda^{3/5}}{2\left(\sqrt{2\pi^{3}}\right)^{8/5}}\cdot\left((1+\varepsilon)^{\sqrt{2\tilde{n}}}\right)^{8/5}$$
$$\approx\frac{(\sqrt{2\pi^{3}}\times10^{-305/2})^{3/5}}{2\left(\sqrt{2\pi^{3}}\right)^{8/5}}\cdot\left((1+\varepsilon)^{\sqrt{2\tilde{n}}}\right)^{8/5}\approx10^{-30} \tag{30}$$

It means in this situation for a time interval that there is expansion to an almost infinite degree, which is commensurate with pressure due to black holes from the prior universe of about 10^61 grams being cut to about 10^6 grams, for say initially 10^59 gram shift in mass for change in mass in Eq. (16) so as to make the resulting pressure P_0 almost inconceivably large. Also [21] [22]should be considered as well as the simpler approaches given in [23][24][25]

In addition, a fractal law as given in [26] may be relevant right after Planckian physics

Appendix, A. Review of Ng,[6] [17] with comments.

First of all, Ng [6][17] refers to the Margolus-Levitin theorem with the rate of operations $< E/\hbar \Rightarrow \#operations < E/\hbar \times time = \frac{Mc^2}{\hbar}\cdot\frac{l}{c}$. Ng wishes to avoid black-hole formation $\Rightarrow M \leq \frac{lc^2}{G}$. This last step is not important to our view point, but we refer to it to keep fidelity to what Ng brought up in his presentation. Later on, Ng refers to the $\#operations \leq \left(R_H/l_P\right)^2 \sim 10^{123}$ with R_H the Hubble radius. Next Ng refers to the $\#bits \propto \left[\#operations\right]^{3/4}$. Each bit energy is $1/R_H$ with $R_H \sim l_P \cdot 10^{123/2}$

The key point as seen by Ng [6] [17] and the author is in, if M is the 'space-time' mass

$$\#bits \sim \left[\frac{E}{\hbar}\cdot\frac{l}{c}\right]^{3/4} \approx \left[\frac{Mc^2}{\hbar}\cdot\frac{l}{c}\right]^{3/4} \tag{1}$$

Assuming that the initial energy E of the universe is not set equal to zero, which the author views as impossible, the above equation says that the number of available bits goes down dramatically if one sets $R_{initial} \sim \frac{1}{\#} \ell_{Ng} < l_{Planck}$? Also Ng writes entropy S as proportional to a particle count via N.

$$S \sim N \cong \left[R_H / l_P \right]^2 \tag{2}$$

We rescale R_H to be

$$R_H \big|_{rescale} \sim \frac{l_{Ng}}{\#} \cdot 10^{123/2} \tag{3}$$

The upshot is that the entropy, in terms of the number of available particles drops dramatically if $\#$ becomes larger.

So, as $R_{initial} \sim \frac{1}{\#} \ell_{Ng} < l_{Planck}$ grows smaller, as $\#$ becomes larger

a. The initial entropy drops
b. The number of bits initially available also drops.

The limiting case of Eq.(2) and Eq. (3) in a closed universe, with no higher dimensional embedding is that both would almost vanish, i.e. appear to go to zero if $\#$ becomes very much larger. The question we have to ask is would the number of bits in computational evolution actually vanish?

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