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Using "Graviton Gas", Suggesting Onset of Gravitational Quantum Pressure Using Very Simple Arguments

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Abstract

Using particle density of a "graviton gas" as a spinoff of the Gross-Pitaevskii Poisson system of self-gravitating Bose Einstein condensates, this suggests quantum pressure. We use the quantum pressure suggestion linked to entropy and go to a matter of what energy levels may be suggested.

Keywords

Graviton Gas, Entropy

1. Start with 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 purports to explain how one could have pre Planckian space-time. We refer to this instinctively as a start to the generation of entropy. Next, [2] refers to if our starting point to expansion of the Universe presumed a NEGATIVE energy. Rosen obtained a miniuniverse and how we examine entropy will 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". Note that in [4], the author worked with graviton gas in order to obtain a cosmological constant. Note in [5] and [6], the idea of a graviton gas, is further elaborated via the methodology presented.

2. Going to Bose Einstein Condensation

To do this we go to page 158 of [3] which has the BEC modeled as by

$$m\cdot\Phi+\frac{4\pi a\hbar^{2}\rho}{m^{2}}-\frac{\hbar^{2}\Delta\sqrt{\rho}}{2m\sqrt{\rho}}=E \tag{1}$$

$$\begin{aligned} &\Phi \in \Re \\ &\rho = Nm \cdot \Phi^2 \\ &a \approx \ell_P \end{aligned} \tag{2}$$

Look over [4] [5] [6] for context before proceeding with the rest of the paper.

FTR

Φ is real valued, $a \approx \ell_P$ is Planck length, m is the "mass" of a "particle" *i.e.* in our case we assume it is proportional to mass of a graviton, 10^{-65} grams [6] [7] and Δ is proportional to the second spatial derivative, and N is assumed to be a counting of gravitons assumed, whereas [8].

Finally we use [3] page 157 for pressure

$$P = \frac{2\pi a \hbar^2 \rho}{m^3} \tag{3}$$

If [7] [8] used for mass of a graviton, as 10^{-60} Planck mass,

$$m = 10^{-60} m_P \tag{4}$$

And we set

$$P = P_0 \cdot \exp\left[-r/\beta \ell_P\right] \tag{5}$$

It now leads to, after con.

3. 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

$$\begin{aligned} M_{BH} &\approx \sqrt{N_{\text{gravitons}}} \cdot m_P \\ S_{BH} &\approx k_B \cdot N_{\text{gravitons}} \end{aligned} \tag{6}$$

4. First Part of Conclusion for Our Document

[9] [10] [11] [12] are recommended reading before proceeding with the rest of this document in full detail.

If we model early universe as like a bound state black hole initially, we can examine what happens if the initial [2] Rosen negative energy state moves to almost zero just before the Planckian state, in Pre Planckian physics, yielding approximately initial entropy, lf $k_B \equiv 1$ and we go from negative to almost zero initial energy.

We should keep in mind that the N in Equation (10) is due to the number of gravitons per black hole, times the number of initially created black holes.

$$\begin{aligned} S_{\text{initial}} &\approx N_{\text{gravitons}-BH} \times (\text{number black holes}) \\ &\propto \frac{P_0}{10^{60} \cdot \left(\dfrac{1}{2\beta^2} - \sqrt{P_0} \exp\left[-r/2\beta\right] \right)^2} \end{aligned} \tag{7}$$

Here:

P_0 pressure is due to the input due to [3] and [12] in what this implies due to [12]. And do review [13].

In a word quantum pressure [14].

5. My Simple Pressure Model Started by an Energy Contribution due to a Million Initial Planck Mass Sized Black Holes

First of all we do one substitution in the following set of equations [3] [12] we make a subtle change

$$
\begin{aligned}
& m \approx \frac{m_P}{\sqrt{N_{\text{gravitons}}}} \\
& M_{BH} \approx \sqrt{N_{\text{gravitons}}} \cdot m_P \\
& R_{BH} \approx \sqrt{N_{\text{gravitons}}} \cdot l_P \xrightarrow{\text{Modification}} R_{BH} \approx \sqrt{N_{\text{gravitons}}} \cdot l_P + \varepsilon^{+} \\
& S_{BH} \approx k_B \cdot N_{\text{gravitons}} \\
& T_{BH} \approx \frac{T_P}{\sqrt{N_{\text{gravitons}}}}
\end{aligned}
\tag{8}
$$

Keep all the other equations the same. If so then go to [15] and write from its page 88 where we have τ as the proper time which in our example becomes t for time. If so then using the idea of geodestics and constants of motion given there.

Begin with

$$
E^2 = \frac{-\left(1-\frac{2M}{r}\right)^3}{\left(\frac{\mathrm{d}r}{\mathrm{d}\tau}\right)^2 - \left(1-\frac{2M}{r}\right)^2} \xrightarrow{\tau \to t} \frac{-\left(1-\frac{2M}{r}\right)^3}{\left(\frac{\mathrm{d}r}{\mathrm{d}t}\right)^2 - \left(1-\frac{2M}{r}\right)^2}
\tag{9}
$$

Using [16] we can write for a single massive graviton

$$
\left(\frac{\mathrm{d}r}{\mathrm{d}t}\right)^2 = c^2 \cdot \left(1 - \frac{m_g^2}{E^2}\right)
\tag{10}
$$

If so, then and using Equations (11)-(13)

$$
E^2 \xrightarrow{c=\ell_P=\hbar=m_P\equiv 1} \frac{r}{4\sqrt{N}} \cdot \left(\frac{\left(\frac{2\sqrt{N}}{r} - 1\right)^3 - 10^{-114}}{1 - \frac{\sqrt{N}}{r}} \right)
\tag{11}
$$

If we assume this is for the early Pre Planck universe being approximately similar to a black hole, we have that if we use Equation (11) for $r = R$ (radius of a Pre Planck Black hole like state).

Simplify further and

$$
E^2 \approx \frac{1}{4} \cdot \left(\frac{\sqrt{N}}{\varepsilon^{+}} - 5 - \left(\varepsilon^{+} / \sqrt{N}\right) \cdot \left(6 + 10^{-114}\right) \right)
\tag{12}
$$

Then if $\varepsilon^{+} \to \frac{1}{6\sqrt{N}}$

$$\begin{aligned} E^{2} &\approx \frac{1}{4}\cdot\left(\frac{\sqrt{N}}{\varepsilon^{+}} - 5 - \left(\varepsilon^{+}/\sqrt{N}\right)\cdot\left(6+10^{-114}\right)\right) \\ &\xrightarrow[\varepsilon^{+}\to\frac{1}{6\sqrt{N}}]{} \frac{1}{4}\cdot\left(6-5-\frac{1}{6N}\cdot\left(6+10^{-114}\right)\right) \end{aligned} \tag{13}$$

I.e. we would be possibly be looking at per black hole an energy contribution of

$$E = \text{energy} \approx \frac{E_{\text{planck}}}{2} \tag{14}$$

Here, N as number of gravitons per black hole could be as low as 4 *i.e.* just at the start of **Table 1** with about 4 gravitons produced per black hole and initially over a million black holes, to start with.

Then the initial black hole temperature for primordial black holes would scale as high as

$$T_{BH(\text{primordinal})} \approx \frac{T_P}{2} \tag{15}$$

In this situation, we could assume that this means that the mass of a black hole would be of the order of say approximately Planck mass or about 10^{-60} the rest mass of a graviton. *i.e.* for say a million black holes, of roughly Planck mass.

Now for a matter of pressure in this situation. What we would possibly look for would be the pressure generated by about a million black holes of Planck size generating 4 gravitons each, *i.e.* about say 4 - 10 million gravitons in a very small physical space.

6. 2nd Part of Conclusion: Quantum Pressure?

We have given an argument based upon what is from Aden, Bazin and Shiffer 2nd edition page 426 [17].

Table 1. From [12] 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 1.989×10^{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 Equation (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}

$$\frac{p/c^2}{\rho} \approx \frac{1}{3} \cdot \frac{v^2}{c^2} \tag{16}$$

I.e. a simple relation of

$$p \approx \left(\frac{v^2}{3}\right) \cdot \rho \tag{17}$$

If

$$p \approx \left(1 - \frac{m_g^2}{\omega_g^2}\right) \cdot \frac{E_{\text{planck}} \times 10^6}{6 \times \left(1 + \left(\varepsilon^+ / \sqrt{N}\right)\right)^3} \tag{18}$$

With N being the number of gravitons per black hole very initially and the term E_{planck} coming from the simplest interpretation

$$\omega_{\text{GRAVITON}} \approx \frac{1}{\Delta t} \tag{19}$$

We can write

$$\begin{aligned} p &\approx \left(1 - \left(10^{-124} \times (\Delta t)^2\right)\right) \cdot \frac{E_{\text{planck}} \times 10^6}{6 \times \left(1 + \left(\varepsilon^+ / \sqrt{N}\right)\right)^3} \\ &\xrightarrow[\Delta t \equiv t_P \to 1, \varepsilon^+ = \frac{1}{\sqrt{N}}, N \to 4]{} \left(1 - \left(10^{-124} \times (\Delta t)^2\right)\right) \times E_{\text{planck}} \times 10^5 \end{aligned} \tag{20}$$

Our interpretation is that the fill in of Equation (19) as a minimum uncertainty principle within the limits of Planck units and delta t being approximately Planck time, normalized to 1 makes this a quantum pressure argument. References [18] and [19] as to the Penrose singularity should be considered as a counterpart to our own efforts and a later publication will be highlighting where and why the Penrose theorem may be held in abeyance. In addition **Appendix** is to understand the role of infinite quantum statistics and quantum bits of information which has some tie into our document.

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Conflicts of Interest

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

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Appendix: Review of Ng and Infinite Quantum Statistics with Comments

First of all, Ng [5] refers to the Margolus-Levitin theorem with the rate of operations $< E/\hbar \Rightarrow \#\text{operations} < E/\hbar \times \text{time} = \frac{Mc^2}{\hbar} \cdot \frac{l}{c}$. Ng wishes to avoid black-hole formation $\Rightarrow M \le \frac{lc^2}{G}$. 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 $\#\text{operations} \le (R_H/l_P)^2 \sim 10^{123}$ with R_H the Hubble radius. Next Ng refers to the $\#\text{bits} \propto [\#\text{operations}]^{3/4}$. Each bit energy is $1/R_H$ with $R_H \sim l_P \cdot 10^{123/2}$.

The key point as seen by Ng [5] and the author is in, if *M* is the 'space-time' mass

$$\#\text{bits} \sim \left[\frac{E}{\hbar} \cdot \frac{l}{c}\right]^{3/4} \approx \left[\frac{Mc^2}{\hbar} \cdot \frac{l}{c}\right]^{3/4} \tag{A1}$$

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 $R_{\text{initial}} \sim \frac{1}{\#} \ell_{Ng} < l_{\text{Planck}}$? Also Ng writes entropy *S* as proportional to a particle count via *N*.

$$S \sim N \cong [R_H/l_P]^2 \tag{A2}$$

We rescale R_H to be

$$R_H\big|_{\text{rescale}} \sim \frac{l_{Ng}}{\#} \cdot 10^{123/2} \tag{A3}$$

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

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

1) The initial entropy drops

2) The number of bits initially available also drops.

The limiting case of Equation (A2) and Equation (A3) 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?