Gedankenexperiment for using Boltzmann Equation for Relic Graviton density , in Pre-Planckian physics conditions if there exists a regime of comparatively low temperatures (Cold Cosmologies)

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Abstract. We look at what may occur if Boltzmann equations, as presented by Muramaya in 2007, Les Houches, are applied to graviton density in a pre Planckian universe setting. Two restrictions are in order. First of all, we are assuming a graviton mass on the order of 10^-62 grams, as if the pre Planckian regime does not change the nature of Graviton mass, in its low end.. Secondly, we are also assuming that a comparatively low temperature regime (far below the Planckian temperature) exist . Secondly we are leaving unsaid what may happen if Gravitational waves enter the Planck regime of ultra high temperature. With those two considerations, we proceed to examine a Graviton density value resulting from perturbation from low to higher temperatures. Either cyclic conformal cosmology as ventured by Penrose may be the genesis of a low temperature regime, or a multiverse.

Key words; Boltzmann Equation, stress energy tensor, quantum bounce, Infinite quantum statistics, heavy Gravity

i. Introduction

We will start off first, with the result of H. Murayama [1] as to an equilibrium number density, of Pre Planckian physics, just before the Planckian physics regime. In this work we wish to allude to several restraints on the following presentation. First, we look at temperatures far below the Plank Temperature scale. Secondly the heavy gravity graviton mass, roughly 10^-62 grams [2] is assumed to be invariant and not changing in spite of the transition from a cold pre Planckian state, to right after the big bang. The author leaves, as a future investigation if the invariance of presumed graviton mass is defensible given a cold to a hot cosmology regime. The cases of cyclic conformal cosmology [3] and a multiverse contribution [4] to Pre Planckian physics are commented upon at the end of this document.

2. The Muramaya Result , i.e. Equilibrium number density with infinitesimal values to the LHS of Eq.(1) below.

Debatable as this may be, the assumption will be that what H. Muramaya postulated in [1] in pre Planckian physics is appropriate as a thought experiment. Muramaya postulated that the conditions which exist are for light particles is a given, which would simplify a Boltzmann equation to have the form

$$a^{-3}\frac{dn_{\chi}a^{3}}{dt}=\langle\sigma_{ann}v\rangle\cdot\left[\left(n_{\chi}^{0}\right)^{2}-\left(n_{\chi}\right)^{2}\right] \tag{1}$$

Muramaya also postulates [1] that

$$n_\chi^0 = \left[\exp(-\bar{x})\right] \cdot \left(\frac{m_\chi}{\sqrt{2\pi\bar{x}}}\right)^3 \tag{2}$$

The approximation we will use is that the right hand side of Eq.(1) is almost zero, i.e.

$$\begin{aligned} & a^{-3}\frac{dn_\chi a^3}{dt} = \langle \sigma_{ann} v \rangle \cdot \left[\left(n_\chi^0\right)^2 - \left(n_\chi\right)^2\right] \sim \xi^+ \\ & \Leftrightarrow n_\chi \sim n_\chi^0 + \xi^+ \cdot a^3 \cdot t_{time} \approx \left[\exp\left(-\frac{m_\chi}{T_{temp}}\right)\right] \cdot \left(\frac{m_\chi}{\sqrt{2\pi\left(\frac{m_\chi}{T_{temp}}\right)}}\right)^3 + \xi^+ \cdot a^3 \cdot t_{time} \end{aligned} \tag{3}$$

From here, we will fill in some would be parameters

3. Looking at what is a range of would be values to insert in Eq. (3)

First of all, assuming in Pre inflation mass (energy) and temperature a ratio of about, for

$$\left(\frac{m_\chi}{T_{temp}}\right) \sim 10^{-5} \tag{4}$$

This would imply for a PrePlanckian density , for a Pre Planckian bounce radii of one Planck length [5,6]

$$S_{gravitons} \sim \mathrm{N}_{graviton-count} \propto 10^{10} \tag{5}$$

4. Implications as far as single repeating universe, multiverse, and other issues.

To start off with, we will be considering having [7]

$$
\begin{aligned}
h_{00}\left(x^{i}\right) &= -\frac{4G}{c^{2}} \cdot \int_{V^{(3)}} \frac{T_{00}^{*}\left(x'^{i}\right)}{R} \cdot d^{3}x' \\
&\sim -\frac{4G}{c^{2}} \cdot \int_{V^{(3)}} \frac{\rho_{Energy-density}\left(x'^{i}\right)}{R} \cdot d^{3}x' \\
&\sim -\frac{4G}{c^{2}} \cdot \int_{V^{(3)}} \frac{\left(\frac{\Re}{32\pi} - \frac{\Lambda_{initial-value}}{16\pi}\right)}{R} \cdot d^{3}x'
\end{aligned} \tag{6}
$$

The relevant quantity to consider here would be, then , with Eq.(5), and [6]

$$
\rho_{Energy-density}\left(x'^{i}\right) \sim S_{graviton} \cdot m_{x=graviton} \tag{7}
$$

$$
m_{x=graviton} \sim 10^{-29} - 10^{-34} eV = 10^{-38} - 10^{-43} GeV \tag{8}
$$

In terms of the multiverse, the expected result would be an input of the form of

This value for the initial time step would be probably lead to Pre Planckian time , i.e. smaller than 10^ -43 seconds, which then leads us to consider, what would happen if a multi verse contributed to initial space-time conditions , then by [8] we would have a metric tensor contribution of for a single universe

$$
m_{graviton} \geq \frac{2\hbar^{2}}{\left(\delta g_{tt}\right)^{2} l_{P}^{2}} \cdot \frac{(E-V)}{\Delta T_{tt}^{2}} \Rightarrow \left(\delta g_{tt}\right)^{2} \geq \frac{2\hbar^{2}}{m_{graviton} \cdot l_{P}^{2}} \cdot \frac{(E-V)}{\Delta T_{tt}^{2}} \tag{9}
$$

But, then if one is looking at a multiverse, we first will start at the Penrose hypothesis for a cyclic conformal universe, starting with [3,4]

$$
\begin{aligned}
&\hat{g}^{uv} = \Omega_{uv} g^{uv} \\
&\Omega_{uv}(new-universe) = (\Omega_{uv}{}^{-1} old-universe) \\
&i.e. \\
&\Omega_{uv} \rightarrow \Omega_{uv}{}^{-1}(inversion)
\end{aligned} \tag{10}
$$

However, in the multiverse contribution to [4]

$$
\Omega_{uv}{}^{-1} old-universe \rightarrow \frac{1}{N} \sum_{j=1}^{N} \left[\Omega_{uv}{}^{-1}(inversion)\right]_{j} \tag{11}
$$

So, does something like this hold ? In a general sense ? if N is the number of contributing multiverse single universes contributing to the beginning of space time, then we would be looking at [8]

$$
\begin{aligned}
&\left(\delta g_{uv}\right)^2\Big|_{initial} \hat{g}^{uv} = \Omega_{uv} g^{uv} \\
&\to \frac{1}{N}\sum_{j=1}^{N}\left[\Omega_{uv}{}^{-1}(inversion)\right]_j g^{uv} \\
&\sim ?? \sim 1/\left[\beta M_{Planck}^2\right] + \varepsilon^+
\end{aligned}
\tag{12}
$$

Then the contribution of the multiverse to the beginning

$$
\begin{aligned}
&\frac{1}{\Delta E}\cdot\frac{N\cdot\hbar}{\left(\left(\sum_j\left[\Omega_{tt}^{-1}\right]_j\right)\cdot\delta g_{tt}\right)} = \frac{N\cdot\hbar/\Delta E}{\left(\sum_j\left[\Omega_{tt}^{-1}\cdot\left(\delta g_{tt}\right)\right]_j\right)} \sim \frac{m_{graviton} l_P \cdot l_P}{2\cdot\left(E-V\right)} \\
&\Leftrightarrow \Delta E \sim 2\cdot\left(E-V\right) \\
&\& \\
&m_{graviton} l_P \cdot l_P \sim \frac{N\cdot\hbar}{\left(\sum_j\left[\Omega_{tt}^{-1}\cdot\left(\delta g_{tt}\right)\right]_j\right)}
\end{aligned}
\tag{13}
$$

And the graviton mass for a multiverse, would be then like

$$
m_{graviton} \sim \frac{N\cdot\hbar/l_P\cdot l_P}{\sum_{j=1}^{N}\left[\Omega_{tt}^{-1}\cdot\left(\delta g_{tt}\right)\right]_j}
\tag{14}
$$

Then for multiverse there would be an energy density looking like, for all this

$$
\rho_{Energy-density}\left(x'^i\right) \sim S_{graviton}\cdot\frac{N\cdot\hbar/l_P\cdot l_P}{\left(\sum_{j=1}^{N}\left[\Omega_{tt}^{-1}\cdot\left(\delta g_{tt}\right)\right]_j\right)}
\tag{15}
$$

If so, there would then be a net Graviton based energy we would set up as given below which is a way to obtain, via a multiverse input to be as follows:

$$
\begin{aligned}
&Energy(net) \sim l_P^3 \times \rho_{Energy-density}\left(x'^i\right) \approx S_{graviton}\cdot\frac{l_P\cdot N\cdot\hbar}{\left(\sum_{j=1}^{N}\left[\Omega_{tt}^{-1}\cdot\left(\delta g_{tt}\right)\right]_j\right)} \\
&\approx S_{graviton}\cdot\hbar\cdot\omega_{graviton}
\end{aligned}
\tag{16}
$$

of the following equation which we will then lead to setting the graviton frequency as following, with N the number of universe contributions to the new universe, and the frequency, as averaged out by

$$\omega_{graviton} \sim \left(N^{-1} \sum_{j=1}^{N} \left[\Omega_{tt}^{-1} \cdot \left(\delta g_{tt} \right) \right]_j \right)^{-1} \tag{17}$$

i.e. the fluctuation in initial time component of metric tensor would be primary way to obtain initial graviton wave frequency. Per graviton

5. Conclusion. Frequency and wavelength minimum for Pre Planckian gravitons. Importance of Multiverse.

The conclusions of Eq.(17) are such that if we look at the value of h, i.e. strain, as given by Tong, Zhang Zhao, Liu, Zhao, and Yang [9] , the following becomes a possibility, namely for a strain, one has an inversion of contributions from N contributing universes, in a multiverse generalization of the Penrose hypothesis, will lead to , if we look at Ω_{tt}^{-1}

$$\begin{aligned}
& h(k,\tau_i) = 8\sqrt{\pi} / \lambda_i \\
& \& \lambda_i \sim c / v(frequency) = 2\pi c / \omega \\
& \Leftrightarrow \omega \sim 2\pi c / \lambda_i = 16\pi^{3/2} c / h(k,\tau_i) \\
& \Leftrightarrow h(k,\tau_i) \sim 16\pi^{3/2} c \times \left(N^{-1} \sum_{j=1}^{N} \left[\Omega_{tt}^{-1} \cdot \left(\delta g_{tt} \right) \right]_j \right)
\end{aligned} \tag{18}$$

The contribution of the 'strain', in terms of the term $\left[\Omega_{tt}^{-1} \cdot \left(\delta g_{tt} \right) \right]_j$ for each of the N sub set universes (of the multiverse) contributions , j = 1 to N, of metric tensor fluctuations δg_{tt}, as for each of the N universes, will mean that this fluctuation contribution is really almost a statistical averaging , since it is divided, by N after the N contributions of each $\left[\Omega_{tt}^{-1} \cdot \left(\delta g_{tt} \right) \right]_j$ conformal "resizing" is finalized. This Eq. (18) should be compared with Eq.(6) above, in terms of absolute magnitude , and will be , especially if $\frac{\left(\frac{\Re}{32\pi} - \frac{\Lambda_{initial-value}}{16\pi} \right)}{R} < 0$ for every value of R, and $\frac{\Re}{32\pi} - \frac{\Lambda_{initial-value}}{16\pi}$ used in Eq.(6). That will be done in the future, as far as research work initiated by the author. With $\Re = Riemann - scalar = -\frac{6 \cdot \tilde{k}_{Curvature-measure}}{\left(a_{initial-value} \right)^2}$ [7]

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