Geddankenexperiment for quark star idea, quantum wavelength limit, minimum time, and early universe temperature, from first principles

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Abstract. **We initially look at a non singular universe representation as given by Rovelli and Vidotto, in terms of a quantum bounce, via quark stars, as a start of how to estimate of entropy and also of the number of operations of an expanding universe. The bench mark used is, to after considering a quark star, to look at the mass of a universe, estimated, and from there, we can obtain the entropy if we look at the Schwartzshield radii of a universe, and then the radii of the universe about 380,000 years after the big bang. In the latter, we show how to get the number of operations as akin to the reasoning used by Seth Lloyd , in 2001, and also from there close with a few comments as to the 'naturalness' of heavy Gravity from this formulation of entropy, which is based upon a start of considering what is a Planck star, as far as minimum quantum effects in Black hole physics, and by extension early universe cosmology.**

1. Introduction, setting up for calculation of using the results of initial temperature T as a way to answer initial time step value, initial energy, and also entropy of the universe, from first principles.

We follow what Ha wrote up [1] that there is a way to outline some basic thermodynamic arguments pertinent to quantum gravity. Our first move will be outlining equations of state, thermodynamically speaking as far as entropy, internal energy and a partition function given by Ng [2] as to 'infinite quantum statistics' which can be used, then to extract, first an initial temperature, T, which then can be linked to the energy per degree of freedom of the initial cosmological configuration. The temperature T so identified with, is proportional to energy per degree of freedom, and if the degrees of freedom as initially configured, by Kolb and Turner [3] are as high as $g_* = 106$, which is in part confirmed by Standard model calculations as given by [3a] . which is part of [3b] Note that values for g_* as far as initial degrees of freedom could be higher than that [3c] And this is affirmed by the Particle data group information [3d] . With degrees of freedom contributing to an initial energy configuration as given by

$$E_{initial} = g_{*S}(initial) \cdot \left[\frac{1}{2} \cdot k_B \cdot T_{initial} \right] \equiv \frac{g_{*S}(initial)}{2} \cdot T_{initial} \tag{1}$$

Then in the spirit of Mukhanov [4] using $\Delta E \Delta t_{time} \doteq \hbar \equiv 1$ to have, here

$$\Delta t_{time}(initial) = 1 / E_{initial} = \frac{2}{g_{*S}(initial) \cdot T_{initial}} \tag{2}$$

Then, we go to the Entropy, and state it is due to calculation given by Kolb and Turner [3]

$$S(initial) \sim n(particle-count) \approx g_{*s}(initial) \cdot V_{volume} \cdot \left(\frac{2\pi^2}{45}\right) \cdot \left(T_{initial}\right)^3 \qquad (3)$$

Our article will be developed by making sense of the above formalism, and we start by getting the entropy , in its final state, pretty well bench marked, and from there scaling back to determine what entropy should be initially. In doing so, we take some arguments from Ruelle and Viddotto, [5, 6] , as to quark stars, and minimum quantum effects, as well as some more details given as to [7,8,9] as to the change in degrees of freedom as given in Eq. (3) above.

2. Entropy, as calculated as a function of quark star arguments, and quantum effects. And number of operations.

The quark star argument comes as to giving the cube of a minimum quantum wavelength for quantum gravitational effects and the linkage to quark stars, etc, as commensurate with [5, 6]

$$\begin{aligned}
&\lambda_{QM-effects-BH} \sim \sqrt[3]{\frac{t_H}{t_{Planck}}} \cdot L_{Planck} \sim 10^{-15} meters \\
&\Leftrightarrow R_{Schwartzshield-radii-BH} \sim \frac{2GM}{r} \sim .0002 \quad meters \\
&\Leftrightarrow \left(\lambda_{QM-effects}\right)_{BH}^{3} \sim 10^{-45} meters^3 \\
&\Leftrightarrow \left(\frac{t_H}{t_{Planck}}\right)_{BH} \sim 8 \times 10^{60} \\
&\Leftrightarrow \left(\omega_{QM-effects}\right)_{BH} \sim .5 \times 10^{21} Hz \\
&\Leftrightarrow \left(R_{Schwartzshield-radii-Universe}\right) \sim 10^{22} \times R_{Schwartzshield-radii-BH} \\
&\sim 10^{33} \times \left(\lambda_{QM-effects}\right)_{BH}^{3} \\
&\Leftrightarrow \frac{4\pi}{3}\left(R_{Schwartzshield-radii-Universe}\right)^3 \\
&\approx \left(S_{Universe} \sim 10^{99}\right) \times \left(\lambda_{QM-effects}\right)_{BH}^{3} \\
&\Leftrightarrow S_{Universe} \sim 10^{99}
\end{aligned} \qquad (4)$$

The end result, is if we use Eq. (3) above, as a proportionality factor as far as how to obtain entropy is in having the following set up, i.e.

$$\begin{aligned}
&\frac{4\pi}{3}\left(R_{Schwartzshield-radii-Universe}\right)^3 \\
&\approx \left(S_{Universe}\right) \times \left(\lambda_{QM-effects}\right)_{BH}^{3}
\end{aligned} \qquad (5)$$

Furthermore, there is a linkage which can be made to Seth Lloyds number of operations, i.e. [10]

$$
\begin{aligned}
&\#(operations) \sim \left(S_{Universe}\right)^{4/3} \sim 10^{126} \\
&\Leftrightarrow \frac{4\pi}{3}\left(R_{Z\sim 1100(first\ \ light-radii-Universe}\right)^{3} \sim 10^{27}\,meters \\
&\simeq \frac{4\pi}{3}\left(\left[\#(operations)\right] \sim 10^{126} \times \left(\lambda_{QM-effects}\right)_{BH}{}^{3}\right)
\end{aligned}
\tag{6}
$$

Note the completely different ways of charactering the number of operations, as given by Eq. (6) in terms of a linkage to the radii of the universe, at Z ~ 1100, as opposed to the entropy as linked to a radii of the Schwartshield "radii", as given in Eq. I5) and part of the evolution displayed in Eq. (4)

3. Conclusion Calculation of temperature , and of all that, as far as Eq. (2). Leading to a graviton mass ?

In order to do this line of reasoning, the temperature can have the following linkage [11]

$$
\lambda = 2\pi \big/ E_{Energy} \doteq 2\pi \bigg/ \left(\frac{T}{2}\bigg|_{Deg.of.freedom} \right) \tag{7}
$$

This would then entail making the following identification. I.e. comparing the wavelength of Eq. (7) with the quantum wavelength and linking it to Eq. (5) so as to then make the following identification. If so, then if Entropy is identifiable with Eq.(5) and then we would use the following identification, namely, if [2]

$$
S_{Entropy} \sim N \approx graviton\# \tag{8}
$$

Also, if a Holographic relationship holds, [12]

$$
N = N_{graviton}\Big|_{r_H} = \frac{c^3}{G\cdot\hbar}\cdot\frac{1}{\Lambda} \approx \frac{1}{\Lambda} \tag{9}
$$

And if [13] is true as well, then perhaps if so we have a first principle confirmation of

$$
\Lambda_{Einstein-Const.} = 1\big/ l^2_{Radius-Universe} \tag{10}
$$

Which in turn may help us understand when the formation of this value occurred, I.e. [12]

$$
m_{graviton} = \frac{\hbar}{c}\cdot\sqrt{\frac{(2\Lambda)}{3}} \approx \sqrt{\frac{(2\Lambda)}{3}} \tag{11}
$$

We are supposing that Eq.(11) holds at the formation of a Schwartzshield mass of the Universe radius. Also, here is our candidate as to the formation of an initial time step. As given.

$$t_{initial} \sim \frac{2}{g_*^{2/3}} \cdot \frac{10^{\alpha}}{N} \cdot L_{Planck} \qquad (12)$$

Then, up to a point, if the above is in terms of seconds, and N sufficiently large, we could be talking about an initial non zero entropy, along the lines of the number of nucleated particles, at the start of the cosmological era. As given by

$$S(initial) \sim \left(N \doteq n\right) \sim \frac{2}{g_*^{2/3}} \cdot \frac{10^{\alpha}}{t_{initial}} \cdot L_{Planck} \qquad (13)$$

Initial entropy would be small, but non zero, and would be affected by g_* strongly, i.e. the initial degrees of freedom assume would play a major role as far as how initial entropy and initial time steps would be initiated.

if g_* increased, then an initial time step would also change. This supposition has to be balanced against the following identification, namely, as given by T. Padmanabhan[14] that there also may be initial quinessence as far as the evolution of the "cosmological constant,

$$\Lambda_{Einstein-Const.Padmanabhan} = 1/l_{Planck}^2 \cdot \left(E/E_{Planck}\right)^6 \qquad (14)$$

With an initial Graviton formation of mass occurring perhaps as early as

$$\omega_{initial}\Big|_{r_H \sim atomic-size} \sim 10^{21} Hz \qquad (15)$$

Pick, then a path from Eq. (15) to a value of E, so as to scale a drop off of Eq. (14) on the value of a

$$E \equiv E_{initial} \propto \frac{T_{initial-temerature}}{2} \sim \frac{\omega_{initial}}{2} \qquad (16)$$

And if the Planck angular frequency is used, then Eq.(14) will then have the value , if Eq.(15) used to set Eq. (16), of

$$\begin{aligned}
& E \equiv E_{initial} \propto \frac{T_{initial-temerature}}{2} \sim \frac{\omega_{initial}}{2} \\
& \& \quad \omega_{Planck} \sim 1.85 \times 10^{43} Hz \equiv 1.85 \times 10^{34} GHz \\
& \Leftrightarrow \left(E_{initial} / E_{Planck}\right)^6 \sim 10^{-132} \\
& \& \left(E_{initial} / E_{Planck}\right)^6 \cdot l_{Planck}^{-2} \sim 10^{123} \times 10^{-132} \cdot l_{Universe}^{-2} \\
& \Leftrightarrow \Lambda_{Einstein-Const.Padmanabhan} = 1/l_{Planck}^2 \cdot \left(E/E_{Planck}\right)^6 \\
& \sim 10^{-9} \cdot l_{Universe}^{-2} \approx 10^{-9} \Lambda_{Today}
\end{aligned} \qquad (17)$$

Paradoxically, the initial frequency, as given in Eq. (15) would be implying that one would be having a "cold universe" start, i.e. not an ultra hot beginning. Perhaps in line with a multiverse start, along the lines of leading up to the void structures as alluded to [15],[16]

This Eq. (15) frequency would be though massively red shifted down due to the onset of inflation. Also, our starting point as to wavelength, is due to the considerations given in [6] and may indeed give confirmation as far as a start to early universe nucleation similar to what is given in the physics written in [17] below. As well as understanding why a graviton mass, as so discussed in Eq. (11) as forming at the edge of the Schwartzshield radii of the universe, may form at a distance 10^18 or so meters from the big bang , and is still congruent with [18][16] in the later universe. We should also note that Chapline and Nauemberg [19,20] [17, 18] also brought up the existence of quark stars, with much the same flavor as done by [5] with the difference that their work is in terms of phase transitions whereas [5] is more in line with a collapse of a black hole, into a white hole, and thereby having much the same phenomenology as what was done with a black hole and transit of information from a black hole to the exploding white hole as a model of space time physics which will be fully developed in a future paper.

We should keep in mind, that as given in [21,22] [19,20] that quark stars are , especially as given in [22] [20] allegedly stable quark stars involve debatable assumptions and that it probably would be best to emphasize the behavior as outlined in [5,6] as far as the models incorporated being useful to talk about a transition to white holes. Of special interest would be if the following were true, as given in [6], namely

Quote

In the scenario we have considered here, on the contrary, the phenomenon is of direct quantum gravitational nature. A quantum gravitational phenomenon can have effects at observable scales because the presence of the large multiplicative factor

tH/ tP ∼ 8 × 10^60 . (cited in our reference [6] as Eq. (9) , and is from our reference [23])

in the physics of the phenomenon. If the observed Fast Radio Bursts are connected to this phenomenon, they represent the first known direct observation of a quantum gravity effect.

End of quote

In addition may be an unconventional way to have initially non zero entropy. I.e. look at an entropy density

As to Eq. (15) our preferred way to treat the entropy, initially, may be to refer to what was done by Pebbles [24] where in fact, on page 371 Pebbles has an entropy density written as

$$s(entropy - density) \sim \frac{4\pi^2 g_* T^3}{90} \tag{18}$$

The frequency value of Eq. (15) plus the dynamics of Eq. (17) may imply a very low but non zero entropy if the temperature T is quite low, and then it would become much higher later, even if $g_*(initial) \sim 106$. This of course has to be investigated.

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