

Particle Nucleation in the Early Universe and Quantum States, Especially Relevant to Particle Counting

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Abstract

We examine the role of particle nucleation in the initial universe, and we can compare, via a thermodynamic argument, to a modified Heisenberg uncertainty principle as to what this says about particle count information. Thereby, we have a richer cosmological picture to contend with. One consideration brought up is initially a cosmological constant term which, in the initial state of the universe, is dependent upon temperature, before settling down to its present value today. Ironically, initially, with a particle counting argument, we can have the temperature T of the universe as proportional to $1/N$, with N as a particle count.

Keywords

Weak Measurements, Modified HUP, Entropy, Quantum

1. Introduction

We start off with a treatment of entropy initially using Muller and Loustos's results [1] as of 2007 as to black hole entropy and entropy of the early universe. Afterwards, we refer to a paper by Crowell [2] as a treatment of black hole entropy.

2. Construction of Temperature Quenching: Preliminary Argument

The main point of the formalism is to establish first-order contributions to the quenching of temperature phenomena. To begin with. Look at how to construct entropy for black holes and the early universe.

Note that for gravity, one has, if k is Boltzmann's constant and N is the number

of microstates, a limiting value for entropy in Equation (1) below.

Now, by Muller and Luosto [1] as well as Crowell [2] one can write for the early universe: The area A is such that, by Crowell [2], we can write this area as, for a black hole of mass M , and setting $A = 16\pi M^2$, we can write this area as, for a black hole of mass M , so then that we have by [3]

$$S = k \ln N \propto kA/4l_p^2 \xrightarrow{A=16\pi M^2} k \cdot 16\pi M^2/4l_p^2 \quad (1)$$

B1. What if one looks at a treatment of black holes? We make the following assertion, *i.e.*, if what Ng writes for Quantum infinite statistics [4] [5] is true, then

$$E = \alpha E_p \sqrt{n} \Leftrightarrow \alpha = \frac{1}{2} \frac{\sqrt{\ln 2}}{\pi} \quad (2)$$

B2. How does one have a real and complex frequency with respect to black holes [2]? *i.e.*, Crowell wrote having a partition function for Black holes, and this was due to normal modes for black holes, of mass M , which was of the form [2] for frequency with an odd frequency value of

$$\omega_n = \alpha^2 = \frac{\ln 3}{8\pi M} + \frac{i}{4M} \cdot \left(n + \frac{1}{2} \right) \quad (3)$$

The imaginary frequency value is, in this case, if we have mini black holes, a template for temperature decline [6]-[12].

We wish to interpret the rise of entropy from a black hole and the entropy of the early universe in the following way. Let a be the scale factor and r_H the horizon radius, with $S = \frac{0.3r_H^2}{a^2}$ [1] [4]. If there is initially a temperature-dependent cosmological constant, then the following should hold:

$$\Lambda \propto T^{\tilde{\beta}} \sqrt{\frac{3}{\Lambda}} \Rightarrow r_H = \sqrt{\frac{3}{\Lambda}} \cong \sqrt{3} T^{-\tilde{\beta}/2} \Rightarrow S \approx 0.3 \cdot 3 T^{-\tilde{\beta}} / a^2 \quad (4)$$

Above means that entropy scales almost exactly as having the universe with entropy proportional to one over the temperature to the minus beta power times one over the square of the scale factor for early universe conditions. If we look at microstates N and then go to particle counting, via n , we have if by [1] $S_{\text{Early Universe}} \sim 16\pi\alpha^2 n$, we get the following temperature quenching right after the big bang, as by

$$\begin{aligned} S_{\text{Early Universe}} &\sim 16\pi\alpha^2 n \sim T^{-\tilde{\beta}} / a^2 \Rightarrow T^{-\tilde{\beta}} \propto 16\pi\alpha^2 n a^2 \\ \Rightarrow T &\approx \frac{1}{(16\pi\alpha^2 n a^2)^{\tilde{\beta}}} \end{aligned} \quad (5)$$

Assuming we have a condition for which α is, for a short period of time, a constant in the early universe, and that we have for H the initial Hubble expansion parameter, and the time, then if what is below is if $a(t) \approx a_0 \exp[Ht]$. We then have in the regime of Planck time we are looking at

$$T \approx \frac{1}{(16\pi\alpha^2 n a^2)^{\tilde{\beta}}} \sim \left[\frac{(1-H \cdot t)^{\tilde{\beta}}}{a_0^{\tilde{\beta}}} \right] \cdot \frac{1}{n^{\tilde{\beta}}} \propto \frac{1}{n^{\tilde{\beta}}} \quad (6)$$

as n is “nucleated” or created, the temperature scales down. The dominant effect of scaling down will be on the creation of $\frac{1}{n^\beta}$ contributions to dropping of the temperature.

C. 1st part of conclusion: Comparing this formulation of initial temperature drop due to a contingent algorithm for particle creation, *i.e.*, what if we do not have a time-varying cosmological constant? Energy flux at the start of inflation?

Space constraints do not allow us to explain more than this, other than to bring up that the Torsion argument is to buttress the following for energy density, which we give as

$$\rho_\Lambda c^2 = \int_0^{E_{\text{Plank}}/c} \frac{4\pi p^2 dp}{(2\pi\hbar)^3} \cdot \left(\frac{1}{2} \cdot \sqrt{p^2 c^2 + m^2 c^4} \right) \approx \frac{(3 \times 10^{19} \text{ GeV})^4}{(2\pi\hbar)^3} \quad (7)$$

$$\xrightarrow{E_{\text{Plank}}/c \rightarrow 10^{-30}} \frac{(2.5 \times 10^{-11} \text{ GeV})^4}{(2\pi\hbar)^3}$$

This means shifting the energy level of Equation (7) downward by 10^{-30} , *i.e.*, the top value energy becomes a downscale of Planck energy times 10^{-30} . We argue that the topping off of this integral is dependent upon Equation (5) with respect to black holes, and that the quantum number comes from [1] [2].

Finally, this also leads to a huge energy flux we can write for Potential energy initially [1] [2]

$$V_0 = \left(\sqrt{\frac{\nu(3\nu-1)}{8\pi}} + \sqrt{2 \cdot (3\nu-1)} \cdot \frac{a_{\text{init}}^2 \cdot (l_2 - l_1)^2}{l^3(c) \cdot (3\Lambda)^{1/2}} \right)^2 \approx \Delta E \quad (8)$$

This energy flux is $3 \times 10^{19} \text{ GeV}$.

This uses a scale factor, which we write as $a(t) \approx a_{\text{init}} t^\nu$.

Now, let us make the following identification, *i.e.*, consider if we have the change in E related to setting energy density as for Equation (7) via

$$(3 \times 10^{19} \text{ GeV}) \cdot \frac{1}{n^\beta} \propto 3 \times 10^{-11} \text{ GeV} \quad (9)$$

Leading to a nucleated variable

$$n^\beta \approx 10^{30} \quad (10)$$

This means that the particle counting value initially for a drop in temperature of the sort given in Equation (7) to what is seen in Equation (9) argues in favor of a huge graviton production at the start of the Universe, allowing for a temperature drop on the order of Equation (10).

We furthermore link this to early universe times via

$$\Delta E \approx \frac{\hbar}{g_u \Delta t} \approx \frac{k_B}{2} \cdot T_{\text{initial}} \quad (11)$$

$$\Leftrightarrow T_{\text{initial}} (\text{initial temperature}) \approx \frac{2\hbar}{k_B \cdot g_u \cdot \Delta t}$$

Hence, we have a final energy commensurate with Equation (9), *i.e.*, 10^{-30} times lower if we have then Equation (10) holding.

This could, in the minimum radii expected by a quantum-induced scale factor, $a_{\min}$ [13] [14], as well as the details of [15] as to how to form g_{tt} .

Comparing this Equation (11) with Equation (9) and picking Δt say of the order of Planck time may indeed add more structure to this problem.

D. 2nd part of conclusion, *i.e.*, the role this has with a massive energy flux of the Universe at the start of inflation.

Keep in mind this is in fidelity to [16], *i.e.*, the start of a modified Penrose cosmological dynamics as given in that reference.

As indicated, there are several states in this presentation. First is the idea of using the HUP from a deterministic embedding in 5 dim, as given in Equation (11). And Equation (20), where we have then [17] [18]

$$\begin{aligned} |dp_\alpha dx^\alpha| &\approx \frac{L}{l} \cdot \frac{h}{c} \cdot \left[\frac{dl}{l} \right]^2 \\ \xrightarrow{\alpha=0} |dp_0 dx^0| &\approx |\Delta E \Delta t| \approx (h/a_{\text{init}}^2 \phi(t)) \\ &\Rightarrow \frac{L}{l} \cdot \frac{h}{c} \cdot \left[\frac{dl}{l} \right]^2 \approx (h/a_{\text{init}}^2 \phi(t_{\text{init}})) \end{aligned} \quad (12)$$

$$\begin{aligned} \sqrt{\Lambda} &= \frac{k_B E}{\hbar c S_{\text{entropy}}} \\ S_{\text{entropy}} &= k_B N_{\text{particles}} \end{aligned} \quad (13)$$

The upshot is that we will be changing the cosmological constant from

$$\left(\frac{8\pi G}{3} \right) \cdot \left[-\frac{2\pi G \sigma^2}{3c^4} \right] + \frac{\Lambda c^2}{3} = 0 \quad (14)$$

What we are arguing is that instead, one is seeing, instead

$$\left(\frac{8\pi G}{3} \right) \cdot \left[-\frac{2\pi G \sigma^2}{3c^4} \right] + \frac{\Lambda_{Pl} c^2}{3} \approx 10^{-122} \times \left(\frac{\Lambda_{Pl} c^2}{3} \right) \quad (15)$$

Our timing as to Equation (14) is to unleash a Planck time interval t about 10^{-43} seconds. As to Equation (14) versus Equation (15), the creation of the torsion term is due to a presumed particle spin density of black holes, each with attendant graviton production

$$n_{Pl} \approx 10^{98} \text{ cm}^{-3} \quad (16)$$

i.e., we get a spin density from Equation (16), which is the engine for how we have black holes form, and linked to a cosmological constant. Black holes are assumed to generate quantum number n .

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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

Having said this, it's now time to go to **Table A1**, which summarizes some of the material as given in references [17] [18].

Following [17] [18], we introduce black hole physics in terms of a quantum number n .

$$\begin{aligned}\sqrt{\Lambda} &= \frac{k_B E}{\hbar c S_{\text{entropy}}} \\ S_{\text{entropy}} &= k_B N_{\text{particles}}\end{aligned}\quad (\text{A1})$$

Note that we are assuming, in [17] [18], that the term N particles refers to the graviton count, as well as $E = M$ (having C set equal to 1).

$$\begin{aligned}M_{BH} &\approx \sqrt{N_{\text{gravitons}}} M_P \\ \Rightarrow (1/M_{BH})^{1/2} &\approx \frac{n_{\text{quantum}}}{2} \approx \frac{1}{(N_{\text{gravitons}})^{1/4}} \\ \Rightarrow n_{\text{quantum}} &\approx \frac{2}{(N_{\text{gravitons}})^{1/4}}\end{aligned}\quad (\text{A2})$$

In other words, if there are a lot of gravitons per black hole, the quantum number n goes DOWN.

These values of Entropy are closely tied to **Table A1**, which is a dynamic interaction of the physics that is also linkable to what Corda brought up in reference [17]. This **Table A1** is from references [18] [19].

Table A1. Assuming Penrose recycling of the Universe as stated in that document.

End of prior universe time frame	Mass (black hole): Supermassive end-of-time BH: 1.98910^{+41} to about 10^{44} grams	Number (black holes) 10^6 to 10^9 of them, usually from the center of galaxies
Planck era Black hole formation Assuming the 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) and Equation (2) 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 pairs forming a single black hole multiple times. 10^{20} to at most 10^{25}

Regarding **Table A1**, we obtain this due to the quantum number n , per black hole dynamics, which we state are also commensurate with [18], [19], and [20].

More details can be ascertained via reference [21].