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Title **Presenting Different time steps, at the start of inflation, Using Kiefer Density Matrix, for the use of an Inflaton, in determining different conceivable time intervals for time flow Analysis**

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Abstract:

\We are using the book "Towards Quantum Gravity with an article by Claus Kiefer as to a quantum gravity interpretation of the density matrix in the early universe. The density matrix we are using is a one loop approximation, with inflaton value and potential terms, like V(phi) using the Padmanabhan values one can expect if the scale factor is a ~ a(Initial) times t ^ gamma , from early times . In doing so, we isolate out presuming a very small initial time step candidates initial time values which are from a polynomial for time values due to the Kiefer Density value.

Keywords: Minimum scale factor, cosmological constant, space-time bubble, Arrow of time

1. Introduction

Our initial goal is to obtain, via a Kieffer Density function candidate minimum time steps which will be for the purpose of giving input into an uncertainty principle of the form [1][2][3]

$$\Delta E \Delta t \approx 4\hbar \tag{1}$$

Whereas our candidate [4] for a density matrix uses

$$H^2 = V_0 \exp\left(-\sqrt{\frac{16\pi G}{\nu}}\phi\right) = V_0 \cdot \left(\sqrt{\frac{8\pi G V_0}{\nu \cdot (3\nu - 1)}} \cdot t\right)^{\frac{1}{2}\cdot\sqrt{\frac{\nu}{\pi G}} - 4\sqrt{\frac{\pi G}{\nu}}} \tag{2}$$

Where [5][6] in turn is referenced directly to having use of the following

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$$
\begin{aligned}
& a(t) = a_{initial} t^{\nu} \\
& \Rightarrow \phi = \ln\left(\sqrt{\frac{8\pi G V_0}{\nu \cdot (3\nu - 1)}} \cdot t\right)^{\sqrt{\frac{\nu}{16\pi G}}} \\
& \Rightarrow \dot{\phi} = \sqrt{\frac{\nu}{4\pi G}} \cdot t^{-1} \\
& \Rightarrow \frac{H^2}{\dot{\phi}} \approx \sqrt{\frac{4\pi G}{\nu}} \cdot t \ \cdot T^4 \cdot \frac{(1.66)^2 \cdot g_*}{m_P^2} \approx 10^{-5}
\end{aligned} \tag{3}
$$

In doing all of this we are making full use of the following from [4] due to a one loop approximation

$$
\rho(\phi, \phi) \approx \left\{ \exp\left(\frac{\pm 3 M_P^4}{8 \cdot V(\phi)} \right) \right\} \cdot \phi^{-\tilde{Z}-2} \tag{4}
$$

Which after we isolate out Δt makes use of Eq. (1), which is derived as given in [1][2][3]

$$
\begin{aligned}
& \Delta t \geq \frac{\hbar}{\Delta E} + \gamma t_P^2 \frac{\Delta E}{\hbar} \Rightarrow (\Delta E)^2 - \frac{\hbar \Delta t}{\gamma t_P^2} (\Delta E)^1 + \frac{\hbar^2}{\gamma t_P^2} = 0 \\
& \Rightarrow \Delta E = \frac{\hbar \Delta t}{2\gamma t_P^2} \cdot \left(1 + \sqrt{1 - \frac{4\hbar^2}{\gamma t_P^2 \cdot \left(\frac{\hbar \Delta t}{2\gamma t_P^2} \right)^2}} \right) = \frac{\hbar \Delta t}{2\gamma t_P^2} \cdot \left(1 \pm \sqrt{1 - \frac{16\hbar^2 \gamma t_P^2}{(\hbar \Delta t)^2}} \right)
\end{aligned} \tag{5}
$$

$$
\begin{aligned}
& \Delta E \approx \frac{\hbar \Delta t}{2\gamma t_P^2} \cdot \left(1 \pm \left(1 - \frac{8\hbar^2 \gamma t_P^2}{(\hbar \Delta t)^2} \right) \right) \\
& \Rightarrow \Delta E \approx either \ \frac{\hbar \Delta t}{2\gamma t_P^2} \cdot \frac{8\hbar^2 \gamma t_P^2}{(\hbar \Delta t)^2}, or \ \frac{\hbar \Delta t}{2\gamma t_P^2} \cdot \left(2 - \frac{8\hbar^2 \gamma t_P^2}{(\hbar \Delta t)^2} \right)
\end{aligned} \tag{6}
$$

$$
\Delta E \approx \frac{\hbar \Delta t}{2\gamma t_P^2} \cdot \frac{8\hbar^2 \gamma t_P^2}{(\hbar \Delta t)^2} \equiv \frac{4\hbar}{\Delta t} \tag{7}
$$

We will be applying Eq. (4) to obtain Δt, and then from this step applying Eq.(1) to say foundational import issues of time flow in the beginning, as it affects initial energy values and from there obtain some matters of observational import in GW astronomy

2. Understanding the import of Eq. (2), Eq. (3) and Eq. (4) for Δt

Our assumption is that time, t, which becomes Δt is extremely small. Hence without loss of generality we write, if as an example, $\tilde{Z} \approx 2$

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And we simplify time dependence by setting $\nu = \frac{3\pi}{\sqrt{2}}$ in Eq.(2), Eq. (3) and Eq.(4)

Then, without loss of generality, if we observe this, and set Θ as a probability density value of Eq. (4), we then have

$$\left(\frac{1}{4}\cdot\exp\left(\pm\frac{3}{8}\cdot\frac{M_P^4}{V_0}\right)\right)\cdot\left(1-4\cdot\left(\sqrt{\frac{8\pi V_0}{\left(\frac{3\pi}{\sqrt{2}}\right)\cdot\left(\frac{9\pi}{\sqrt{2}}-1\right)}}\right)\cdot\Delta t\right)\approx\Theta \tag{8}$$

If so, then we have a minimum time step of the form

$$\Delta t \approx 4\left(\sqrt{\frac{\left(\frac{3\pi}{\sqrt{2}}\right)\cdot\left(\frac{9\pi}{\sqrt{2}}-1\right)}{8\pi V_0}}\right)\cdot\left(1-4\Theta\exp\left(\pm\frac{3}{8}\cdot\frac{M_P^4}{V_0}\right)\right) \tag{9}$$

3. **Interpreting Eq. (9) in terms of the affects it has on Eq. (1)**

We have to consider what Θ may or may not be. The core of the derivation of Eq. (4) in [4] due to[7] is dependent on having the following, namely

Quote

The quantum gravitational scale of inflation is calculated by finding a sharp probability peak in the distribution function of chaotic inflationary cosmologies driven by a scalar field with large negative constant Ξ of nonminimal interaction. In the case of the no-boundary state of the universe this peak corresponds to the eternal inflation, while for the tunnelling quantum state it generates a standard inflationary scenario. The sub-Planckian parameters of this peak (the mean value of the corresponding Hubble constant $H \cong 10^{-5} m_p$, its quantum width $\Delta H/H \cong 10^{-5}$ and the number of inflationary e-foldings $N \cong 60$) are found to be in good correspondence with the observational status of inflation theory, provided the coupling constants of the theory are constrained by a condition which is likely to be enforced by the (quasi) supersymmetric nature of the sub-Planckian particle physics model

End of quote

Notice here that this is akin to making use of Eq.(3.4) of [7] so that we have restrictions on particle manufacturing for the theory. This is in line with

$$\Delta E \approx \hbar\cdot\left(\sqrt{\frac{8\pi V_0}{\left(\frac{3\pi}{\sqrt{2}}\right)\cdot\left(\frac{9\pi}{\sqrt{2}}-1\right)}}\right)\cdot\left(1+4\Theta\exp\left(\pm\frac{3}{8}\cdot\frac{M_P^4}{V_0}\right)\right) \tag{10}$$

The consequences for frequency of signals is as follows. First, we make an estimation as to the width of the wavefront of a DeBroglie wave, which may be a consequence of a signal, as well as the position of the phenomenon of generation of say Gravitons. In

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doing so we wish to refer to the following as motivation in order to link this to graviton mass and other such concerning heavy gravity, In [8] we have the following, as to how to obtain the mass of an inflaton, namely use, if

$$m^2 = \left.\frac{d^2V}{d\phi^2}\right|_{\phi=0,t=3.9776\cdot t_P} = \frac{16\pi}{\left(3\pi/\sqrt{2}\right)} \tag{11}$$

$$\Rightarrow m = 2.74635619187$$

IMO the inflaton mass is 2.746356 times Planck Mass, and this is a starting value of inflaton mass at t = 3.9776 Planck time

Having this value of inflaton mass should be compared with the value of energy density as given by

$$\rho \approx \frac{\dot{\phi}^2}{2} + V(\phi) \equiv \frac{\gamma}{8\pi G}\cdot t^2 + V_0 \cdot \left\{ \sqrt{\frac{8\pi G V_0}{\gamma(3\gamma-1)}}\cdot t \right\}^{\sqrt{\frac{\gamma}{4\pi G}} - \sqrt{\frac{8\pi G}{\gamma}}} \tag{12}$$

Using the coefficient of the scale factor chosen, this above becomes simplified to become, if

$$V_0 \approx M_P^4 \xrightarrow[\hbar=\ell_P=t_P=k_B=G=1]{} 1 \tag{12a}$$

This is a way to obtain the following value for density as can be seen below

$$\rho = \frac{3\sqrt{2}}{8}\cdot\left(\frac{(3.997+\varpi)}{t_P \xrightarrow[\hbar=\ell_P=M_P=k_B=G=1]{} 1}\right)^{\frac{3\pi}{\sqrt{2}}} + \left(V_0 \approx M_P^4 \xrightarrow[\hbar=\ell_P=t_P=k_B=G=1]{} 1\right) \tag{12b}$$

We then can look at how this will be larger than Planck energy where our starting point will be if we set ϖ close to zero, and then have, due to how close the time is to Planck time, a sitaution for which we are looking at nearly Planck length, cubed as a starting volume, then we have initially, having a near Planck sized initial volume, we have then

$$1+\left(\frac{3\sqrt{2}}{8}\right)\cdot(3.997+\varpi)^{\frac{3\pi}{\sqrt{2}}} \approx \sqrt{\frac{8\pi}{\left(\frac{3\pi}{\sqrt{2}}\right)\cdot\left(\frac{9\pi}{\sqrt{2}}-1\right)}}\cdot\left(1+4\Theta\cdot\exp\left(\pm\frac{3}{8}\right)\right) \tag{13}$$

Then up to an initial round off error, in the beginning, we can have

$$\Theta \approx \frac{1}{4}\cdot\left[\exp\left(\pm\frac{3}{8}\right)\right]\cdot\{\ \}$$
$$\{\ \} = \left\{-1+\sqrt{\frac{\left(\frac{3\pi}{\sqrt{2}}\right)\cdot\left(\frac{9\pi}{\sqrt{2}}-1\right)}{8\pi}}\cdot\left[1+\left(\frac{3\sqrt{2}}{8}\right)\cdot(3.997+\varpi)^{\frac{3\pi}{\sqrt{2}}}\right]\right\} \tag{14}$$

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Θ is in the initial setting a way to bring up what Θ is as a probability density value, and this is the point to remember.

In **quantum mechanics**, a probability amplitude is a complex number used in describing the behaviour of systems. The modulus squared of this quantity represents a **probability density**. Note that the Interpretation of **values** of a wave function as the probability amplitude is a pillar of the Copenhagen interpretation of **quantum mechanics**

We are then reproducing in this method the idea of [9] namely that the following is true.

Probability Density of Particles. The **probability density** (or probably distribution) is given by taking the square of the absolute value of the **wave function**. It gives us the likelihood of finding an electron (or some other system) at some given point in space.

4.Conclusion: Making use of the idea of a nonzereo probability density of "masses" of some 'particle within the Copenhagen interpretation of Quantum Mechanics, in the vicinity of the big bang

Here what we are going to say, is that due to a fluctuation in time, given by Eq. (9), that the probability density of finding, say traces of the infllaton, as given in Eq.(11) will be nonzero, and varying in ways which could be experimentally tested.

Given a mass, m , as in Eq. (11) could be interpreted as being of value of effective space-time mass > 1 Planck mass, and if these are broken apart, in the matter of [10] for black holes, we could have, with the evolution of time a template for investigating the applicability of graviton masses being generated by black holes being broken up in the vicinity of a quantum bounce, with each quantum generated

$$m_g = \frac{\hbar\sqrt{\Lambda}}{c} \tag{15}$$

Whereas we have a thermality relationship which may be useful for analysis of the form given by

$$\frac{H^2}{\dot{\phi}} \approx 10^{-5} \tag{16}$$

And also the use of the following at the start of inflation, as given in [11] and [12] as well as the ideas given by Uptal Sarkar in [13] and [14]. We will also be examining if our construction will allow for the development of spin off of ideas given by Eq. (13) and (14)

$$H = 1.66\sqrt{g_*} \cdot \frac{T_{temp}^2}{m_P} \tag{17}$$

The term g_* can refer to the initial degrees of freedom and can go as high as 110, whereas Eq. (13) is a bound in the amount of inhomogenity. Whereas our future research objective is to find a way to allow the idea of a nonzero probability density, to ascertain different values of say graviton production if we make use of having from Freeze [10] of a mechanism of breaking up initially speaking black holes, due to the following criteria as given by Freeze

$$\rho_{BH-breakup-density} = \frac{M_P^4}{32\pi} \cdot \left(\frac{M_P^4}{m^4} \right) \cdot \frac{1}{|1+3\omega_Q|} \quad \textbf{(18)}$$

This breakup of black holes by the physics so outlined may give us a way to ascertain if the following entropy, initially is verifiable experimentally, whereas we wish to examine in full ideas given in the series of multiple references [15],[16],[17],[18],[19],[20],[21],[22],[23],[24], and [25], starting with verification of

$$S \sim 3 \cdot [1.66\sqrt{g_*}]^2 T^3 \quad (19)$$

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