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Investigating Quantum Mechanics in 5th Dimensional Embedding via Deterministic Structure, Small Scale Factor, and Initial Inflaton Field

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Abstract

We consider if a generalized HUP set greater than or equal to Planck's constant divided by the square of a scale factor, as well as an inflaton field, yields the result that Delta E times Delta t is embedded in a 5 dimensional field which is within a deterministic structure. Our proof concludes with Delta t as of Planck time, resulting in enormous potential energy. If that potential energy is induced by a repeating universe structure, we get a free value of Delta E that is almost infinite, supporting a prior conclusion.

Keywords

Quantum Mechanics, Planck's Constant, Potential Energy

1. Introduction

In this document we are revisiting the following statement made earlier [1] [2].

Quote

Using the following

$$T_{ii} = diag\left(\rho, -p, -p, -p\right) \quad (1)$$

Then

$$\Delta T_{tt} \sim \Delta\rho \sim \frac{\Delta E}{V^{(3)}} \quad (2)$$

Then, Equation (1) and Equation (2) together yield

$$\begin{gathered} \delta t \Delta E \geq \frac{\hbar}{\delta g_{tt}} \neq \frac{\hbar}{2} \\ \text{Unless } \delta g_{tt} \sim O(1) \end{gathered} \tag{3}$$

By the initial idea given in Equation (3), the GUP is look complicated at the initial variation, we make the following treatment at the start of expansion of the Universe [1] [2] [3]

$$\delta g_{tt} \sim a^2(t) \cdot \phi \ll 1 \quad \text{Goes to become effectively almost ZERO.} \tag{4}$$

If this is effectively almost zero, the effect would be to embedd Quantum mechanics within a 5 dimensional structure.

Snip

i.e. this deterministic embedding is in part in spirit similar to what is given by Wesson [3].

End of quote

We add more context to this through using the Wesson result directly in our own work and further use it to prove a deterministic contribution in line with Equation (3) and Equation (4).

2. Modus Operandi Statement in Terms of an Inflaton Field

Before proceeding, we state that the inflaton field used in Equation (3) and Equation (4) satisfies the following properties [4] [5] [6],

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

In the spirit of use of the inflaton field what we will propose is that

$$\phi = \ln\left(\sqrt{\frac{8\pi G V_0}{\nu \cdot (3\nu - 1)}} \cdot t\right)^{\sqrt{\frac{\nu}{16\pi G}}} \approx \sqrt{\frac{\nu}{16\pi G}} \cdot \left(\sqrt{\frac{8\pi G V_0}{\nu \cdot (3\nu - 1)}} \cdot t - 1\right) \tag{6}$$

i.e. assuming that if the initial time step is near Planck time which is normalized to 1 that

$$V_0 \approx \text{initial energy} \tag{7}$$

In addition we will go to Wesson [7] and to make the following adjustments.

3. Wesson's Treatment of Embedding of the HUP in Deterministic Structure [7]

$$\left| \mathrm{d}p_{\alpha} \mathrm{d}x^{\alpha} \right| \approx \frac{L}{l} \cdot \frac{h}{c} \cdot \left[\frac{\mathrm{d}l}{l} \right]^2 \tag{8}$$

where we will define l and as follows.

First, we define L in terms of the cosmological "constant" by [7]

$$\Lambda = \frac{1}{3L^2} \tag{9}$$

Also [7]

$$\mathrm{d}S_{5-d}^2 = \frac{L^2}{l^2}\mathrm{d}S_{4-d}^2 - \frac{L^4}{l^4}\mathrm{d}l^2 \tag{10}$$

Also 5 we have a dimensional wave number which is defined via Equation (11) below

$$K_l = 1/l \tag{11}$$

In the case of Pre Planckian space-time the idea is to do the following [7]

$$\begin{aligned} &\left|\mathrm{d}p_\alpha \mathrm{d}x^\alpha\right| \approx \frac{L}{l}\cdot\frac{h}{c}\cdot\left[\frac{\mathrm{d}l}{l}\right]^2 \\ &\xrightarrow[\alpha=0]{} \left|\mathrm{d}p_0 \mathrm{d}x^0\right| \simeq \left|\Delta E \Delta t\right| \approx h/a_{init}^2 \phi(t) \\ &\Rightarrow \frac{L}{l}\cdot\frac{h}{c}\cdot\left[\frac{\mathrm{d}l}{l}\right]^2 \approx h/a_{init}^2\phi(t_{init}) \end{aligned} \tag{12}$$

Use of all this leads to below equation [7],

$$\int_{l_1}^{l_2} \mathrm{d}l/l^{3/2} \approx \frac{l_2 - l_1}{l^{3/2}(c)} \approx \frac{(3\Lambda)^{1/4}}{a_{init}\cdot\left(\frac{\nu}{16\pi G}\right)^{1/4}\cdot\left(\sqrt{\frac{8\pi G V_0}{\nu\cdot(3\nu-1)}}\cdot t - 1\right)^{1/2}} \tag{13}$$

4. Extracting Time Initially from Equation (13) and Assuming Time Equal to Planck Time? Extract V_0

Our approximation is to set $G = 1 = h$ (Planck units) with Planck time normalized to 1. Then

$$t = t_{\text{planck}} \to 1 = \sqrt{\frac{\nu(3\nu-1)}{8\pi V_0}} + \sqrt{\frac{2\cdot(3\nu-1)}{V_0}}\cdot\frac{a_{init}^2\cdot(l_2-l_1)^2}{l^3(c)\cdot(3\Lambda)^{1/2}} \tag{14}$$

Then we have that at Planck time, normalized to 1 we look at

$$V_0 = \left(\sqrt{\frac{\nu(3\nu-1)}{8\pi}} + \sqrt{2\cdot(3\nu-1)}\cdot\frac{a_{init}^2\cdot(l_2-l_1)^2}{l^3(c)\cdot(3\Lambda)^{1/2}}\right)^2 \tag{15}$$

5. At initial Configuration in Planck Time Make the Following Assumption

We assume that we have an emergent space-time. If so, and

$$V_0 = \left(\sqrt{\frac{\nu(3\nu-1)}{8\pi}} + \sqrt{2\cdot(3\nu-1)}\cdot\frac{a_{init}^2\cdot(l_2-l_1)^2}{l^3(c)\cdot(3\Lambda)^{1/2}}\right)^2 \approx \Delta E \tag{16}$$

Implication is, that if we use the present value of the cosmological constant Λ, that the initial energy, as induced by Equation (16) becomes almost infinite, thereby confirming by default what is brought up by Equation (4).

6. Discussion

Our value of the initial energy specifies an almost infinite value, so does this confirm deterministic embedding of the HUP initially in 5 dimensions, in a deterministic structure?

We argue it does, because Equation (16) still uses the 5 dimensional inputs specified by l which is one over a wave number in an additional dimension of space time. Furthermore we can also compare this expression in (16) with [4]

$$V_0 = \left(\frac{0.022}{\sqrt{qN_{\text{efolds}}}}\right)^4 = \frac{\nu(\nu-1)\lambda^2}{8\pi G m_P^2} \tag{17}$$

" λ " is set in our analysis as a dimensionless parameter. From [4] we have a Chameleon mechanism for fifth force as given by reference [4] below

$$F_{\text{5th-force}} = -\frac{\tilde{\beta}\cdot\left(\vec{\nabla}\phi\right)}{m_P} \tag{18}$$

We use here Pre Planckian conditions

$$t = \frac{r}{\varpi c} \tag{19}$$

First, r is almost Planck in length, if so then.

Using this instead of the ω_{gw}^6 expression, then write the rest of it as follows which would have a minimum value as [4] [8]

$$\begin{aligned}
&\omega_{gw}^6 \approx c^7 \times \frac{\tilde{\beta}}{2m_P r}\cdot\sqrt{\frac{\nu}{\pi G}} \times \frac{1}{Gc\cdot\left(M_{\text{mass}}\right)^2\left\langle r^2\right\rangle^2} \\
&\Rightarrow \omega_{gw} \approx G, m_P, r \approx \ell_P \xrightarrow{\text{Planck normalization}} 1 \\
&M_{\text{mass}} \approx \varsigma\cdot m_P \xrightarrow{\text{Planck normalization}} \varsigma \\
&\left\langle r^2\right\rangle^2 \approx \ell_P^4 \xrightarrow{\text{Planck normalization}} 1 \\
&\therefore \omega_{gw} \xrightarrow{\text{Planck normalization}} \left(\sqrt{\frac{\nu}{\pi G}} \times \frac{\tilde{\beta}}{\varsigma^2}\right)^{1/6}
\end{aligned} \tag{20}$$

$$\omega_{gw} \approx \frac{c^{7/6}\tilde{\beta}^{1/6}}{\left(2m_P r\right)^{1/6}}\cdot\left(\frac{\nu}{\pi G}\right)^{1/12}\cdot\frac{1}{\left(GcM_{\text{Mass}}^2\cdot\left\langle r^2\right\rangle^2\right)^{1/6}} \quad \text{so if } G = m_P = \ell_P = 1 \tag{21}$$

We then will conclude this by stating the connection with Equations (16) and (17) so

$$\lambda = \left(\sqrt{\frac{\nu(3\nu-1)}{8\pi}} + \sqrt{2\cdot(3\nu-1)}\cdot\frac{a_{init}^2\cdot\left(l_2-l_1\right)^2}{l^3(c)\cdot(3\Lambda)^{1/2}}\right)\cdot\sqrt{\frac{8\pi}{\nu(\nu-1)}} \tag{22}$$

In doing so, we have thoroughly planted 5 dimensional lengths as given by l into our analysis, with the caveat the value of Equation (16) and Equation (17) can become enormous with a small enough value of the cosmological constant. Note that the expression $\frac{(l_2 - l_1)^2}{l^3(c)}$ has two lengths, l_2 and l_1 in 5 dimensions, with the first length, l_2 larger in magnitude than l_1 and $l^3(c)$ being the cube of the length,

$$l_2 > l(c) > l_1 \tag{23}$$

and

$$a_{init} \approx 10^{-40} \tag{24}$$

Finally the power of initial gravitational waves at the start of the universe is such that [4] [8] [9],

$$\begin{aligned} P_{GW} &\approx \frac{Gc \cdot (M_{\text{mass}})^2 \omega_{gw}^6 \langle r^2 \rangle^2}{c^6} \\ &\approx c \times |F_{\text{5th-force}}| = \left| -c \times \frac{\tilde{\beta} \cdot (\vec{\nabla}\phi)}{m_P} \right| \approx c \times \frac{\tilde{\beta}}{2m_P r} \cdot \sqrt{\frac{\nu}{\pi G}} \end{aligned} \tag{25}$$

This concluding discussion will allow for setting as given in our manuscript a specific value for $\tilde{\beta}$.

7. Conclusion

We investigated the quantum mechanics along with the concepts of Heisenberg Uncertainty Principle, small scale factor and Inflaton field in the context of 5 dimensional Embedding. Using Wesson's treatment of Embedding we conclude that delta t is Planck time and resulted in enormous induced Energy and becomes almost infinite, by a repeating universe structure. This induced energy is basically potential energy and it confirms the Embedding of the HUP initially in 5 dimensions within Deterministic Structure. We found that QM is embedded in 5^{th} dimensional embedding come about due to deterministic setting implying small scale factor and Inflaton field values initially. The reason for this inquiry is to determine an onset of when quantum conditions apply. A summary of what we have tried to prove is that quantum mechanics as represented by the HUP is embedded in a deterministic setup at the onset of the universe, with the results that Corda's results of no firewalls, for black holes due to a mix of quantum physics, and relativistic effects applies after the start of the expansion of the universe as given in [10].

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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