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Examining a Fifth Force Application by Using Dilaton Model and Padmanabhan Inflaton Scalar Field in Early Universe to Generate GW and Gravitons

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Abstract

On page 17 of a book on Modified Gravity by Li and Koyama, there is a discussion of how to obtain a Fifth force by an allegedly non-relativistic approximation with a force proportional to minus the spatial derivative of a scalar field. If the scalar field says for an inflaton, as presented by **Padmanabhan** only depends upon time, of course, this means that no scalar field contributing to a fifth force our proposal in the neighborhood of Planck time is to turn the time into being equal to r/[constant times c]. This is in the neighborhood of Planck time. Then having done that, consider the initially Plank regime inflaton field as being spatially varying and from there apply a fifth force as a way to help initiate black hole production and possibly Gravitons.

Keywords

Dilaton Model, Padmanabhan Inflaton Scalar Field, GW, Gravitons

1. Start off with the Following from [1] [2] with an Assumed Value as Stated

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

This of course makes uses of

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

We will make the following calculation [3] [4] where we start off with [3], page 19 that

$$A(\phi) = 1 + \frac{\phi^2}{2m_S} = 1 + \frac{A_2\phi^2}{2m_P} = 1 + \frac{\phi^2}{2\tilde{\beta}m_P} \tag{3}$$

Whereas

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

We can then set the coefficient λ as a dimensionless parameter which can be calculated by Equation (4).

And then we close this with the input from [3], page 17 as looking at the Chamelon mechanism for fifth force as

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

Here is the thing. If the scalar field was solely defined in terms of Equation (1), we would only have time dependence, meaning that we would have Equation (5) as equal to zero. Now, we assume a Pre Planckianto Planckian regime approximation where this is not true.

2. How We Can Have a Transition from PRE Planckian to Planckian Regime of Space-Time. This So Eq. (5) is Not Zero Valued

To do this, we will assume in an initial "bubble' of space-time that we can make the initial approximation of, assuming c is the speed of light, and r is a radial spatial dimension of

$$t = \frac{r}{\varpi c} \tag{6}$$

The term of ϖ is a dimensionless value less than or at most equal to the value 1, and never negative.

If so, then Equation (5) will yield a radial force component which we will write as [3] [4]

$$F_{\text{5th-force}} = -\frac{\tilde{\beta} \cdot (\nabla\phi)}{m_P} \approx -\frac{\tilde{\beta}}{2m_P r} \cdot \sqrt{\frac{\nu}{\pi G}} \tag{7}$$

3. What Is the Power of Production of Gravitons Due to an Initial Fifth Force? How This Would Initially Lead to an Almost Infinite Expansion Speed for Starting Universe Conditions

The easiest way is to look at power expressions for GW and to make them linked to Equation (7).

We will discuss next what this non zero value of a fifth force would have to do with the nearly infinite degrees of problem next, and to do this first remember that Power = Force, time velocity. To start this off look at

$$P = \text{Power} = F\left(\text{force}\right)\times v\left(\text{velocity}\right) \tag{8}$$

This is very elementary. We will do some very simplified models of how to have Power in terms of gravitational waves discussed, and then link that to Gravitons, as a first start [5] [6] [7].

Begin first with a simple expression for power of the form [7],

$$P_{GW} \approx \frac{GM_{\text{mass}}\omega_{gw}^{2}}{c^{2}} \tag{9}$$

Usually, the mass M above in Equation (9) is moving. But take into account if we want to look at GW quadrupoles, [6], page 3123 of that reference

$$\ddot{Q}^{2} \approx \left[\left(\frac{\omega_{gw}^{2}}{c^{2}}\right)\cdot\left\langle r^{2}\right\rangle\right]^{2} \tag{10}$$

Whereas

$$P_{GW} \approx \frac{Gc\cdot\left(M_{\text{mass}}\right)^{2}\omega_{gw}^{6}\left\langle r^{2}\right\rangle^{2}}{c^{6}} \tag{11}$$

Our first stop is to look at comparing the absolute value of Equation (7) times c (speed of light) as

$$\begin{aligned} P_{GW} &\approx \frac{Gc\cdot\left(M_{\text{mass}}\right)^{2}\omega_{gw}^{6}\left\langle r^{2}\right\rangle^{2}}{c^{6}} \approx c\times\left|F_{\text{5th-force}}\right| \\ &= \left|-c\times\frac{\tilde{\beta}\cdot\left(\nabla\phi\right)}{m_{P}}\right| \approx c\times\frac{\tilde{\beta}}{2m_{P}r}\cdot\sqrt{\frac{\nu}{\pi G}} \end{aligned} \tag{12}$$

This then would have, given this, a corresponding GW behavior, which we would give as

$$\begin{aligned} \omega_{gw}^{6} &\approx c^{7}\times\frac{\tilde{\beta}}{2m_{P}r}\cdot\sqrt{\frac{\nu}{\pi G}}\times\frac{1}{Gc\cdot\left(M_{\text{mass}}\right)^{2}\left\langle r^{2}\right\rangle^{2}} \\ \Rightarrow \omega_{gw} &\approx \left(\sqrt{\frac{\nu}{4\pi G}}\times\frac{\tilde{\beta}\cdot c^{6}}{G\cdot\left(M_{\text{mass}}\right)^{2}m_{P}r\cdot\left\langle r^{2}\right\rangle^{2}}\right)^{1/6} \end{aligned} \tag{13}$$

Now, normalizing this in terms of Planck Unit normalization where we can make the following substitutions

$$\begin{aligned} &\omega_{gw}^{6} \approx c^{7}\times\frac{\tilde{\beta}}{2m_{P}r}\cdot\sqrt{\frac{\nu}{\pi G}}\times\frac{1}{Gc\cdot\left(M_{\text{mass}}\right)^{2}\left\langle r^{2}\right\rangle^{2}} \\ &\Rightarrow \omega_{gw} \approx G, m_{P}, r \approx \ell_{P} \xrightarrow{\text{Planck normalization}} 1 \\ &M_{\text{mass}} \approx \varsigma\cdot m_{P} \xrightarrow{\text{Planck normalization}} \varsigma \\ &\left\langle r^{2}\right\rangle^{2} \approx \ell_{P}^{4} \xrightarrow{\text{Planck normalization}} 1 \\ &\therefore \omega_{gw} \xrightarrow{\text{Planck normalization}} \left(\sqrt{\frac{\nu}{4\pi}}\times\frac{\tilde{\beta}}{\varsigma^{2}}\right)^{1/6} \end{aligned} \tag{14}$$

We find then we have something very expected. That in the immediate beginning of inflation, that the fifth force, will be yielding an almost Planck frequency value of 1.855 times 10^43 Hertz, we would need to have the term ν be roughly proportional to 10^502 which would be factored into Equation (1) and the scale factor value for the term ν. This would mean effectively that for the fifth force argument that we would have an almost infinitely quick expansion in the neighborhood of Planck length for the start of inflation. A hardly surprising development in terms of cosmological evolution...

What this means is that we should make a linkage between the coefficient ν in the initial genesis of GW which will be seen to be in the Planckian space-time to be

$$\nu \xrightarrow{\text{Planck normalization}} 4\pi \times \left(\omega_{gw}\right)^{12} \times \frac{\left(\varsigma\right)^{4}}{\tilde{\beta}^{2}} \tag{15}$$

If we are looking at Planck time, and assuming we have Plank frequency, this means in the Planck era $\nu \propto \left(\omega_{\text{Planck}}\right)^{12}$, meaning that the rate of expansion in the early universe is commensurate with inflation.

4. Interpreting the Value of the Force Assumed in Terms of Ehrenfests Theorem

From Gasiorowitz, [5]

$$F = \frac{\mathrm{d}\langle p\rangle}{\mathrm{d}t} = -\left\langle \frac{\mathrm{d}V}{\mathrm{d}r} \right\rangle_{t} \tag{16}$$

We can interpret this in our situation as leading to

$$\langle p\rangle = -\frac{\tilde{\beta}}{2m_{P}} \cdot \sqrt{\frac{\nu}{\pi G}} \cdot \frac{\ln t}{\varpi c} \tag{17}$$

For sufficiently small time step, t, this would be leading to using a simple version of the uncertainty principle, [5]

$$\begin{aligned} &\text{If } \langle p\rangle \approx \Delta p \approx \frac{\tilde{\beta}}{2m_{P}} \cdot \sqrt{\frac{\nu}{\pi G}} \cdot \frac{\left|\ln \varepsilon^{+}\right|}{\varpi c} \\ &\Delta p \Delta x \approx \hbar \Rightarrow \Delta x \approx \frac{\hbar}{\frac{\tilde{\beta}}{2m_{P}} \cdot \sqrt{\frac{\nu}{\pi G}} \cdot \frac{\left|\ln \varepsilon^{+}\right|}{\varpi c}} \le l_{P} \end{aligned} \tag{18}$$

Meaning that we would have increasingly high momentum, leading to enormous energy values, for sufficiently small time say smaller than Planck time.

5. Relationship to Energy Values, and Also the Degrees of Freedom Initially

In an earlier paper, we have the following value for initial mass [8]

$$\begin{aligned} M &= \sqrt{\sqrt{g_{*}} \cdot \frac{1.66\hbar}{64\pi^{2} m_{P} G^{2} k_{B}^{2}}} \cdot \sqrt{\frac{t}{\gamma}} \sqrt{N_{\text{Gravitons}}} \cdot m_{\text{Planck}} \\ &\xrightarrow{\text{Planck Units}} \approx \sqrt[4]{g_{*}} \cdot \sqrt{\frac{1.66}{64\pi^{2}}} \cdot m_{\text{Planck}} \approx \sqrt{N_{\text{Gravitons}}} \cdot m_{\text{Planck}} \approx 10^{60} \cdot m_{\text{Planck}} \end{aligned} \tag{19}$$

If so then the strange situation we have would be resolvable if

$$\sqrt[4]{g_*}\cdot\sqrt{\frac{1.66}{64\pi^2}}\approx 10^{60} \tag{20}$$

i.e. the initial degrees of freedom, would be a staggering value of about

$$g_*\approx 10^{240}\cdot\left(\frac{64\pi^2}{1.66}\right)^2\approx 10^{240}\times 144791\propto 10^{245} \tag{21}$$

The magnitude of Equation (21) is assumed to have a value ten to the 245 value, whereas the value of the fourth power of the degrees of freedom, is 10 to about the 61st power.

Effectively this means that the contribution to the degrees of freedom just before inflation is nearly infinite.

Why is this important? Again by [8] we obtained that

$$\begin{aligned}&m_{\text{graviton}}\approx 10^{-60}m_P\Rightarrow N_{\text{Gravitons}}\approx 10^{120}\\&\Rightarrow N_{\text{Gravitons}}\approx 10^{120}\approx S_{\text{entropy}}\\&\Leftrightarrow g_*\approx 10^{240}\cdot\left(\frac{64\pi^2}{1.66}\right)^2\approx 10^{240}\times 144791\propto 10^{245}\end{aligned} \tag{22}$$

If we are using Planck Values, what we have is that the degrees of freedom, independent of assumed entropy values will commence to have an enormous value for M, and if we are using in Planck units that E, energy, is the same as mass, we are stating that our construction will be leading to for high degrees of freedom.

This is directly due, if we are assuming a non zero fifth force, due to an initial value of $t=\dfrac{r}{\varpi c}$ that the value of Equation (5) would be a large negative value, and if we are correct this substitution into Equation (5) for an inflaton we would write as

$$\phi\left(\frac{r}{\varpi c}\right)=\sqrt{\frac{\nu}{4\pi G}}\ln\left(\sqrt{\frac{8\pi G V_0}{\nu(\nu-1)}}\cdot\left(\frac{r}{\varpi c}\right)\right) \tag{23}$$

We will next discuss the meaning and comments as to the fifth force as we see it in terms of the Dilaton model.

6. Dilaton Model and Extension beyond General Relativity

In [3], page 17, the following is given as a Non-relativistic geodestic equation for a "test particle"

$$\ddot{\boldsymbol{x}}=-\nabla\Psi-\frac{\tilde{\beta}\cdot(\nabla\phi)}{m_P} \tag{24}$$

The first term has a gravitational potential Ψ. The second term involves the fifth force. What we have assumed in this Pre Planck to Planck regime is that we are neglecting, in this Ψ. In a word for Pre Planck to Plank physics what we are assuming is

$$\ddot{\boldsymbol{x}} = -\vec{\nabla}\Psi - \frac{\tilde{\beta}\cdot(\nabla\phi)}{m_P} \xrightarrow[\text{Pre Planck}]{} \ddot{\boldsymbol{x}} = -\frac{\tilde{\beta}\cdot(\nabla\phi)}{m_P} \tag{25}$$

The assumption is for our idea the following

$$\begin{aligned}
&-\nabla\Psi \xrightarrow[\text{Pre Planck}]{} 0 \\
&-\frac{\tilde{\beta}\cdot(\nabla\phi)}{m_P} \xrightarrow[\text{Pre Planck}]{} \text{NOT zero} \\
&t \xrightarrow[\text{Pre Planck}]{} t = \frac{r}{\varpi c} \\
&t \xrightarrow[\text{Planck}]{} t \neq \frac{r}{\varpi c} \\
&-\frac{\tilde{\beta}\cdot(\nabla\phi)}{m_P} \xrightarrow[\text{Planck}]{} \text{Very small value} \\
&-\nabla\Psi \xrightarrow[\text{Planck}]{} \text{Not zero}
\end{aligned} \tag{26}$$

In addition as far as the term in Equation (4), this also is tied into the following comparison [1] [2] [3] [4]

$$V(\phi) = V_0 \exp\left(-\frac{\lambda\phi}{m_P}\right) \leftrightarrow V_0 \exp\left(-\sqrt{\frac{16\pi G}{\nu}}\cdot\phi\right) \tag{27}$$

In the regime of Pre Planck physics, we are presuming that Equation (5) would be enormous, whereas the fifth force as we are describing it here for Plank regime and beyond would be extremely small, and the Gravitational physics term due to a gravitational potential Ψ would predominate in Equation (24).

7. Review and Summary, before Discussion of Gravimagnetism

The idea in a word is to assume, via a deviation from usual relativity and also Newtonian physics the existence of a fifth force which in the Pre Planckian to Planckian regime may have a cache as far as developing conditions for a very large initial degrees of freedom value.

We are considering what if Equation (5) and Equation (6) insert fifth force physics into cosmology in a convincing manner.

What has to be determined are experimental verifications of Equation (23) and Equation (24). Otherwise what we are doing is not going to have any experimental falsifiability.

Furthermore in this is the assumption put in as far as a non singular start to the expansion of the Universe

Some sort of experimental verification of both these details is recommended.

Finally the model included as far as [9] and [10] need to be looked at as well.

8. Gravimagnetism as a Wrap up and Concluding Remarks

We will conclude with a discussion of Gravimagnetism and its possible links to this problem [11]. Whereas on page 48 of [11]

$$\begin{aligned}&\frac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t} \equiv -grad\,\phi + 2\boldsymbol{\Omega}\times\boldsymbol{v}\\&\leftrightarrow \text{Lorentz-force} = \boldsymbol{K} = q\cdot\left(\boldsymbol{E} + \frac{\boldsymbol{v}}{c}\times\boldsymbol{B}\right)\end{aligned} \tag{28}$$

In this case, the Electromagnetic correspondences are exact whereas the Einstein equations result of the first line of Equation (28) is approximate.

What we are indicating is that in the Pre Planck regime of space-time that what is actually an imprecise linearized

$$\frac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t} \equiv -grad\,\phi + 2\boldsymbol{\Omega}\times\boldsymbol{v} \tag{29}$$

We assume the contrary development from assumed precision, to using the following approximation. Namely, in the Pre Planckian regime, we will actually have

$$\frac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t} \equiv -grad\,\phi + 2\boldsymbol{\Omega}\times\boldsymbol{v} \xrightarrow[\text{Pre Planckian}]{} \frac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t} \equiv -grad\,\phi \approx -\partial_r\phi \tag{30}$$

Whereas we have the time component of the term

$$\phi(t) \xrightarrow[\text{Pre Planckian}]{} \phi\left(\frac{r}{\varpi c}\right) \tag{31}$$

The feasibility of Equation (30) and Equation (31) as well as the match up given in Equation (29) and its linkages to Equation (28) need to be confirmed in experimental vetting of data sets.

If this is done, then the following Graviton condensate relationship as argued by the author before should also be examined as far as experimental verification, especially if the initial configuration of the Universe right after the Pre Planck physics written out is amendable to black holes in the start of inflation [12]

$$\begin{aligned}&m \approx \frac{M_P}{\sqrt{N_{\text{gravitons}}}}\\&M_{BH} \approx \sqrt{N_{\text{gravitons}}}\cdot M_P\\&R_{BH} \approx \sqrt{N_{\text{gravitons}}}\cdot l_P\\&S_{BH} \approx k_B\cdot N_{\text{gravitons}}\\&T_{BH} \approx \frac{T_P}{\sqrt{N_{\text{gravitons}}}}\end{aligned} \tag{32}$$

Having a change in initial conditions from Pre Planckian physics to Planckian physics would be enough to initiate shifting from Equation (28), Equation (29) and Equation (30) to initiate the beginning of black hole physics, if we are correct and Equation (32) being applied as well as if m in Equation (32) is actually the mass of a graviton.

If so, by Novello [11] [13] we then have a bridge to the cosmological constant as given by

$$m_g = \frac{\hbar\cdot\sqrt{\Lambda}}{c} \tag{33}$$

Answering a question raised by the head editor of JHEPGC, the value given in Equation (33) as to when the graviton may have a small mass forming is of the order of Planck time to have a maximum value of when Equation (33) may be valid of say 10 to the minus 3 seconds, *i.e.* we are saying that the magnitude of the preconditions for the formation of "heavy graviton" mass will be commensurate with the inflation process.

In a word, the next step to ascertain would be how Equation (31), as given breaks down, and then we have application of Equation (32) with m set with m becoming the mass of a graviton as given in Equation (33).

Confirming these details should be the object of future research as can also be seen in [13]. In addition, we have the argument given in [14] as to use another procedure as to the choice of the Starobinsky potential as well as the Adler, Bazin and Shiffer as to the use of radial acceleration as a way of confirming the cosmological constant.

The way indicated in [14] may be a way to fix the value of m, after determining M, as an input into Equation (32) and then from there ascertain the right-hand side of Equation (33) whereas in [8], we will be determining the right-hand side of Equation (33), namely Λ and then after doing that, assuming Equation (33) to work backwards into the M of Equation (32).

That is how to reconcile the [8] and [14] references whereas we will be using this current document to ascertain the existence of a Fifth force which would be a bridge between Pre Planckian to Planckian physics, finally though what is implicitly assumed is [15], and which is an application of Klauder enhanced quantization.

Finally is the imponderable, *i.e.* the generalization of Penrose CCC theory, which is in [8], which is a generalization of what is in Penrose single universe recycling of universes which may be seen in [16].

All these steps need to be combined and rationalized into three different pieces.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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