Fifth force potentials, compared to Yukawa modification of Gravity for massive Gravitons, to link Gravitation, and NLED modified GR

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We use a linkage between gravitation and electrodynamics the author shared with Unnishkan . First step will be to write up a Yukawa potential modification of Gravity for the usual 1/r potential, and comparing it to fifth force potentials.. Details as to NLED and Unnishkhan's theories are added for an electromagnetic flavor to fifth force considerations. Leading to a first principle evaluation of the primordial graviton mass as linked to NLED.

Keywords: heavy gravity, fifth forces

1. Introduction; defining the problem in terms of α_{ij}

We start off with a description of both the Fifth force hypothesis of Fishbach and Talmadge[1] as well as what Unnishkan brought up in Rencontres De Moriond[2,3] with one of the predictions dove tailing closely with use of Gravitons as produced by early universe phase transition behaviour, leading to how QM relates to a semi classical approximation for E and M and other physical processes. For the Fifth force used, we use Fishbach[1], namely

$$V_{5th-force} = \frac{-G_{\infty} \cdot m_i \cdot m_j \cdot \left(1+\alpha_{ij} \exp(-r/\lambda)\right)}{r} \tag{1}$$

Here, then if $m_i = \mu_i \cdot m_H$, and if $\xi = f^2 / G_{\infty} m_H^2$, then

$$\alpha_{ij} = -Q_i \cdot Q_j \cdot \xi / \mu_i \mu_j \tag{2}$$

Eq. (1) and Eq.(2) should be compared with the gravitational potential of a Yukawa type which looks like

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$$V_{heavy-gravity} = \frac{-G_{\infty} \cdot m_i \cdot m_j \cdot \exp(-\kappa \cdot m_{graviton} \cdot r)}{r} \quad (3)$$

If we take the spatial derivatives of Eq. (1) and Eq. (3) with respect to r, and equate the results for force , we obtain that the range of the fifth force λ is

$$\lambda^2 \approx \frac{\alpha_{ij}}{\left(\frac{\alpha_{ij}}{r^2} - 1 + \left(\kappa \cdot m_{graviton}\right)^2\right)} \xrightarrow[\alpha_{ij} \to (\# \neq 0)]{m_{graviton} \to \varepsilon_{(small)}} r^2 \quad (4)$$

We will now determine something of the forces connected with Eq.(1) and Eq.(3) to see if the fifth force is , indeed, almost infinite in duration . And this will entail looking at the influence of what the fifth force charges as we can determine them due to the suggestion made by Dr. Unnishkan in Rencontres Du Moriond [2,3] . Obtaining more precise information for the fifth force charges, as to ask how applicable Eq.(4) is, when we consider Heavy Gravity. This is

$$\left| Q_i \cdot Q_j / G_{\infty} \cdot m_i \cdot m_j \right| \approx 10^{-1} - 10^{-3} \quad (5)$$

The first part of our document will compare the force so created by Eq.(1) with the situation created by a more typical Yukawa potential for gravity when there is a massive Graviton, with a value initially calculated as in the conclusion. We have that Unnishkan shared in Rencontres Du Moriond [2,3] which is an extension of what he did in [3], i.e. looking at, if $i_1 \& i_2$ are currents in electricity and magnetism, and $i_{1g} \& i_{2g} = m_1 v_1 \& m_2 v_2$, are what we do with a linkage between Gravity and electromagnetism with $m_1 v_1$ and $m_2 v_2$ the mass times the velocity of particle 1 and particle 2 , so that the following, up to a point holds

$$\left[\frac{i_1 \cdot i_2}{r^2} = k \cdot \frac{(q_1 \cdot v_1)(q_2 v_2)}{r^2}\right]_{E\&M} \sim \left[\frac{G}{c^2} \cdot \frac{i_{1g} \cdot i_{2g}}{r^2} = \frac{G}{c^2} \cdot \frac{(m_1 \cdot v_1)(m_2 v_2)}{r^2}\right]_{Gravity} \quad (6)$$

$$\frac{dA}{dt} \equiv \frac{\Phi_N}{c^2} \cdot \frac{dv_i}{dt} \quad (7)$$

The above relationship with its focus upon interexchange relations between gravity and magnetism is in a word focused upon looking at , if A, the nominal vector potential used to define the magnetic field as in the Maxwell equation, the relationship we will be using at the beginning of the expansion of the universe, is a variation of the quantized Hall effect, i.e. from Barrett [4], the current I about a loop with regards to electronic energy U, of a loop with the A vector potential going through the loop is given by, if L is a unit spatial length, and we approximate the beginning of the universe as having some of the same characteristics as a quantized Hall effect, then, if n is a particle count, then [4]

$$I(current) = (c / L) \cdot \frac{\partial U}{\partial A} \Leftrightarrow A = n \cdot \hbar \cdot c / e \cdot L \tag{8}$$

We will be taking the right hand side of the A field, in the above, and approximate Eq.(4) as given by

$$\frac{dA}{dt} \approx \frac{dn}{dt} \cdot \left(\hbar \cdot c / e \cdot L \right) \tag{9}$$

Then, we have an approximation for writing [4]

$$\frac{dA}{dt} \approx \frac{dn}{dt} \cdot \left(\hbar \cdot c / e \cdot L \right) \equiv \frac{\Phi_N}{c^2} \cdot \frac{dv_i}{dt} \Leftrightarrow \Phi_N \approx \frac{dn}{dt} \cdot \left(\hbar \cdot c^3 / e \cdot L \right) / \left(\frac{dv_i}{dt} \right) \tag{10}$$

Eq. (10) needs to be interpolated, up to a point. I.e. in this case, we will conflate the n, here as a ‘graviton’ count, initially, i.e. the number of early universe gravitons, then assume that dv_i / dt is a net acceleration term linked to the beginning of inflation, i.e. that we look then at Ng’s ‘infinite’ quantum statistics [5] , with entropy given as , initially a count of gravitons,. Then , we refer to the n of Eq. (5) to Eq. (7) being the number of particles , and entropy is by Ng, [5] $S \sim n_{gravitons}$ .This shows up in the end of our document.

2. Entropy, its spatial configuration near a singularity and how we use this definition , with NLED inputs

The usual treatment of entropy, if there is the equivalent of a event horizon is, that (Padmanabhan) [6] with $r_{critial}$ to be set at the end of the article. And L in Eq. (7) is of the order of magnitude proportional to L_P. i.e. also to be set at the end of this article, i.e. we will suggest a formal relationship between L and L_P. Here

$$S(classical-entropy)=\frac{1}{4L_P^2}\cdot\left(4\pi r_{critial}^2\right)\Leftrightarrow Energy\equiv\frac{c^4}{2G}\cdot r_{critial} \tag{11}$$

If so, then we have that from first principles

$$\frac{dn}{dt}\sim 2\pi L_P^{-1} r_{critical}\cdot\frac{dr_{critical}}{dt} \tag{12}$$

Then Eq. (7) is re written in terms of [4] adopted formulation as given by

$$\Phi_N\approx\frac{dn}{dt}\cdot\left(\hbar\cdot c^3/e\cdot L\right)/\left(\frac{dv_i}{dt}\right)\propto 2\pi\frac{r_{critical}}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\frac{dv_i}{dt}\right)^{-1}\left(\hbar\cdot c^3/e\cdot L\right) \tag{13}$$

The following parameters will be identified, i.e. what is dv_i/dt , what is L, and what is $r_{critical}$. These values will be set toward the end of the manuscript, with the consequences of the choices made discussed in this document as suggested new areas of inquiry. However, Eq.(13) will then imply

$$\frac{dA}{dt}\sim 2\pi\frac{r_{critical}}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right) \tag{14}$$

If the value of the time derivative of $r_{critical}$ is ALMOST time independent, Eq.(14) will then lead to a primordial value of the A vector field , for which we can set the E field

$$E\sim -c^{-1}\cdot\left[\frac{2\pi}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right)\cdot\left(r_{critical}+t\cdot\frac{dr_{critical}}{dt}\right)\right]-\nabla\phi \tag{15}$$

To reconstruct ϕ we have that we will use $\nabla\cdot A=-c^{-1}\cdot\frac{\partial\phi}{\partial t}$ by [4] . Then if

$$\phi\sim -t^2\cdot\left[\frac{\pi}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right)\right] \tag{16}$$

The density, then is read as by [4]

$$\rho=-\frac{1}{4\pi c^2}\cdot\frac{\partial^2\phi}{\partial t^2}\sim\frac{1}{2L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right) \tag{17}$$

The current we will work with, is by order of magnitude [4] similar to Eq.(18)

$$J = \frac{1}{4\pi c} \cdot \frac{\partial^2 A}{\partial t^2} \sim \frac{2}{L_P} \cdot \left(\frac{dr_{critical}}{dt} \right)^2 \cdot \left(\hbar \cdot c / e \cdot L \right) \tag{18}$$

Then we get a magnetic field, based upon the NLED approximation [7,8]

$$\rho_\gamma = \frac{16}{3} \cdot c_1 \cdot B^4 \sim \frac{1}{2L_P} \cdot \frac{dr_{critical}}{dt} \cdot \left(\hbar \cdot c^2 / e \cdot L \right)$$
$$\Leftrightarrow B_{initial} \sim \left(\frac{3}{32 L_P \cdot c_1} \cdot \frac{dr_{critical}}{dt} \cdot \left(\hbar \cdot c^2 / e \cdot L \right) \right)^{1/4} \tag{19}$$

Then we can also talk about an effective charge of the form, given by applying Gauss's law to Eq.(20) of the form

$$Q = \varepsilon_0 \oint_S E \cdot n \cdot da = \int_V \rho_\gamma dV \sim \frac{2\pi r^3_{critical}}{3L_P} \cdot \frac{dr_{critical}}{dt} \cdot \left(\hbar \cdot c^2 / e \cdot L \right) \tag{20}$$

This charge, Q, so presented, will be part of the effective 5th force [1] , as to linking E and M and gravity, of Eq. (1) . Furthermore,

$$Energy \sim \rho_\gamma \cdot \left(r_{critial}{}^3 \right) = \frac{16}{3} \cdot c_1 \cdot \left(r_{critial}{}^3 \right) \cdot B^4 \sim \frac{\left(r_{critial}{}^3 \right)}{2L_P} \cdot \frac{dr_{critical}}{dt} \cdot \left(\hbar \cdot c^2 / e \cdot L \right) \sim \frac{c^4}{2G} \cdot r_{critial} \tag{21}$$

Then $dr_{critical} / dt \sim c$, and by Padmabhan [9], $G\hbar = L_P^2 c^3$, so $n_{initial} \sim 10^{37}$ and

$$r^2_{critial} \sim n_{initial} \frac{L_P^2}{\pi} \Leftrightarrow E_{initial} \equiv \frac{c^4}{2G} \cdot r_{critial} \sim \frac{c^4 L_P}{2G} \sqrt{\frac{n_{initial}}{\pi}} \tag{22}$$

3. Conclusion.

We obtain a lower bound for the Magnetic field implying a graviton frequency, and we set the graviton frequency according to the magnetic field being initially less than 1 Tor with the E and B fields of the same magnitude , using [8]

$$B > \frac{1}{2 \cdot \sqrt{10 \mu_0 \cdot \omega}} \tag{23}$$

and the initial E field is given by Eq. (22), then if $n_{initial} \sim 10^{37} \sim$ N for a graviton count in a universe smaller than 1 meter in diameter, α_{ij} is then sufficiently small so Eq. (4) in its limits hold, as well. In addition by having $\omega_{initial}\big|_{r_H \sim 1meter} \sim 10^{21} Hz$ and [9]and [10] using $N = N_{graviton}\big|_{r_H} = \frac{c^3}{G \cdot \hbar} \cdot \frac{1}{\Lambda}$, with

$$m_{graviton} = \frac{\hbar}{c} \cdot \sqrt{\frac{(2\Lambda)}{3}} \qquad (24)$$

if we are using $n \doteq n(particles) = n(gravitons) = N$. Note that the numerical values then link a setting of graviton mass directly to the value of the E field. We should compare this N with the todays entropy , with S ~ N given in [11].

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