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 supposition are added to add an electromagnetic flavor to the fifth force considerations. Leading to a crude initial calculation of mass of a graviton

Keywords: heavy gravity, fifth force, Non linear Electrodynamics,

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 the following from Fishbach [1], namely what is admittedly an oversimplified model , as

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

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

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

If we take the spatial derivatives of Eq. (1) and Eq. (3) with respect to r, and equate the results for force , we obtain after some round off and algebra that the effective range of the fifth force λ is, then in the limit of almost vanishing mass for a graviton, up to first order

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

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 (is it a short or long distance force ? And this will entail looking at the influence of what the fifth force charges as we can determine them due to the suggestion which was made by Dr. Unnishkan made in Rencontres Du Moriond [2,3] . In doing so we are supplying details to α_{ij} . Our supposition is that Eq. (4) holds even the beginning of the universe. I.e. the fifth force is limitless.

2. Obtaining more precise information for the fifth force charges, as to ask how applicable Eq.(4) is, when we consider Heavy Gravity

This second term in the Eq. (1) potential has fifth force charges we set as[1]

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

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[2,3]

$$\left[\frac{i_1 \cdot i_2}{r^2} = k \cdot \frac{(q_1 \cdot v_1)(q_2 v_2)}{r^2} \right]_{E\&M} \sim \left[\frac{G}{c^2} \cdot \frac{i_{1g} \cdot i_{2g}}{r^2} = \frac{G}{c^2} \cdot \frac{(m_1 \cdot v_1)(m_2 v_2)}{r^2} \right]_{Gravity} \tag{3}$$

$$\frac{dA}{dt} \equiv \frac{\Phi_N}{c^2} \cdot \frac{dv_i}{dt} \tag{4}$$

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 E and M 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 being the same as a quantized Hall effect, then, if n is a particle count sort, then[4]

$$I(current) = (c/L) \cdot \frac{\partial U}{\partial A} \Leftrightarrow A = n \cdot \hbar \cdot c/e \cdot L \tag{5}$$

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

$$\frac{dA}{dt} \approx \frac{dn}{dt} \cdot \left(\hbar \cdot c/e \cdot L\right) \tag{6}$$

Then, we have an approximation for writing [2,3]

$$\frac{dA}{dt} \approx \frac{dn}{dt} \cdot \left(\hbar \cdot c/e \cdot L\right) \equiv \frac{\Phi_N}{c^2} \cdot \frac{dv_i}{dt} \Leftrightarrow \Phi_N \approx \frac{dn}{dt} \cdot \left(\hbar \cdot c^3/e \cdot L\right) / \left(\frac{dv_i}{dt}\right) \tag{7}$$

Eq. (7) 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 which will be 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, with $\mathbb{N}$ a generalized count. Then , if $\mathbb{N} \doteq n(particles)$, and we refer to the n of Eq. (5) to Eq. (7) as being the same as $\mathbb{N}$, keeping in mind some pitfalls of entropy in spacetime considerations as given in [5] $S \sim \mathbb{N} \approx \mathbb{N}_{Graviton-count}(\inf) \sim n_{gravitons}$ .This shows up as important in the very end of our document.

3. Entropy, its spatial configuration near a singularity and how we use this definition to work in effects of non linear electrodynamics

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, with suggestions for future work. 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 we leave this as to be a determined parameter

$$S(classical-entropy)=\frac{1}{4L_P^2}\cdot\left(4\pi r_{critial}^2\right)\Leftrightarrow Energy\equiv\frac{c^4}{2G}\cdot r_{critial} \qquad (8)$$

If so, then we have that from first principles, (and here we also will set a value $dr_{critical}/dt$ formally at the end of the paper, with suggested updates as far as an investigation)

$$\frac{dn}{dt}\sim 2\pi L_P^{-1}r_{critical}\cdot\frac{dr_{critical}}{dt} \qquad (9)$$

Then Eq. (7) is re written in terms of [2,3] adopted formulation as given by

$$\Phi_N\approx\frac{dn}{dt}\cdot\left(\hbar\cdot c^3/e\cdot L\right)/\left(\frac{dv_i}{dt}\right)\propto 2\pi\frac{r_{critical}}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\frac{dv_i}{dt}\right)^{-1}\left(\hbar\cdot c^3/e\cdot L\right) \qquad (10)$$

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.(10) will be linkable to re writing Eq. (4) as

$$\frac{dA}{dt}\sim 2\pi\frac{r_{critical}}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right) \qquad (11)$$

If the value of the time derivative of $r_{critical}$ is ALMOST time independent, Eq.(11) will then lead to a primordial value of the magnitude of the A vector field , for which we can set the E field

$$E\sim -c^{-1}\cdot\left[\frac{2\pi}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right)\cdot\left(r_{critical}+t\cdot\frac{dr_{critical}}{dt}\right)\right]-\nabla\phi \qquad (12)$$

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

$$\phi\sim -t^2\cdot\left[\frac{\pi}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right)\right] \qquad (13)$$

Thereby

$$E\sim -c^{-1}\cdot\left[\frac{2\pi}{L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right)\cdot\left(r_{critical}+t\cdot\frac{dr_{critical}}{dt}\right)\right] \qquad (14)$$

The density, then is read as

$$\rho = -\frac{1}{4\pi c^2}\cdot\frac{\partial^2\phi}{\partial t^2} \sim \frac{1}{2L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right) \tag{15}$$

The current we will work with, is by order of magnitude similar to Eq.(16) of

$$J = \frac{1}{4\pi c}\cdot\frac{\partial^2 A}{\partial t^2} \sim \frac{2}{L_P}\cdot\left(\frac{dr_{critical}}{dt}\right)^2\cdot\left(\hbar\cdot c/e\cdot L\right) \tag{16}$$

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

$$\begin{aligned}
&\rho_\gamma = \frac{16}{3}\cdot c_1\cdot B^4 \sim \frac{1}{2L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right)\\
&\Leftrightarrow B_{initial} \sim \left(\frac{3}{32L_P\cdot c_1}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right)\right)^{1/4}
\end{aligned} \tag{17}$$

Then we can also talk about an effective charge of the form, given by applying Gauss's law to Eq.(18) of the form

$$Q = \varepsilon_0\oint_S E\cdot n\cdot da = \int_V \rho_\gamma dV \sim \frac{2\pi r^3_{critical}}{3L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right) \tag{18}$$

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,

$$Energy \sim \rho_\gamma\cdot\left(r_{critial}{}^3\right) = \frac{16}{3}\cdot c_1\cdot\left(r_{critial}{}^3\right)\cdot B^4 \sim \frac{\left(r_{critial}{}^3\right)}{2L_P}\cdot\frac{dr_{critical}}{dt}\cdot\left(\hbar\cdot c^2/e\cdot L\right) \sim \frac{c^4}{2G}\cdot r_{critial} \tag{19}$$

This will lead to an evaluation of as well as setting the value of $dr_{critical}/dt \sim c$, and by Padmabhan [6], $G\hbar = L_P^2 c^3$, so then $n_{initial} \sim 10^{37}$ (for a 1 meter universe)

$$r^2_{critial} \sim n_{initial}\frac{L_P^2}{\pi} \Leftrightarrow E_{initial} \equiv \frac{c^4}{2G}\cdot r_{critial} \sim \frac{c^4 L_P}{2G}\sqrt{\frac{n_{initial}}{\pi}} \tag{20}$$

4. 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 [8]

$$B > \frac{1}{2 \cdot \sqrt{10 \mu_0 \cdot \omega}} \tag{21}$$

and the initial E field is given by Eq. (20), 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 setting $\omega_{initial}\Big|_{r_H \sim 1meter} \sim 10^{21} Hz$ and as well as using [9] for graviton mass and N [10] for a numerical count proportional to entropy, if [5] holds below, and [11]

$$m_{graviton} = \frac{\hbar}{c} \cdot \sqrt{\frac{(2\Lambda)}{3}} \quad \& \quad N = N_{graviton}\Big|_{r_H} = \frac{c^3}{G \cdot \hbar} \cdot \frac{1}{\Lambda} \tag{22}$$

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