Using Dyson's probability expression for Gerstsenshtein coupling between Photons and Graviton interaction for minimum B field in Tokamak GW Detection Experiment, and possible developments if a refinement on the Gertsenshtein process is confirmed experimentally

A. Beckwith[1]

1) abeckwith@uh.edu, Chongqing University department of physics;Chongqing, PRC, 400044;

Abstract

As of 2012, and put in a journal in 2013, Dyson came up with criteria as to the Gertsenshtein process in photon-graviton coupling, with criteria as to the likelihood as to if the Gertsenshtein process actually can occur. This methodology is applied to a small spatial geometry as to Tokamak's with a 100% probability of Gertsenshtein coupling of gravitons and photons, if there is a magnetic field of magnitude 10 to the 9th power, Gauss. This coupled with a GW and graviton frequency of order 10 to the 9th power, Hertz. The high GW frequency is justified in a prior analysis done by the author, and the magnetic field of 10 to the 9thpower Gauss is enough to insure that within a GW detector that there is the likelihood of the Gertsenshtein process occurring. This threshold magnetic field strength is tied into a probability of measurement of the Gertsenshtein process, allowing for GW measurements as a signature, in the Tokamak GW experiment. As a first finding, should these criteria be verified, the next focus will be on beginning to determine if higher dimensional versions of gravity have experimental signature, which will be the focus of the next paper. That and trying to determine if a graviton could have a small mass. The GW signatures are then finally discussed in terms of early space-time geometry alternations which is in terms of GW signatures if a refinement of the Gertsenshtein process is proved and finalized after the Tokamak GW experiment.

Key words: *"heavy" gravity, Tokamaks, Gertsenshtein effect.*

1. Introduction:

Dyson in [1] derived a minimum probability for the occurrence of the Gertsenshtein effect [2]. While the Gertsenshtein effect is not the only way to explain a coupling between photons and gravitons[3] the criteria so derived by Dyson, [1] is effective in terms of small device geometry as represented by [4] and [5] as to generation of GW. As Dr. Li and others relate in their research work [6], gravitons coupled to photons are a mainstay as to GW detection, use of Dyson's criteria in [1] is an excellent way to initiate a minimum strength of a magnetic field coupled with 10 to the 9th value of GW frequency [4]. Once this is established, and if gravitons are determined to exist, the next step would be in terms of the 'heavy gravity' problem [7], which will be the conclusion of what is written up in this document, in terms of a work in progress. Commensurate with the 'heavy gravity problem is the one of 'higher dimensional' gravity[8] , which will be the focus point of the next paper written up.

II. Probability for the Gertsentshtein effect, as described by Dyson for the Tokamak experiment.

We will briefly report upon Dyson's well written summary results, passing by necessity to the parton the likelihood of the Gertsenshtein effect occurring in a laboratory environment [1]. In doing so we put in specific limits as to frequency and the magnetic field, since in our work the objective will be to have at least theoretically a 100% chance of photon-graviton interaction [2] which is the heart of what Dyson reported in his research findings. What we find, is that with a frequency of about 10 to the 9th Hertz and a magnetic field of 10 to the 9th Gauss that there is nearly 100% chance of the Gertsentshtein effect being observed, within the confines of the Tokamak experiment as outlined in [2].

In general relativity the metric $g_{ab}(\boldsymbol{x}, t)$ is a set of numbers associated with each point which gives the distance to neighboring points. I.e. general relativity is a classical theory. By necessity, perturbations from flat Euclidian space, are usually configured as ripples in ‘flat space’, which are the imprint of gravitational waves in space-time. Our paper is to first of all give the probability of a pairing of photons to gravitons linkage, the Gertentshtein effect, as to how the signatures of a perturbation to the metric $g_{ab}(\boldsymbol{x}, t)$ is linkable to photons and vice versa. The Gertentshtein effect is linked to how there is a linkage, signal wise, between gravitons and photons, and we are concerned as to what is a threshold as to insure that GW may be matched to the photons used by Dr. Li and others to signify GW in a detector [6]. To do so let us look at the Dyson criteria as a minimum threshold for the Gertentshtein effect happening [1], namely

$$D \cdot B^2 \cdot \omega \leq 10^{43} \tag{1}$$

The propagation distance is given by ***D,*** the magnetic field by ***B,*** and the frequency of gravitational radiation is given by ω . We assume that the gravitational frequency is commensurate with the gravitational frequency of gravitons, i.e. that they are, averaged out one and the same thing. In doing so, making use of [3] we suppose on the basis of analysis that*D* is of the order of 10 to the 2nd power, since ***D*** is usually measured in centimeter, and by [2] we are thinking of about a 1 meter **If *B* is of the order of 10 to the 9thGauss Hertz**, as deemed likely by [3], then we have that if the **GW frequency , ω is likewise about 10 to the 9th Hertz** , that Eq.(1) is easy to satisfy. Note that if one has a vastly extended value for ***D*, say 10 to the 13th centimeters** that the inequality of Eq.(1) does not hold, so that by definition, as explained by Dyson that in a lot of cases, not relevant to [3] , that Eq.(1) is not valid, hence there would be no interexchange between gravitons and photons, and hence, if applied to the Dr. Li detector [6] no way to measure gravitons by their photonic signature. Fortunately, as given by [3] this extended version of ***D*, say 10 to the 13th centimeters**does not hold. And that then Eq. (1) holds. If so then, the probability of the Gertentshtein effect is presentable as, approximately,

$$P \leq \left(10^{36} / B^2 \cdot \omega^2 \right) \propto 10^{36} / 10^{18} \cdot 10^{18} \ \square \ 1 \equiv 100\% \tag{2}$$

Summing up Eq. (2) is that the chosen values, namely if ***D***is of the order of 10 to the 2nd power, *B* is of the order of 10 to the 9th power Gauss, and ω is likewise about 10 to the 9th Hertz leads to approximately 100% chance of seeing Gertsenshtein effects in the planned Tokamak experiment in [3].In making this prediction as to Eq. (2), we can say that the left hand side, leading up to the evaluation of P with a numerator equal to 10 to the 36th power will be about unity for the values of *B* detector fields in Gauss (magnetic field) or the generated gravitational field frequency ω from the Tokamak, making an enormous magnetic field in the GW detector itself mandatory, which would necessitate a huge cryogenics effort, with commensurate machinery. Keep in mind that the GW detector is, as given in [3] about five meters above the Tokamak [4], i.e. presumably the one in Hefei, PRC [5]

Note, that , ironically, Dyson gets much smaller values of Eq.(2) than the above, by postulating GW frequency inputs as to the value of ω about 10 to the 20th Hertz, i.e. our value of ω is likewise about 10 to the 9th Hertz, much lower. If one has such a high frequency, as given by Dyson, the of course, Eq.(2) would then be close to zero for the probability of the Gertentshtein effect happening. I.e. our analysis indicates that a medium high GW frequency, presumably close to 10 to the 9th Hertz, and ***D*** 10 to the 2nd power, presenting satisfaction of both Eq.(1) and Eq.(2). Note the main point though, for large values of ***D,*** Eq. (1) will not hold, making Eq.(2) not relevant, and that means in terms of the Dyson analysis, that far away objects generating gravitons will not be detectable. Via the Gertentshtein effect.There is no such limitation due to a failure of Eq.(1) in the Tokamak GW generation setup [3] since then, for Tokamaks, ***D***is very small. But if ***D*** is large in the case of a lot of astrophysical applications, then almost certainly one never gets to Eq.(2) since the Gertsenshtein effect is ruled out. We assume, next that refinements as to the Gertsenshtein effect are in the works, as given by [6] and next work out a protocol as to the next topic, i.e. early universe shift in space-time geometry leading to GW signals. We will briefly mention what the GW signals are, which are probably accessible if the Gertsenshtein effect is improved upon. Note that the following discussion in terms of alteration of early universe space-time being identified via a small phase shift, which is discussed below. If that is not feasible, and we cannot even verify a sensitivity to GW via photonic linkage, via the Gertsenshtein effect, then the following discussion is not even worth considering.

III. Generalization of Eq.(2) to larger cosmological problems. i.e. what if refinements of the Gertsenshtein effect occur, and allow early universe GW astronomy?

IIIa. Discussion of the geometry alteration due to the evolution from pre-Planckian to Planckian regimes of space time

The simplest way to consider what may be involved in alterations of geometry is seen in the fact that in pre-**Octonion** space time regime (which is pre-Planckian), one would have (Crowell, 2005)[9]

$\left[x_j, x_i\right] \neq 0$ **under ANYcircumstances, with low to high temperatures, or flat or curved space.** (3)

Whereas in the **Octonion** gravity space time regime where one would have Eq. (3) hold that for enormous temperature increases(Crowell, 2005)[9]

$$\left[x_j, x_i\right] = i \cdot \left[\Theta_{ji}\right] \xrightarrow[Temp \to \infty]{} 0 \quad (4)$$

Here,

$$\Theta_{ji} \sim \Lambda_{NC}^{-2} \sim \left[\Lambda_{4-Dim}\right]^{-2} \propto 1 \big/ \left[T^{2\beta}\right] \xrightarrow[T \to \infty]{} 0 \quad (5)$$

Specifically Eq. (3) transformed to Eq. (5) will undergo physical geometry changes which show up in δ_0 .The space-time shift from pre Planck to the Planck epoch has gravity wave background radiation containing the imprint of the very earliest event.Next, is to consider what happens if Quantum (**Octonion**geometry) conditions hold. The supposition as given by in [10](Lee, 2010)

Considering all these recent developments, it is plausible that quantum mechanics and gravity has information as a common ingredient, and information is the key to explain the strange connection between two.

When quantum geometry holds, as seen by Eq. (6) , GW information isloaded into the **octonion** space time regime, and then transmitted to the present via relic GW which identified via the phase shift in GW as measured in a GW detector. This phase shift is δ_0. The following flow chart is a bridge between the two regimes of (Crowell, 2005)[9]the case where the commutators for QM hold and then again to where the commutators for QM do not hold at all.

$$\left[x_j, p_i\right] \neq -\beta \cdot \left(l_{Planck} / l\right) \cdot \hbar T_{ijk} x_k \xrightarrow[Transition-to-Planckian-regime]{} \left[x_j, p_i\right] = -\beta \cdot \left(l_{Planck} / l\right) \cdot \hbar T_{ijk} x_k \quad (6)$$

Eq.(6) above represents the transition from pre-Planckian to Planckian geometry.

Also questions relating to how pre and post Planckian geometries evolve can be answeredby a comparison of how entropy, in flat space geometryis linked with quantum mechanics (Lee, 2010)[10] . Once Eq.(6) happens, Beckwith hopes to look at the signals in phase shift δ_0

$$\left[x_j, p_i\right] = -\beta \cdot \left(l_{Planck} / l\right) \cdot \hbar T_{ijk} x_k \xrightarrow[Transition-to-release-of-relic-Gravitational-waves-in-flat-space]{} Planckian - Era - Generated - GW \quad (7)$$

Lee's paper (Lee, 2010) gives the details of information theory transfer of information from initially curved space geometry to flat space. When one gets to flat space, then, by Eq. (7) one then has a release of relic GW.

The readers arereferred to appendix A summarizing the relevant aspects of[10](Lee, 2010)in connecting space time geometry (initially curved space, of low initial degrees of freedom) to Rindler geometry for the flat space regime occurring when degrees of freedom approacha maxima, initially from t > 0s up to about t <1s as outlined in an argument given below in Eq. (8). One of the primary results is reconciling the difference in degrees of freedom versus a discussion of dimensions. Also, as Eq. (8) occurs, there will be a build up in the number of degrees of freedom, from a very low initial level to a higher one, as in the Gaussian mapping [11] (Beckwith, 2010a)[11]

$$x_{i+1} = \exp\left[-\tilde{\alpha} \cdot x_i^2\right] + \tilde{\beta} \quad (8)$$

The feed in of temperature from a low level, to a higher level is in the pre Planckian to Planckian thermal energy input as by (Beckwith, 2010a)[11]

$$E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \left[\Omega_0 \breve{T}\right] \sim \tilde{\beta} \qquad (9)$$

Eq. (8) would have low numbers of degrees of freedom, with an eventual Gauss mapping up to 100 to 1000 degrees of freedom, as described by (Kolb and Turner, 1990).[12]

IV.**Understanding how phase shift in Gravitational waves may be affected by the transition to a causal discontinuity, and different models of emergent structure**

In research work as given by [6](Li, and Yang, 2009), (Beckwith, 2010_ [13]outlined in Chongqing November 2010 the following representation of amplitude, i.e. as by reading (Li, and Yang, 2009)[6] the following case for amplitude

$$A_{\otimes} = A_{\oplus} = \breve{A} (10)$$

Furthermore, first order perturbative terms of an E&M field have its components written as(Li, and Yang, 2009)[6]

$$\tilde{F}_{0\ 2}^{(1)} = i\tilde{F}_{0\ 1}^{(1)} (11)$$

Secondly, there is a way to represent the" number" of transverse first order perturbative photon flux density as given in an earth bound high frequency GW detector .(Li, and Yang, 2009).[6]

$$n_r^{(1)} = \frac{c}{2\mu_0 \hbar \omega_{e^-}} \operatorname{Re}\{\ \} (12)$$

$$\{\ \} = i\left(\exp\left[-i\theta\right]\right) \cdot \tilde{F}_{0\ 1}^{(1)*} \cdot \left[\frac{i}{\omega_{e^-}} \cdot \left(\frac{\partial \Psi_x}{\partial y} - \frac{\partial \Psi_y}{\partial x}\right)\right] (13)$$

Here the quantity $\frac{i}{\omega_{e^-}} \cdot \left(\frac{\partial \Psi_x}{\partial y} - \frac{\partial \Psi_y}{\partial x}\right)$represents the z component of the magnetic field of a Gaussian beam used in an EM cavity to detect GW.We introduce the quantity Q, the quality factor of the detector cavity set up to observe GW, and $\breve{A}$, the experimental GW amplitude.In the simplest case, $\hat{B}_y^{(0)}$is a static magneticfield. Then $\tilde{F}_{0\ 2}^{(1)} = i\tilde{F}_{0\ 1}^{(1)}$ leads to (Li, and Yang, 2009)[6]

$$\tilde{F}^{(1)}_{0\,1} = i2\breve{A}\hat{B}^{(0)}_{y}Q \cdot \left[\sin\left[\frac{n\pi z}{b}\right]\right] \cdot \exp\left[i\left(-\omega_g t + \delta_0\right)\right] (14)$$

The formula $E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \tilde{\beta}$ [13] is a feed into ω_g provided time $t \propto$ Planck time, and set Eq. (14) with $\omega_g \sim \omega_g$ by setting up $E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \approx \tilde{\beta}$. In other words, for relic GW production, a interrelationship between $\tilde{\alpha}$ and $E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \tilde{\beta}$ for \increases in degrees of freedom. This is a different perspective than what is normally used in analyzing what happens in a transition between initial Planck time ~ 10^{-44} seconds, and cosmological evolution up to 10^{-30} seconds The next discussion is on research done by .(Li, et al, 2003) [3], as to identifying traces of massive gravitons.(Beckwith, 2011b)

V. Re casting the problem of GW/ Graviton in a detector for "massive" Gravitons

We now turn to the problem of detection. The following discussion is based upon with the work of Dr. Li, Dr/ Beckwith, and other physics researchers in Chongqing University.(Li, et al, 2003), (Beckwith,2010b).. What (Li et al, 2003)have shown in 2003 which Beckwith made an extension (Beckwith, 2011b) is to obtain a way to present first order pertubative electromagnetic power flux, i.e. $\overset{(1)}{T}{}^{uv}$in terms of a non zero four dimensional graviton rest mass, in a detector , in the presence of uniform magnetic field (Li et. al., 2003) [3] ,(Beckwith, 2010b).What if we have curved space time with an energy momentum tensor of the electro magnetic fields in GW fields as given by (Li et. al., 2003) [3] ?

$$T^{uv} = \frac{1}{\mu_0} \cdot \left[-F^{\mu}_{\alpha} F^{\nu\alpha} + \frac{1}{4} \cdot g^{\mu\nu} F_{\alpha\beta} F^{\alpha\beta} \right] (15)$$

(Li et al,2003)[3]state that $F_{\mu\nu} = F^{(0)}_{\mu\nu} + \tilde{F}^{(1)}_{\mu\nu}$, with $\left|\tilde{F}^{(1)}_{\mu\nu}\right| << \left|F^{(0)}_{\mu\nu}\right|$ will lead to

$$T^{uv} = \overset{(0)}{T}{}^{uv} + \overset{(1)}{T}{}^{uv} + \overset{(2)}{T}{}^{uv} (16)$$

The 1st term to the right side of Eq. (16) is the energy – momentum tensor of the back ground electro magnetic field, and the 2nd term to the right hand side of Eq. (16) is the first order perturbation of an electro magnetic field due to the presence of gravitational waves [13], [14],[15]

$$J_{effective} \cong n_{count} \cdot m_{4-D-Graviton} (17)$$

As stated , [13], [14], [15] $m_{4-D-Graviton} \sim 10^{-65}\, grams$, while n_{count} is the number of gravitons which may be in the detector sample. What Beckwith and Liintend to do is to isolate out an $\overset{(1)}{T}{}^{uv}$assuming a non zero graviton rest mass. . I.e. use $\tilde{\beta} \cong |F|$ and make a linkage with $\overset{(1)}{T}{}^{00}$. The term $\overset{(1)}{T}{}^{00}$ isolated out from $\overset{(1)}{T}{}^{uv}$. The point is that detected GW helps constrain Eq. (17).

VI. Conclusion:

We have in this document, outlined as to first of all a test for confirmation of the Gertshenshtein process in a Tokamak GW generating device. As stated before, we do not assume that the Gertshenshtein process is the last word as to a photon-graviton connection, but that verification of the Gertshenshtein process is mandatory if one goes by the processes as outlined in [16] [17] for a GW detector, as allowing for a photon-graviton interface. If there are improvement on the Gertshenshtein process, as alluded to in [6], then the second part of the document is a speculative venture as to how to obtain first order perturbation from an early universe phase transition which may allow for gravitational perturbation effects to be found. The pre octonionic to Octonionic transformation as alluded to is in tandem to the Eq.(11) Gaussian mapping as was worked out by the Author in DICE 2010 [11]. To get there though, a tuning fork confirmation is required, as to a known GW signal, as by the [3] reference.

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Appendix A: Highlights of J.-W. Lee's paper

The following formulation is to highlight how entropy generation blends in with quantum mechanics, and how the break down of some of the assumptions used in Lee's paper coincide with the growth of degrees of freedom. What is crucial to Lee's formulation, is Rindler geometry, not the curved space formulation of initial universe conditions.. First of all. [10] (Lee, 2010),

"Considering all these recent developments, it is plausible that quantum mechanics and gravity has information as a common ingredient, and information is the key to explain the strange connection between two. If gravity and Newton mechanics can be derived by considering information at Rindler horizons, it is natural to think quantum mechanics might have a similar origin. In this paper, along this line, it is suggested that quantum field theory (QFT) and quantum mechanics can be obtained from information theory applied to causal (Rindler) horizons, and that quantum randomness arises from information blocking by the horizons

To start this we look at the Rindler partition function, as by (Lee, 2010)[10]

$$Z_R = \sum_{i=1}^{n} \exp\left[-\beta H(x_i)\right] = Trace \cdot \left(\exp\left[-\beta H\right]\right) \text{ (A.1)}$$

As stated by Lee [10] , ..*we expect* Z_R *to be equal to the quantum mechanical partition function of a particle with mass* m *in Minkowski space time*. Furthermore, there exists the datum that:Lee made an equivalence between Eq. (A1) and (Lee, 2010)[10]

$$Z_Q = N_1 \int \wp x \cdot \exp\left[\frac{-i}{\hbar} \cdot I(x_i)\right] \text{(A2)}$$

Where $I(x_i)$ is the action 'integral' for each path x_i, leading to a wave function for each path x_i

$$\psi \sim \exp\left[\frac{-i}{\hbar} \cdot I(x_i)\right] \qquad \text{(A3)}$$

If we do a rescale $\hbar = 1$, then the above wave equation can lead to a Schrodinger equation,

<u>**The example given by (Lee**</u>, 2010) is that there is a Hamiltonian for which

$$H(\phi) = \int d^3x \cdot \left\{ \frac{1}{2} \cdot \left(\frac{\partial \phi}{\partial t}\right)^2 + \frac{1}{2} \cdot (\nabla \phi)^2 + V(\phi) \right\} \text{(A4)}$$

Here, V is a potential, and ϕ can have arbitrary values before measurement, and to a degree, Z represent uncertainty in measurement. In Rindler co-ordinates, $H \to H_R$, in co-ordinates (η, r, x_2, x_3) with proper time variance $ard\eta$ then

$$H_R(\phi) = \int drdx_{\perp} ar \cdot \left\{ \frac{1}{2} \cdot \left(\frac{\partial \phi}{\partial r}\right)^2 + \frac{1}{2} \cdot \left(\frac{\partial \phi}{ar\partial \eta}\right)^2 + \frac{1}{2} \cdot (\nabla_{\perp} \phi)^2 + V(\phi) \right\} \text{ (A5)}$$

Here, the $\perp$ is a plane orthogonal to the (η, r) plane. If so then

$$Z = tr \exp\left[-\beta H\right] \mapsto Z_R = tr \exp\left[-\beta H_R\right] \qquad \text{(A6)}$$

<u>**Now, for the above situation, the following are equivalent**</u>

1. Z_R thermal partition function is from information loss about field beyond the Rindler Horizon
2. QFT formation is equivalent to purely information based statistical treatment suggested in this paper
3. QM emerges from information theory emerging from Rindler co-ordinate

Lee also forms a Euclidian version for the following partition function, if $I_E(x_i)$ is the Euclidian action for the scalar field in the initial frame. I.e.

$$Z_Q^E = N_1 \int \wp x \cdot \exp\left[\frac{-i}{\hbar}\cdot I_E\left(x_i\right)\right] \text{(A7)}$$

There exist analytic continuation of $\tilde{t} \mapsto it$ leading to $Z_Q^E \mapsto Z_Q =$ Usual zero temperature QM partition function of Z_Q for ϕ fields.

Important Claim: The following are equivalent

1. Z_R and Z_Q are obtained by analytic continuation from Z_Q^E
2. Z_R and Z_Q are equivalent .

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