Reviewing Dyson's analysis of GW and gravitons, as a template to investigate a Tokamak GW linkage, LIGO, and the feasibility of the Gerstsenshtein coupling between Photons and Graviton interaction with a realistic B field strength

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Abstract

In a 2013 paper, Freeman Dyson presented thought experiments challenging the detectability of gravitons via LIGO interferometry and via the Gertsheshtein effect. Dyson assumed a distance of several light years would be required for detection of the interaction between gravitational waves (GWs) and tenuous B fields and photons, making gravitons experimentally undectable. In this paper, we present contrary theoretical evidence for detectability of near-field interaction of gravitons, photons, and a magnetic field. Our first example of 100% probability of the Gertshenshtein effect working is due to a GW generated by a Tokamak with a interaction of GW, B field, and photons, in a volume on the order of a few cubic meters. The 100% probability of the Gertshenshtein effect working leads to gravitons interacting with a strong uniform magnetic field, resulting in photons which are detected by appropriate instrumentation and research protocols. We furthermore outline how Dyson was giving misleading information on the efficiency of LIGO, which is inimical to that research initiative on gravitational wave still very pertinent to essential gravitational physics, via the interferometer arrays, which has been noted and corrected

Key words ; *Gertshenshtein effect, Tokamak, GW, LIGO*

1. INTRODUCTION

Dyson in [7] derived criteria as to the probability one could obtain physical phenomenon theoretically modeled by the Gertsenshtein effect [8] . The Gertsenshtein effect [8] is the coupling of magnetic fields, gravitons, and photons. In the Dyson treatment [7] of the Gertsenshtein effect [8] , Dyson hypothesized distances up to many light years for an interaction of magnetic fields, gravitons and photons, for experimental signals which could be detected on the Earth's surface. This assumed geometry of many light years distance lead to the predicted Gertshenshtein effect [8] unable to allow for graviton detection. In contrast to this assumed vast distances for the Gertshenshtein effect in reference [7], the author has devised via Tokamak generation of gravity waves[3] , which lead to an interaction length of meters for the magnetic field, gravitons, and photons. The reduced length is due to the magnetic field which the gravitons interact with, being inside the detector itself, thereby insuring a 100 % probability for the Gertsenshtein effect occurring. This is commensurate with predictions given in reference [14].The Tokamak example brings up an important point, that even if one wants to measure gravitational waves and detect gravitons from the early universe, that in the 3DSR model for GW detection [22], the Gertshenshtein effect for gravitons, magnetic field, and photons is within the small 3 dimensional geometry of the detector, with an enormous magnetic field. Having the Gerteshenshtein effect [8] in such a small volume dramatically raises the likelihood of detection of gravitons, via resultant photons being picked up by the 3DSR device. Finally , we mention an error in Dyson's argument against LIGO, in which he incorrectly rendered the value of gravitational constant G, times 1 solar mass, divided by the speed of light, squared as equal to about 10 ^ -33 centimeters. The correct value is 1.5 kilometers. It is extremely relevant and very important to keep in mind that interferometric based gravitational wave detectors like LIGO as well as its numerous updates in India and Europe are important also to set up the falsifiable experimental inputs needed to really test gravity theories, as it has been shown very strongly by Dr. Corda in 2009 [5] , and that Dr. Dyson has severely criticized a valuable addition to what is needed to understand gravitational physics. Noting Dr. Dyson's mistake about LIGO [7] is essential for vetting all needed operational tools needed to understand gravity. While Dyson is important, the record needs to be set straight as has been done in this manuscript.

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

We will briefly report upon Dyson's well written summary results, passing by necessity to the part on the likelihood of the Gertsenshtein effect occurring in a laboratory environment[7] . 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 [7] 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 [3 , 16] .

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 [7] to signify GW in a detector . To do so let us look at the Dyson criteria as a minimum threshold for the Gertentshtein effect happening [7], 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 [7] 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 [7] we are thinking of about a 1 meter If *B* is of the order of 10 to the 9th Gauss Hertz, as deemed likely by [3] , then we have that if the GW frequency , ω is likewise about 10 to the 9th Hertz , that (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 (1) does not hold, so that by definition, as explained by Dyson that in a lot of cases, not relevant to[3] , that (1) is not valid, hence there would be no interexchange between gravitons and photons, and hence, if applied to the Dr. Li detector [13, 22] 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 (1) holds. If so then, the probability of the Gertentshtein effect is presentable as, approximately,

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

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 (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 [3] , i.e. presumably the one in Hefei, PRC [16] .

Note, that , ironically, Dyson gets much smaller values of(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, (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 (1) and (2). Note the main point though, for large values of ***D*****,** (1) will not hold, making (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 (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 (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 [15,17,18] 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 we will review, briefly, what was given by Weinberg [21] as a black body analysis as to the feasibility of GW/ graviton production via an analysis similar to the black body radiation protocols, and show that the above mentioned figures as to GW/graviton production

3. Brief review of graviton production for massless gravitons, using Weinberg Black body analogy

From the book written by [21].For frequencies, between ω and $\omega + d\omega$: the number of gravitons is given by Weinberg[21], page 287 Formula 10.89 as

$$n(\omega)d\omega = \frac{\omega^2}{\left[\pi^2 \cdot \left(\exp\left[\frac{\hbar \cdot \omega}{k_B T}\right] - 1\right)\right]} \cdot d\omega \tag{3}$$

Integrate this, between two band widths of frequency for the graviton, or for a very narrow graviton frequency width $\bar{\omega}$, the following approximation is acceptable as a modification of (3) as from [21]

$$n(\bar{\bar{\omega}}) \approx \frac{\bar{\omega}^2}{\left[\pi^2 \cdot \left(\exp\left[\frac{\hbar \cdot \bar{\omega}}{k_B T}\right] - 1\right)\right]} \tag{4}$$

Note that k_B above is for the Boltzmann constant, and that T can be set by ANYTHING one wants to have it set by, and the upshot, is that for frequencies approximately as $\bar{\omega}$ approximately of about 10^9 Hz, and with a temperature, of a Plasma as of about 100 KeV, then for (4) figure that one is going to have (4) per unit meter, cubed, in volume, which would lead to variations of easily 10^4 in magnitude from a baseline starting point of say 1 graviton per cubic centimeter, per second. This becomes important when comparing this graviton number, per cubic centimeter against the purported graviton flux number appearing in the case of the Earth given as a Graviton detector which appears in this paper. I.e. see (6) below. The contrast with (4) is stunning.

4 . Why the work by Dyson is not pertinent to long distance approximations as done in his manuscript if the main magnetic field for the Gertsenshtein effect occurs within a detector?

On the face of it, the way the question as to if the Gertsenshtein effect [8] occurs outside a gravitational wave detector appears to be contrived. We assert this is not a contrived question, since the planned detector has a magnetic field many times stronger than what would be expected by conditions on the Earth surface, with Gertsenshtein effects occurring due to the Earth's comparatively very minor magnetic field not playing a role. As given by [8] there is a well defined physical process for graviton-magnetic field interactions which would lead to a photon cascade, enough so, so that large D values, as given above to the tune of many kilometers in length are not advisable or necessary. Needless to say, if one does not believe that the Gertsenshtein effect is not mainly restricted within a GW detector, there are still serious problems with the Dyson formulation.

Review of (1) and (2) above come up with the datum that satisfying (1) is necessary for implementation of (2), i.e. (2) in full generality would likely read as[7]

$$P \sim \sin^2 \sqrt{\left(10^{36}/B^2 \cdot \omega^2\right)} \tag{5}$$

The main absurdity of this formulation is that usually, in interstellar space that one has low B field magnitudes, and low GW frequency values, i.e. ω as low as 100 Hz. Or as high as $\omega \sim 10^9 - 10^{10}\, Hz$ i.e. in that sense, the Dyson examples chosen as of implementation of (1) and (2) go off the rails, with it being extraordinarily easy for enormous values of $\left(10^{36}/B^2 \cdot \omega^2\right)$ in many situations. I.e. Dyson picked the values of B and also the picked value of $\omega \sim 10^{20}\, Hz$ is chosen for the purpose of making $P \sim \sin^2 \sqrt{\left(10^{36}/B^2 \cdot \omega^2\right)} \propto 10^{36}/B^2 \cdot \omega^2 << 1$, i.e. Dyson [7] cherry picked the numbers to make the probability for the Gertsenshtein effect as almost non existent, even if (1) were satisfied. But show me an example where one would have $\omega \sim 10^{20}\, Hz$ in interstellar space? This is important since $\omega \sim 10^{20}\, Hz$ is not feasible to entertain in most examples, and if one is looking at GW detectors, as has been done in [3] one is visualizing $\omega \sim 10^9 - 10^{10}\, Hz$ in the high end of the GW frequency values, as is given in the Tokamakak example in Section II. I.e. Dyson's analysis [7] of $P \sim \sin^2 \sqrt{\left(10^{36}/B^2 \cdot \omega^2\right)} \propto 10^{36}/B^2 \cdot \omega^2 << 1$ was arbitrarily picked to kill the possibility of a reading of the Gertsenshtein effect [8]. We close this section by asserting that Dyson [7] is confused as to where the Gertsenshtein effect should occur in terms of space-time interactions for proper utilization of a Device physics analysis of where gravitons and B fields interact, and that the large D values he postulates, are not relevant to the case where the Gertsenshtein effect occurs, mainly inside a GW detector. This concludes our analysis of Dyson's failure to properly set up the benchmarks as to analysis of where the Gertsenshtein effect really occurs. So then, we conclude with this statement, and then move to the deficiencies as to Dyson's assertion as to the Earth as a graviton detector, which is section IV below.

5 . Dyson's analysis of the Earth as a GW detector. Incomplete physics, and why

We now review the particulars of Dyson's analysis of the Earth as a GW detector [7]. In doing so we are using the same numbers,and our break down of the results show that Dyson is making some assumptions here, which need to be seriously reviewed. In debt with the methodology of finding out what is germane in his analysis to research. To begin with, Dysons, formulae as given in reference [7] which Dyson in his reference calls formula (23) has a next flux of Gravitons hitting the surface of the Earth from the Sun

F(flux)-gravitons hitting Earth = 4×10^{-4} **Gravitons per cm, squared, per second** (6)

In this , using Dysons numbers, he claims that only **1 graviton out of 10 to the 32nd power of gravitons can be detected by the Earth's surface**, assuming a graviton has about a kilovolt of energy i.e. this is, in its heart a situation where Dyson [7] is assuming an absorbtion cross section 10 to the minus 41st power per square centimeter per gram for the Earth, and an absurdly low collision rate. If this were true we are neglecting the Gertsenshtein interaction, since we are assuming no magnetic interface with incoming gravitons. This is only justifiable if there is a hard sphere collision between incoming 'gravitons' and ordinary matter. The analysis is incomplete and unnecessary since Dyson has set up a reseach meme where the Gertsenshtein [7,8] interaction regime stretching kilometers in duration with no fidelity as to the fact that the interaction space between gravitons and a magnetic field is within a GW detector, and does not stretch kilometers in duration away from the GW detector. Having said, that, there is an even more significant error as to Graviton detection and GW in the Dyson analysis of the LIGO device, which is to be brought up next.

6. Looking at the problem of LIGO , and reviewing Dyson's claims

From [1] there is the following diagram given in their document which we reproduce below as

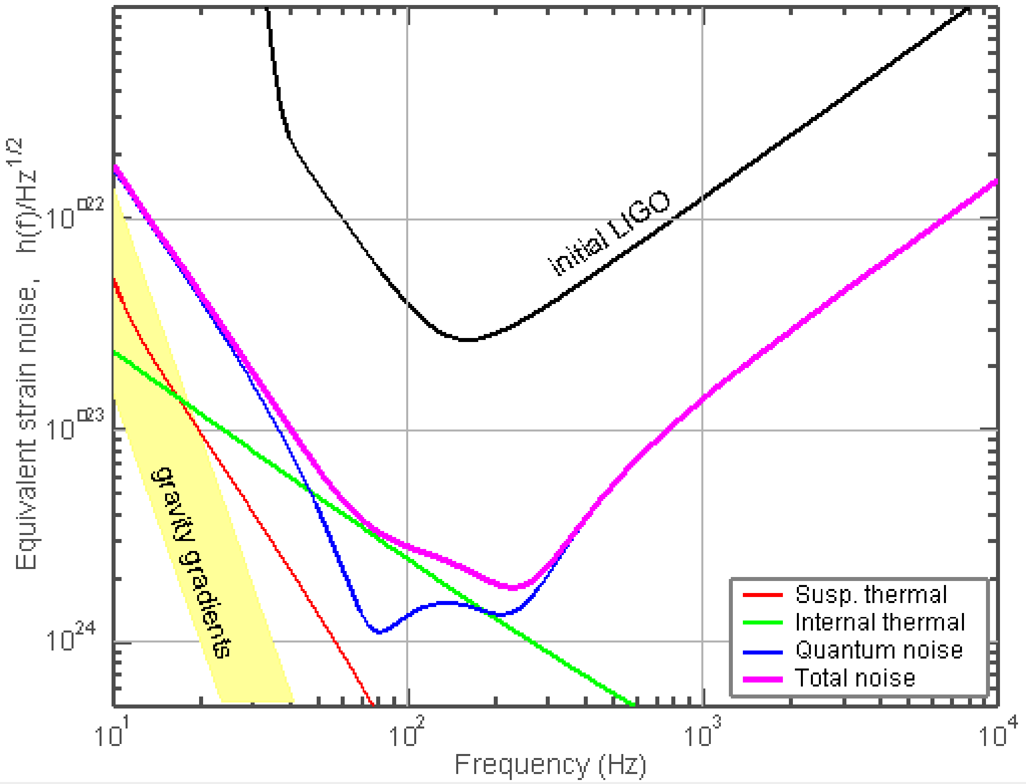

Figure 1 Noise Anatomy of Advanced LIGO. This model of the noise performance is based on the LIGO current requirements set, and represents the principal contributors of the noise and the least-squares sum of those components expressed as an equivalent gravitational wave strain.

From [1] comes the following claim, as given

Quote:

- ***BH+BH mergers and ringdowns:*** When rapidly spinning BH's collide, they should trigger large-amplitude, nonlinear oscillations of curved spacetime around their merging horizons. Little is known about the dynamics of spacetime under these extreme circumstances; we can learn about it by comparing LIGO's observations of the emitted waves with supercomputer simulations. Advanced LIGO can detect the merger waves from BH binaries with total mass as great as 2000 solar mass to cosmological redshifts as large as z=2.

Futhermore, [1] leads to the following descriptions of detectability, namely as given in its document the following diagram [1] which is reproduced below as

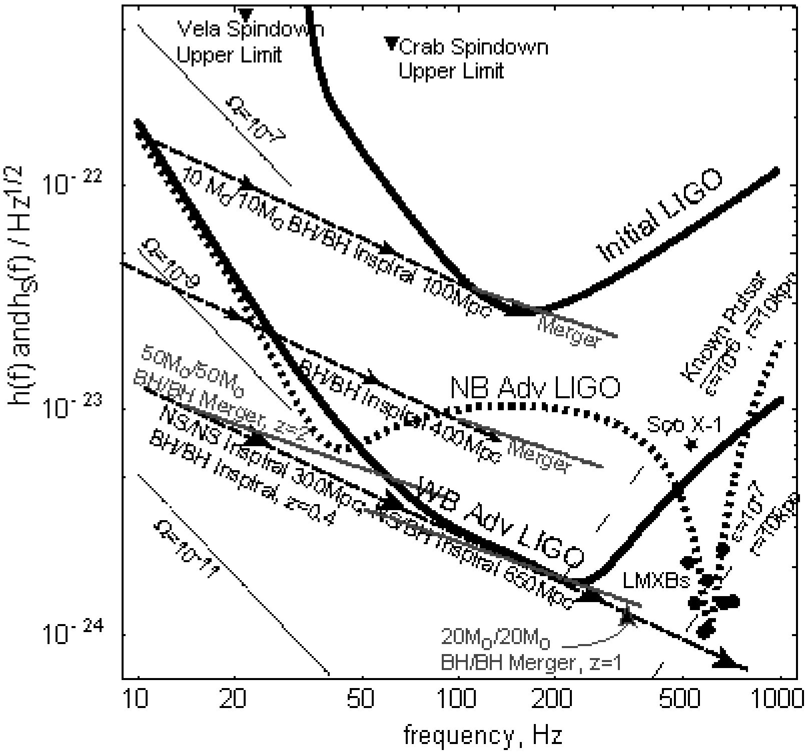

Figure 2 The estimated signal strengths hs(f) from various sources (thin lines, filled circles and star) compared with the noise h(f) (heavy lines) of three interferometers: initial LIGO, Advanced LIGO in a wideband (WB) mode, and Advanced LIGO narrowbanded (NB) at 600 Hz. See text for explanations of sources. The signal strength hs(f) is defined in such a way that, wherever a signal point or curve lies above the interferometer's noise curve, the signal, coming from a random direction on the sky and with a random orientation, is detectable with a false alarm probability of less than one per cent using currently understood data analysis algorithms.

The signal strength of LIGO as given by [2] depends upon

$$h \sim \frac{GM}{c^2} \times \frac{1}{r} \times \left[\frac{v}{c}\right]^2 \tag{7}$$

Here, r is the distance of this gravitational generation from the detector, and v/c is the ratio of say objects within the gravitational detector, and the speed of light. Usually, v/c is much less than 1 , so (7) is particularly relevant to the problem of inspiraling black holes falling into each other, and so, now with this, we should review what Dyson had to say about gravitons, and GW, as well as LIGO .

Right before Dyson's reference [7], in his section 4, there is a statement that the frequency rage for a single graviton to kick an electron out of a single atom, which is 10^{15} Hertz [7]. We will later on comment this estimate [7] as a way to obtain a graviton-photon interaction and also refer to Dyson's claim just before his section5, about thermal graviton generators, that the absorption cross section of ordinary matter (for a graviton) is 10^{-41} square centimeters per gram. For LIGO, the frequency range is about 10^{2} Hz for two black holes inspiraling into each other, not 10^{15} Hertz, so the option of having a single graviton displace an electron from an atom, is zero. Which leads us to consider the relation given by

Dyson, as his [7] formula (10), namely an upper bound to a minimum separation between two objects, say in a LIGO grid, is given by

$$\frac{GM}{c^2} > D \tag{8}$$

If M is the mass of the sun, then the L.H.S. of (8) is 1.482 times 10 ^ 3 meters, i.e. roughly 1.5 kilometers, or approximately a mile. Assume that then we wish to compare (7) with (8) with a value of V/c ~ 10^ -3, we obtain that two inspiraling black holes with a strain value of h ~ 10^- 22 are about 1000 light years from Earth, for two black holes , combined mass of about one solar mass.

This example in itself, plus Dyson's mathematics should alert the reader, that Dyson, while undoubtedly brilliant in terms of his field theory work and research as up to the 1970s, is not parsing the problem of graviton detection correctly.

Having said this, the next step will be to review what could be done as far as looking at the early universe, as a source of GW, while moving beyond the mistakes we just outlined. In doing so, we assume that if our analysis is complete, we may be able to investigate early universe conditions, via considering if an improvement over the Gertsenshtein effect is possible.

7 . Using the good part of the Dyson analysis, and keeping in mind improvments as to the Gertsenshtein graviton-magnetic field regime are in the offing.

What we have done is to ascertain that the Gertsheshtein interaction is valuable in near field device physics geometry. We have in Section II, where the Dyson analysis can FIX appropriate GW and graviton frequency values, and magnetic field values, so the Gertenshtein interaction is certain to occur. In this, Dyson is warmly thanked for the insight. What we will bring up in closing is that the Gertshenshtein interaction is not necessarily the last word in effective graviton-magnetic field interactions and that improvments are in the offing which could enhance the role of GW detection. To do so, we can make an estimate that from a very simplistic viewpoint, that the view point of what is called the Li effect [13,15,22] involves a magnetic field of the same frequency, direction and appropriate phase of the gravtional wave field. The Gertsenshtein effect does not involve that E and M field and is proportional to h squared, not h, and in sensitivity the Gertsenshtein effect is about 30 orders of magnitude smaller than the Li effect. For GW of interest. This involves h, which is the strain value of incoming GW entering in a detector.

Eq. (7) and Eq. (8) theoretically could in themselves, if one assumed h ~ 10 ^ - 30, lead to very early universe detection. No one, however, posits that such sensitivity low values could be remotely detectable with conceived of, or extrapolated laser inferometer technology. Also, even in the matter of BHs, entropy speculations, leading to, that the 'entropy' of a BH is given by, where M is the mass of the

BH, L_P Planck length, and A_{hor} is the area of the Event Horizon of a black hole., and we state the entropy as [10]

$$S = 4\pi M^2 = \frac{1}{4} \cdot \left(\frac{A_{hor}}{L_P^2} \right) \qquad (9)$$

Here, in reference [10] we have that in its (reference [10]) formulae (24), that its main result is about the differential of the area of an event Horizon which is given as, if there is a Brane theory connection to the formation of BHs, with N the number of dimensions, say up to 10, that what is known as super-radiance , ie. bouncing of incoming radiation off the event horizon is a consequence, of the following derivation, namely if

$$dA_{hor} = \frac{8\pi r_H}{\mathrm{B}} dM_{BH} \cdot \left(1 - \frac{1}{\omega} \sum_{j=1}^{N/2} m_j \cdot \Omega_j \right) \qquad (10)$$

If dM < 0, then the quantity $\left(1 - \frac{1}{\omega} \sum_{j=1}^{N/2} m_j \cdot \Omega_j \right)$ < 0, where the quantum numbers m_j>0 and $\Omega_j = \frac{a_J}{a_J^2 + r_H^2}$ as *frequency of BH arising due to the jth component of BH angular Momentum* J_j as correlated to event horizons of the BH . Such an analysis would have profound effects upon the Dyson analysis of the probability of Graviton detection, where the phenomenon of super-radiance could play a major role as far as GW and gravitons emitted by BHs, especially in the case of inspiraling black holes [10] collapsing upon each other. $a = \sqrt{x^2 + y^2}$ can go to zero, and also $r_H = M_{BH} - \sqrt{M_{BH}{}^2 - a^2}$. Corresponding to BHs with, or without spin, which would affect GW and graviton production.

Having said, that we should examine what could happen if we have a refinement of the Gertsenshtein effect, and its aftermath. Especially as to early universe astronomy

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

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 [6])

$\left[x_j , x_i \right] \neq 0$ **under ANY circumstances, with low to high temperatures, or flat or curved space.** (11)

Whereas in the **Octonion** gravity space time regime where one would have(12) below hold that for enormous temperature increases (Crowell, 2005)[6]

$$\left[x_j , x_i \right] = i \cdot \left[\Theta_{ji} \right] \xrightarrow[Temp \to \infty]{} 0 \qquad (12)$$

Here,

$$\Theta_{ji} \sim \Lambda_{NC}^{-2} \sim \left[\Lambda_{4-Dim}\right]^{-2} \propto 1/\left[T^{2\beta}\right] \xrightarrow[T\to\infty]{} 0 \tag{13}$$

Specifically (12) transformed to (13) 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 [12] (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 (14) , GW information is loaded 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)[6] the case where the commutators for QM hold and then again to where the commutators for QM do not hold at all.

$$\left[x_j, p_i\right] \neq -\beta \cdot \left(l_{Planck}/l\right) \cdot \hbar T_{ijk} x_k \xrightarrow[Transition-to-Planckian-regime]{} \left[x_j, p_i\right] = -\beta \cdot \left(l_{Planck}/l\right) \cdot \hbar T_{ijk} x_k \tag{14}$$

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

Also questions relating to how pre and post Planckian geometries evolve can be answered by a comparison of how entropy, in flat space geometry is linked with quantum mechanics (Lee, 2010)[12] . Once (14) happens, Beckwith hopes to look at the signals in phase shift δ_0

$$\left[x_j, p_i\right] = -\beta \cdot \left(l_{Planck}/l\right) \cdot \hbar T_{ijk} x_k \xrightarrow[Transition-to-release-of-relic-Gravitational-waves-in-flat-space]{} Planckian - Era - Generated - GW \tag{15}$$

Lee's paper (Lee, 2010) [12] 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 (15) one then has a release of relic GW. The readers are referred to appendix A summarizing the relevant aspects of [12] (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 approach a maxima, initially from t > 0s up to about t <1s as outlined in an argument given below in (16). One of the primary results is reconciling the difference in degrees of freedom versus a discussion of dimensions. Also, as Eq. (16) 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 [4,13].

$$x_{i+1} = \exp\left[-\tilde{\alpha} \cdot x_i^2\right] + \tilde{\beta} \tag{16}$$

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 [4]

$$E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \left\lfloor \Omega_0 \breve{T} \right\rfloor \sim \tilde{\beta} \tag{17}$$

(17) 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)[11] .

It is important to note that the above proposed phase transition is speculative, but it could lead to another source of GW and maybe even Graviton production which with suitable analysis, would lead to more experimental opportunities for astrophysics investigations

Briefly put, this (17) could lead to the other development, namely that in research work as given by [15] (Li, and Yang, 2009), the following case for amplitude

$$A_{\otimes} = A_{\oplus} = \breve{A} \tag{18}$$

Furthermore, first order perturbative terms of an E&M field have its components written as (Li, and Yang, 2009)[15]

$$\tilde{F}^{(1)}_{0\ 2} = i\tilde{F}^{(1)}_{0\ 1} \tag{19}$$

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)[15] .

$$n_r^{(1)} = \frac{c}{2\mu_0 \hbar \omega_{e^-}} \mathrm{Re}\{\ \} \tag{20}$$

$$\{\ \} = i\left(\exp[-i\theta]\right) \cdot \tilde{F}^{(1)*}_{0\ 1} \cdot \left[\frac{i}{\omega_{e^-}} \cdot \left(\frac{\partial \Psi_x}{\partial y} - \frac{\partial \Psi_y}{\partial x} \right) \right] \tag{21}$$

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 magnetic field. Then $\tilde{F}^{(1)}_{0\ 2} = i\tilde{F}^{(1)}_{0\ 1}$ leads to (Li, and Yang, 2009)[15]

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

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 (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) [14], as to identifying traces of massive gravitons

8a . 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 [14]**..** What (Li et al, 2003) have shown in 2003 [14] which Beckwith made an extension is to obtain a way to present first order perturbative 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) [14] .What if we have curved space time with an energy momentum tensor of the electro magnetic fields in GW fields as given by [14] ?

$$T^{uv} = \frac{1}{\mu_0}\cdot\left[-F_{\alpha}^{\mu}F^{v\alpha} + \frac{1}{4}\cdot g^{\mu v}F_{\alpha\beta}F^{\alpha\beta}\right] \qquad (22)$$

(Li et al,2003) [14]]state that $F_{\mu\nu} = F_{\mu\nu}^{(0)} + \tilde{F}_{\mu\nu}^{(1)}$, with $\left|\tilde{F}_{\mu\nu}^{(1)}\right| << \left|F_{\mu\nu}^{(0)}\right|$ will lead to

$$T^{uv} = \overset{(0)}{T}{}^{uv} + \overset{(1)}{T}{}^{uv} + \overset{(2)}{T}{}^{uv} \qquad (23)$$

The 1st term to the right side of (23) is the energy – momentum tensor of the back ground electro magnetic field, and the 2nd term to the right hand side of (23) is the first order perturbation of an electro magnetic field due to the presence of gravitational waves helps constrain (24). This discussion as to section 8 is admittedly very preliminary, but it could be a way forward as to beginning to use the concept of a 'current' as in a GW/graviton detector, which with much more detail could take into account early universe phase transitions which occur at the beginning of the inflationary era. Secondly in conjunction with reference [20], it may remove problems associated with heavy gravity.

$$J_{effective} \cong n_{count}\cdot m_{4-D-Graviton} \qquad (24)$$

As stated , [9,11] $m_{4-D-Graviton} \sim 10^{-65}\,grams$, while n_{count} is the number of gravitons which may be in the detector sample. What Beckwith and Li intend 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

9. Conclusion. Much work needs to be done, including refinement of the Gerstsenshtein effect, and analysis of where GW /graviton production is investigated for astrophysical processes.

This paper raises questions as to the appropriateness of the Dyson analysis, in particular the Dyson dismissal of LIGO is based upon an incomplete rendering of a distance, D, as less than Planck Length, which we disprove by elementary analysis of the left hand side of (8) which with one solar mass is 1.48 kilometers, 1 mile, in value, as opposed to the Dyson sub Planck length. It is worth noting that LIGO has kilometer long interferometer arms, and plenty of space, as to the obtaining GW and/or Graviton itself in instrumentations. Dyson [7] also insisted upon evaluation of the Gertsheshtein effect in terms of light year distances as to light and magnetic field interactions, thereby concluding with virtually non existent Graviton interaction with instrumentation. For one thing, as given in the early part of the manuscript, what Dyson hypothesized for the probability of Gertshenshtein interaction for measurable GW/ gravitons as to a Tokamak generation of GW is appropriate and may be , for sufficiently large strain values of h~ 10^-25, may be detected with advanced instrumentation. The problem is this. What Dyson postulates as to the probability of a Gertsenshtein interaction between Gravitons and a magnetic field is no issue in that situation. I.e. a very strong magnetic field would be inside the detector itself.

The Tokamak discussion is the opposite situation from the vast distances Dyson postulated photons traveled versus intervening galactic magnetic fields, as then producing gravitons, is actually the reverse of the situation expected and modeled by Dr. Li and others [13 ,15, 22] I.e. the Gertenshtein effect is for within a DETECTOR device, and Dyson's calculations [7] as to light year distance of traveling of photons through magnetic fields is the reverse of the situation which was designed by the American and Chinese teams using 3DSR technology[22].

Dyson's analysis is in several specific cases not related to the actual situation of GW/ Graviton detection. As an example, Dyson states that 10^{15} Hz for a graviton is required as to kicking an electron out of an atom [7], as though such a frequency is what would be expected of gravitons/GW. The fact is, that the Gertshenshtein effect does not need a frequency of 10^{15} Hz due to GW / gravitons, to lead to detectable signals, in a detector.

At the same time, the directness of the questions asked by Dyson is welcome and the author acknowledges that until Dyson framed his article questions, that much of the GW/graviton issues were too incompletely rendered to permit an analysis of the relevant experimental issues.

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