"How Graviton power values, and a Graviton count from the electro weak era gives strain and heavy gravity values.

A. Beckwith[1]
Chongqing University *Department of Physics: Chongqing University*, Chongqing , PRC , 400044

E-mail: abeckwith@uh.edu

Abstract. The following was achieved, i.e. general and particular solutions to the strain equation as outlined by Durrer and others**.** The general solution unsurprisingly has a strain value which is too small for any detector to pick up, namely $h \sim 10^{-36}$ then the problem is that the particular solution, namely due to quark – gluon turbulence toward the end of the electro weak era, is neglected. But this particular solution as outlined by the author below has a much larger strain value, namely $h \sim 10^{-25}$ is a derivation which would allow a much better chance of detection than the general strain value, which is 11 orders of magnitude smaller. Secondly, we also find arguments as to the existence of heavy gravity and a GW frequency of at least 10^{7} and then these two together argue for investigation of relic gravity waves in a matter not considered when the earlier prohibitive strain value of $h \sim 10^{-36}$ was considered unchallenged. The particular solution argues in favour of investigating updates as to the laser interferometer system pioneered by LIGO and Thorne.

1. Introduction

We first of all can mention the results of a problem in Lightman, Press, Price, and Teukolsky [1] which in their problem book gives answers as to GW generated by an explosion generating energy *E*. The results given on page 509 [1] give arguments for characteristic quadrupole gravitational wave power of a physical process, the 'internal power flow', E/τ , and the typical graviton numerical count which is given in [1] via $N_{gravitons} \sim \left(E^2/\tau\right)\Big/\left(\hbar/\tau\right) \sim E^2/\tau$, and τ is the characteristic time, where we have $N_{gravitons} \sim E^2/(10^{16} ergs)^2$ and all this will be used to quantify inputs into the particular solution of how to solve the evolution equation for tensor perturbation of the space-time metric given by [2] which has h_{ij}^T as strain, and $\frac{\dot{a}}{a} = H_c =$ Hubble equation which we call constant in the early universe, and a as scale factor and Π_{ij} as anisotropic strain. h_{ij}^T convention we will be using is to

1 To whom any correspondence should be addressed.

call the right hand side of the first equation initially to be a constant, which will allow for a particular solution to h_{ij}^T

$$\ddot{h}_{ij}^T + 2\frac{\dot{a}}{a}\dot{h}_{ij}^T + k^2 h_{ij}^T = 8\pi G a^2 p \Pi_{ij} \qquad (1)$$

Here we have h_{ij}^T as having general and particular solutions, with the particular solution having a strain magnitude of $h \sim 10^{-25}$, the general solution having a magnitude of $h \sim 10^{-36}$, and the general solution being the preferred solution by the GW community, i.e. the solution of the following equation is too small to be evaluated experimentally, namely the following is worthless to experimental inquiry if we are looking at the behavior of h_{ij}^T from the electro-weak era $(10^{-36} - 10^{10}\,\text{sec})$ to today. Note that the following equation is given in Fourier momentum space. As is Eq.(1) above. These both will be inverse Fourier transformed back to position space to conclude our analysis of the homogeneous and particular solutions. We find that h_{ij}^T as given as a general solution of Eq.(1) which has analytic behavior as given by Eq.(2) below will, in position space be such that it effectively does not contribute experimentally.

$$\ddot{h}_{ij}^T + 2\frac{\dot{a}}{a}\dot{h}_{ij}^T + k^2 h_{ij}^T = 0 \qquad (2)$$

To consider h_{ij}^T from the electro-weak era to today we fix $\frac{\dot{a}}{a} = H_c =$ as constant in the early universe, meaning the general solution obeys the damping conventions for differential equations given by [3] whereas we will examine first the k space particular solution, namely if the r.h.s. of Eq.(1) may be approximated by a constant, with regards to time, then Eq. (1) has a time independent solution as given by

$$h_{ij}^T\left(particular\right) = 8\pi G a^2 p \Pi_{ij} \big/ k^2 \qquad (3)$$

This Eq.(3) as it stands is what gives us the $h \sim 10^{-25}$ as an experimentally measurable contribution which is new , as opposed to the general solution for h_{ij}^T we outline which has $h \sim 10^{-36}$ as an unmeasurable contribution . We will be evaluating solutions to Eq.(2) and Eq. (3) in k space, and then inverse Fourier transform back to position space. In three dimensions this means using, here integrating back to r via

$$\int_{-\infty}^{\infty} \left(4\pi\right) \cdot dk \cdot k^2 \cdot \exp\left(-ikr\right) \qquad (4)$$

2.Conditions permitting an evaluation of Eq. (2), in k and then position space, whereas afterwards evaluating Eq.(3) in k and then position space

Looking at Eq. (2) is the same as looking at the following, analyzing how [3] leads to the following k space solution, namely in k space

$$h_{ij}^T(general) \propto \left[\exp\left(-H_c\tau\right)\right] \cdot \left[A \cdot \exp\left(i \cdot \sqrt{k^2 - H_c^2} \cdot \tau\right) + A^* \cdot \exp\left(-i \cdot \sqrt{k^2 - H_c^2} \cdot \tau\right)\right] \qquad (5)$$

Inverse Fourier transformed back to position space the general position space looks like

$$h_{ij}^{T}(general-r) \propto \sqrt{\frac{2}{\pi}}\left[\exp\left(-H_c\tau\right)\right]\cdot\int_{-\infty}^{\infty} dk\cdot k^2 e^{-ikr}\left[A\cdot\exp\left(i\cdot\sqrt{k^2-H_c^2}\cdot\tau\right)+A^*\cdot\exp\left(-i\cdot\sqrt{k^2-H_c^2}\cdot\tau\right)\right] \quad (6)$$

This Eq.(6) had an experimentally unmeasurable value of $h \sim 10^{-36}$. Or smaller. As given by Maggiore [4] this above equation should be compared as similar to

$$h_{ij}^{T}(general-r) \sim \begin{pmatrix} h_{\oplus} & h_{\otimes} & 0 \\ h_{\otimes} & -h_{\oplus} & 0 \\ 0 & 0 & 0 \end{pmatrix}_{ij} \cdot\cos\left[\omega\cdot\left(\tau-\frac{z}{c}\right)\right] \quad (7)$$

We therefore look at the inverse Fourier transform of Eq. (3) using Eq.(4) in order to obtain , if Eq. (3) is time independent, which is an approximation, namely we look at

$$h_{ij}^{T}\left(particular-r\right) \propto \frac{16\pi}{\sqrt{2\cdot\pi}}\int_{-\infty}^{\infty} dk\cdot e^{-ikr} G a^2 p \Pi_{ij} \quad (8)$$

Note that the strain Π_{ij} has values from [1] which will be put into Eq. (7) in order to justify values $h \sim 10^{-25}$

3. Conclusion: Arguing for $h \sim 10^{-25}$ value for Eq. (8) due to explicit inputs into Π_{ij}

The entire Π_{ij} proof of $h \sim 10^{-25}$; the value of such lies upon Π_{ij} with a magnetic field from the quark gluon Plasma of the sort from [1] and [5] ,[6] , and [7] so then that

$$\left\langle h_{ij}^{T}\left(particular-r\right)\right\rangle_{spatially-averaged} \propto \frac{(2\pi)^9}{\sqrt{2\cdot\pi}} G\cdot p\cdot\frac{B_0^4}{k_c^3} \quad (9)$$

The conjecture for evaluating Eq. (9) is in looking at B_0 and $N_{gravitons} \sim E^2/(10^{16} ergs)^2$ and having an energy value, E with $\mathrm{E} \sim \frac{B_0^2}{2}$. Of which then if the electroweak interval has 10 to the 50 th power number of gravitons, then the following are to be expected

a). Mass of the graviton : $10^{-31} eV/c^2 < m_{graviton} < 10^{-29} eV/c^2$

b) $\omega_c > 10^7 Hz$

c) $h \sim 10^{-25}$

References

1. A.Lightman, W. Press, R. Price, and S. Teukolsky,"Problem book in relativity and Gravitation",Princeton University Press, Princeton, NJ, 1975
2. T. Kahniashvili, R. Durrer,"CMB anisotropies caused by Gravitational waves: Dependence on Cosmological Parameters and Primordial Magnetic Field Influence", pp 287-292, of 'Gravitational Waves and Experimental Gravity, Rencontres De Moriond, 2000,edited by J. Tran Thanh Van, J. Dumarchez, S.Reynaud, C. Salomon, S. Thorsett,J.Vinet, World publishers , Hanoi, Vietnam, 2000.
3. J. Jose, E. Saletan,"Classical Dynamics, A contemporary approach", Cambridge University Press, Cambridge, UK,1998.

4. M. Maggiore, “Gravitational Waves ,Volume 1, theory and experiment”, Oxford University press, Oxford, UK, 2008
5. R. Durrer *Fundamentals in Cosmic Physics*, 15, 209, (1994)
6. R. F. Abott, and M. B. Wise, *Nuclear Physics B***244**, 541,(1984)
7. R. Durrer, T. Kahniashivili, and A. Yates, *Phys. Rev D* **58**, 1230004(1998)