Gedankenexperiment for speed of Gravitational Waves, massive Gravitons, and GW signals from Inflation.

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Abstract. **We examine the consequence of experimentally determining what the consequences of massive gravitons from the big bang would be, in terms of Clifford Will's model of the speed of gravitational waves via a local inertial frame , with variation from the speed of light in GW propagation caused by gravitational rest mass non zero and E as a graviton rest energy. One of the consequences, being that the wavelength of GW would be 1/100 the radius of the present universe, with unimaginably low frequencies for GW of the order of 10^-16 Hertz, if there were maximally favourable conditions for generation of GW at the start of inflation, which puts restrictions we will specify as to an initial scale factor, the maximal red shift Z so specified, plus other details.**

1. Introduction

We reference what was done by Will in his living reviews of relativity article as to the 'Confrontation between GR and experiment". Specifically we make use of his experimentally based formula of [1,2] , with $v_{graviton}$ the speed of a graviton, and $m_{graviton}$ the rest mass of a graviton, and $E_{graviton}$ in the inertial rest frame given as:

$$\left(\frac{v_{graviton}}{c}\right)^2 = 1 - \frac{m^2_{graviton}c^4}{E^2_{graviton}} \tag{1}$$

Furthermore, using [2], if the rest mass of a graviton is very small we can make a clear statement of

$$\begin{aligned} \frac{v_{graviton}}{c} &= 1 - 5\times 10^{-17}\cdot\left(\frac{200Mpc}{D}\right)\cdot\left(\frac{\Delta t}{1\sec}\right) \\ &\doteq 1 - 5\times 10^{-17}\cdot\left(\frac{200Mpc}{D}\right)\cdot\left(\frac{\Delta t = \Delta t_a - (1+z)\cdot\Delta t_b}{1\sec}\right) \\ \Leftrightarrow \frac{2m_{graviton}c^2}{E_{graviton}} &\approx 5\times 10^{-17}\cdot\left(\frac{200Mpc}{D}\right)\cdot\left(\frac{\Delta t_a - (1+z)\cdot\Delta t_b}{1\sec}\right) \end{aligned} \tag{2}$$

Here, Δt_a is the difference in arrival time, and Δt_e is the difference in emission time/in the case of the early Universe, i.e. near the big bang, then if in the beginning of time, one has, if we assume that there is an average $E_{graviton} \approx \hbar \cdot \omega_{graviton}$, and

$$\begin{aligned} &\Delta t_a \sim 4.3 \times 10^{17} \sec \\ &\Delta t_e \sim 10^{-33} \sec \\ &z \sim 10^{50} \end{aligned} \tag{3}$$

Then, $\left(\dfrac{\Delta t_a - (1+z) \cdot \Delta t_b}{1 \sec} \right) \sim 1$, and if $D \sim 4.6 \times 10^{26} meters = radii(universe)$, so one can set

$$\left(\frac{200 Mpc}{D} \right) \sim 10^{-2} \tag{4}$$

And if one sets the mass of a graviton [3] into Eq. (1) , then we have in the present era, that

$$\begin{aligned} &\hbar \cdot \omega_{graviton} \sim 1.783 \times 10^{-38} eV \\ &\Leftrightarrow \lambda_{graviton} \sim 1.24 \times 10^{24} meters \\ &\Leftrightarrow \lambda_{graviton} \sim 1.24 \times 10^{24} meters \\ &\sim (1/100)\, radius(universe - today) \\ &\Leftrightarrow \omega_{graviton} \sim 2.41 \times 10^{-16} Hertz \end{aligned} \tag{5}$$

Note that the above frequency, for the graviton is for the present era, but that it starts assuming genesis from an initial inflationary starting point which is not a space – time singularity.

Note this comes from a scale factor, if $z \sim 10^{50} \Leftrightarrow a_{scale-factor} \sim 10^{-50}$, i.e. 50 orders of magnitude smaller than what would normally consider, but here note that the scale factor is not zero, so we do not have a space – time singularity. Close but no cigar

We will next discuss the implications of this point in the next section, of a non zero smallest scale factor

2.Non zero scale factor, initially and what this is telling us physically. Starting with a configuration

Begin with a relation ship between Graviton mass, and the frequency, i.e. we have initially the following configuration [4], with N ~ Entropy ~ S , as according to [5], if we scale to the present era

$$m_{graviton} \sim \frac{\hbar H}{c^2} \sim \frac{\hbar N}{c^2 t_{Universe}} \sim 10^{-61} grams$$
$$\omega_{graviton} \sim \frac{1.8 \times 10^{36}}{N} Hertz \quad (6)$$

This would lead to , N > 10 ^ 50 to have the graviton frequency commensurate with Eq. (5) frequency.

Note though that we are trying to have initial conditions, that we will then be looking at in [16] there exists a scaled parameter λ, and a parameter a_0 which is paired with α_0. For the sake of argument, we will set the $a_0 \propto \sqrt{t_{Planck}}$, with t_{Planck} ~ 10^ - 44 seconds. Also, Λ is a cosmological 'constant' parameter and the minimum scale factor parameters are described in [6] via:

$$\alpha_0 = \sqrt{\frac{4\pi G}{3\mu_0 c}} B_0 \quad (7)$$

$$\lambda = \Lambda c^2 / 3 \quad (8)$$

Then if ,

$$t_{\min} \approx t_0 \equiv t_{Planck} \sim 10^{-44} s \quad (9)$$

Whenever one sees the coefficient like the magnetic field, with the small 0 coefficient, for values of Λ, this should be the initial coefficient at the beginning of space-time which helps us make sense of the non zero but tiny minimum scale factor[6]

$$a_{\min} = a_0 \cdot \left[\frac{\alpha_0}{2\lambda} \left(\sqrt{\alpha_0^2 + 32\lambda\mu_0\omega B_0^2} - \alpha_0 \right) \right]^{1/4} \quad (10)$$

This value for the initial scaling would be of the order of 10 ^ -50 with, likely initial density scaling as

$$\rho \sim a^{-4} \quad (11)$$

3. Conclusion. Does the Waleka relationship between density and time hold.

Here, we would be looking at the Waleka relationship of time and density as given by[7]

$$t_{initial} \approx \frac{1}{\sqrt{6\pi\rho_{initial}}} \sim \frac{a_{\min}^2}{\sqrt{6\pi}} \quad (12)$$

If , indeed , the minimum time can be defined this way, and the rest of the derivations hold, a consistent scaling of GW, from initial configurations, to the enormous final wavefront of primordial GW may be then obtained.

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