Analysis of How High Frequency Gravitational Waves Could Commence from Early Universe

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Abstract

We will be reduplicating the Book "Dark Energy" by M. Li, X-D. Li, and Y. Wang, zero-point energy calculation with an unexpected "length' added to the 'width' of a graviton wavefunction just prior to the entrance of 'gravitons' to a small region of space-time prior to a nonsingular start to expansion of the Universe. In doing so, the initially large wavelength is in a 'multiverse' domain of space-time. The eventual exit of matter and energy from this nonsingular starting point will be where we form a cosmological constant, a density of dark energy , and the mass of gravitons prior to expansion into our present universe. The papers conclusion, after we set a mass m(graviton) per graviton is to access an initial frequency for Planckian to at latest the electroweak era of cosmology.

Key Words: Minimum scale factor, cosmological constant, space-time bubble, Penrose singularity

I. Begin first with the Zero-point energy calculation, as in [1] and its subsequent modification to obtain Dark Energy/ Cosmological constant.

As of the Zero-point energy calculation, we start off with the following as given by [1]

$$\frac{1}{2}\cdot\sum_i \omega_i \equiv V\left(volume\right)\cdot\int_0^{\hat{\lambda}}\sqrt{k^2+m^2}\,\frac{k^2 dk}{4\pi^2}\approx\frac{\hat{\lambda}^4}{16\pi^2}$$
$$\xrightarrow[\hat{\lambda}=M_{Planck}]{}\rho_{boson}\approx 2\times 10^{71}GeV^4\approx 10^{119}\cdot\left(\rho_{DE}=\frac{\Lambda}{8\pi G}\right) \qquad (1)$$

In stating this we have to consider that $\rho_{DE}=\frac{\Lambda}{8\pi G}\approx\hbar\cdot\frac{\left(2\pi\right)^4}{\lambda_{DE}{}^4}$, so then that the equation we have to consider is a wavelength $\lambda_{DE}\approx 10^{30}\ell_{Planck}$ which is about 10^{30} times a Plank length radius of a space-time bubble which we discuss in [2] as a start point for a nonsingular expansion point for Cosmology, at the start of inflation with the space-time bubble of about a Plank length radius

In order to obtain space-time for a wavelength approximately 10^{30} times ℓ_{Planck} a of the starting point which is of radii ℓ_{Planck} , as given in [2] we specify a generalization of Penrose Cyclic conformal cosmology, as given usually by the identification of a contribution to a partition function of our present universe which we call Ξ_j

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$$\Xi_j\Big|_{j-before-nucleation-regime} \approx \sum_{k=1}^{Max} \tilde{\tilde{\Xi}}_k\Big|_{black-holes-jth-universe} \qquad (2)$$

With each partition function per universe defined by $\left\{\Xi_i\right\}_{i\equiv1}^{i\equiv N} \propto \left\{\int_0^\infty dE_i \cdot n(E_i)\cdot e^{-E_i}\right\}_{i\equiv1}^{i\equiv N}$. As in [3] and

we specify a formation of a nontrivial gravitational measure as a new big bang for each of the N universes as by $n(E_i)\cdot$ the density of states at a given energy E_i for partition function which [2] and [3] specify

Then the main methodology in the Penrose proposal has been in utilizing Eq. (2) evaluating a change in the metric g_{ab} by a conformal mapping $\hat{\Omega}$ to [2]

$$\hat{g}_{ab} = \hat{\Omega}^2 g_{ab} \qquad (3)$$

Penrose's suggestion has been to utilize the following [2]

$$\hat{\Omega} \xrightarrow[ccc]{} \hat{\Omega}^{-1} \qquad (4)$$

We thereby bundle in a multiverse contribution to Eq. (2), Eq.(3) and Eq., (4) after the following averaging of N partition functions from prior universes for our present universe

$$\frac{1}{N}\cdot\sum_{j=1}^{N}\Xi_j\Big|_{j-before-nucleation-regime} \xrightarrow[vacuum-nucleation-tranfer]{} \Xi_i\Big|_{i-fixed-after-nucleation-regime} \qquad (5)$$

We specify that while this is going on, we have a Pre Planckian space-time allowing for $\lambda_{DE} \approx 10^{30}\,\ell_{Planck}$, and then evolution to forming a graviton mass, in the Pre-Planckian state via $m_g = \frac{\hbar\sqrt{\Lambda}}{c}$ [4] , and having done this we can now discuss our conclusion which is how to obtain High Frequency Gravitational waves in relic conditions

II. Having specified a graviton mass, via a procedure to obtain a DE density value proportional to 1he cosmological constant, how do we obtain relic high frequency Gravity waves?

Using [5] a scale factor $a(t) = a_{\min} t^{\gamma}$ we obtain the following relation,

$$\begin{aligned}&\left(1+z_{initial-era}\right) \equiv \frac{a_{today}}{a_{initial-era}} \approx \left(\frac{\omega_{Earth-orbit}}{\omega_{initial-era}}\right)^{-1} \\ &\Rightarrow \left(1+z_{initial-era}\right)\omega_{Earth-orbit} \approx 10^{25}\,\omega_{Earth-orbit} \approx \omega_{initial-era}\end{aligned} \qquad (6)$$

We postulate that we specify an initial era frequency via dimensional analysis which is slightly modified by Maggiore for the speed of a graviton[6] whereas $c\left(light-speed\right) \approx \omega_{initial-era}\cdot\left(\lambda_{initial-post-bubble} = \ell_{Planck}\right)$

and that dimensional comparison with initially having a temperature built up so as $\Delta E \approx \hbar \omega_{initial-era}$ where

$T_{universe} \approx T_{Plank-temerature} = 1.22 \times 10^{19}$ **GeV** . If so then the initial temperature would be extremely high leading to a change in temperature from Pre Planckian conditions to Planck era leading to

$$\Delta E = \frac{d(\dim)}{2} \cdot k_B \cdot T_{universe} \qquad (7)$$

Where we would be assuming $\omega_{initial-era} \approx \frac{c}{\ell_{planck}} \leq 1.8549 \times 10^{43}\, Hz$ so then we would be looking at

frequencies on Earth from gravitons of mass m(graviton) less than of equal to $\omega_{Earth-orbit} \leq 10^{-25} \omega_{initial-era}$
And this partly due to the transference of cosmological 'information' as given in [7] for a phantom bounce type of construction as well as the work done in [2]

Further point that since gravitons travel at nearly the speed of light [6], that gravitons are formed from the surface of a bubble of space-time up to the electroweak era that mass values of the order of 10^-65 grams (rest mass of relic gravitons) would increase due to extremely high velocity would lead to enormous $\Delta E \approx \hbar \omega_{initial-era}$ values per graviton, which would make the conflation of ultrahigh temperatures with gravitons traveling at nearly the speed of light as given in Eq. (7) compared with $\Delta E \approx \hbar \omega_{initial-era}$

Details of making sense out of this would by necessity await experimental confirmation and data sets

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Bibliography

[1] Miao Li (Author), Xiao-Dong Li (Contributor), Shuang Wang (Contributor), Yi Wang (Contributor), "**Dark Energy", Peking University Press, World Scientific, Singapore, Republic of Singapore, 2015**

[2] Andrew Walcott Beckwith, "Using "Enhanced Quantization" to Bound the Cosmological Constant, (for a Bound-on Graviton Mass), by Comparing Two Action Integrals (One Being from General Relativity) at the Start of Inflation", pp 21-36, of " Fundamental Physics and Physics Education Research", editors of Burra G. Sidharth • Jesús Carnicer Murillo • Marisa Michelini • Carmen Perea, Published by Springer Nature Switzerland AG 2021 , in Gewerbestrasse 11, 6330 Cham, Switzerland

[3] Poplawski, N. (2011) Cosmological Constant from QCD Vacuum and Torsion. Annals of Physics (Berlin), 523, 291. https://doi.org/10.1002/andp.201000162

[4] Novello, M. (2005) The Mass of the Graviton and the Cosmological Constant Puzzle. https://arxiv.org/abs/astro-ph/0504505

[5] Padmanabhan, Thanu, "An Invitation to Astrophysics", World Press Scientific, World Scientific Series in Astronomy and Astrophysics: Volume 8, Singapore, Republic of Singapore, 2006

[6] Maggiorie, Michele, " Gravitational waves, Volume 1, theory and Experiment", Oxford University Press, New York City, New York, USA, 2008

[7] Katherine Freeze, Mathew Brown, and William Kinney, "The Phantom Bounce, A new proposal for an oscillating Cosmology", pp 149-156, of " The Arrows of Time, A debate in cosmology", Fundamental theories in physics, Volume 172, with Laura Mercini-Houghton, and Rudy Vaas , editors, Springer Verlag, Heidelberg, Federal Republic of Germany, 2012