Addressing strength of GW radiation affected by additional dimensions

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Abstract: We examine whether gravitational waves would be generated during the initial phase, δ_0 of the universe when triggered by changes in space-time geometry; i.e. We hope to find traces of the breakdown of the Entropy/QM space-time regime during δ_0. In particular, we look at if higher dimensions affect the relative strength of Ω_{GW}, and comment as to how this magnitude may affect opportunities for detection of GW from relic sources**. In particular, we will explain the reason why Ω_{GW} of the pre big bang model is so strong, up to 10 to the – 6 power, while the Ω_{GW} of ordinary inflation is so weak. In relic conditions.**

Keywords: High-frequency Gravitational Waves (HFGW), symmetry, causal discontinuity

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1. Introduction

This paper examines geometric changes that may have occurred in the very earliest phase of the universe, or δ_0, and explores how we might be able to gain insight into this epoch through gravitational wave research. The Planck epoch has remained mysterious, and may be invisible to all other kinds of detectors, but the universe's gravity wave background radiation likely contains the imprint of even the very earliest events. Changes in the geometry of space-time near the Planck scale could be revealed or studied in this manner. We discuss how to obtain insights into δ_0, initially, while looking at the geometric considerations determining space and time development which would create relevant space-time geometry phase changes during the early universe. Each such phase change should produce gravitational waves. Secondly, we review what are other candidate models which may have experimental verification if GW astronomy becomes a reality. In particular, is the datum that Ω_{GW} may be directly affected by the dimensions of space time available. I.e. additional dimensions may have observational consequences. Doing so will touch upon giving an explanation as to why. Ω_{GW} of the pre big bang model can be so comparatively large. We will to the end state that the Ω_{GW} of ordinary inflation is weak since we do not have to have a thermal 'introduction' of flux energy from a prior universe, or universes to the present universe. In both the pre big bang, and the string theory model, the introduction of thermal flux from a prior to the present universe gives a relatively high level for Ω_{GW}. The summary is in table 3 below. The pre big bang model also has a restricted geometry space for the creation of gravitational waves. I.e. of extremely small dimensions. As referred to in tables 1 and tables 2. This forces a high frequency relic gravity wave condition. The string theory model, even with a particularly large Ω_{GW} does not have a tiny nucleation space for the creation of gravity waves, leading to much lower frequencies. If the nucleation space for synthesis of gravitational waves is large, then the relative frequency will drop. I.e. frequency is inversely proportional the wavelength as brought up in tables 1 and 2 of this document. We next then refer to vacuum expectation value behavior expected for a successful inflationary model.

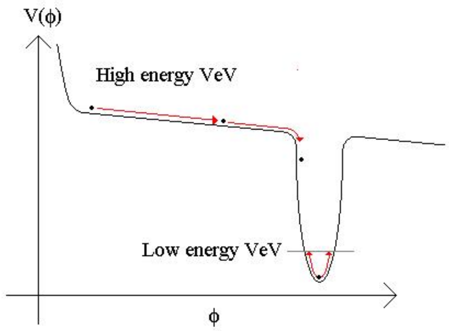

Figure 1, as supplied by L. Crowell, in correspondence to A. W. Beckwith, October 24, 2010 [8]

As stated by L. Crowell [1], [2], in an email sent to A. Beckwith, the way to delineate the evolution of the VeV issue is to consider an initially huge VeV, due to initial inflationary geometry. As stated by L. Crowell [2]

> *"The standard inflationary cosmology involves a scalar field φ which obeys a standard wave equation. The potential is this function which I diagram 'above'. The scalar field starts at the left and rolls down the slope until it reaches a value of φ where the potential is V(φ) ~ φ^2. The enormous VeV at the start is about 14 orders of magnitude smaller than the Planck energy density ~ (1/L_p) ^4 on the long slope. The field then enters the quadratic region, where a lot of that large VeV energy is thermalized, with a tiny bit left that is the VeV and CC of the observable universe. The universe during this roll down the long small slope has a large cosmological constant, actually variable λ = λ(φ,∂φ), which forces the exponential expansion. There are about 60-efolds of the universe through that period. Then at the low energy VeV the much smaller CC gives the universe with the configuration we see today."*

One of the ways to relate an energy density to cosmological parameters and a vacuum energy density may be using a relation as given by (1), as given by Poplawski [3]:

$$\rho_{\Lambda} = H\lambda_{QCD} \tag{1}$$

Where if λ_{QCD} is at least 200MeV and is similar to the QCD scale parameter of the SU (3) gauge coupling constant, and H a Hubble parameter. We can then equate vacuum potential with vacuum expectation values as follows:

$$\rho_{Vacuum} = \left[\Lambda/8\pi \cdot G\right] \approx \rho_{\Lambda} \approx H\lambda_{QCD} \Leftrightarrow V \sim 3\langle H\rangle^{4}/16\pi^{2} \sim V_{\inf} \approx \phi^{2} \tag{2}$$

Different models for the Hubble parameter, H exist, and can be directly linked to how one forms the inflaton. The authors presently explore what happens to the relations as given in Eq. (2) before, during, and after inflation. We will be first discussing how we can form a model of the pre big bang which will give a way to estimate the size of Ω_{GW}, next. In particular, the injection of thermal energy for the pre big bang from a 'multiverse's structure, as stated below will be one of the reasons for the comparatively large value of Ω_{GW} in pre big bang models. To get at them we look at a Kaluza – Klein construction, below

1.1 A review as to the role of additional dimensions as to the magnitude of Ω_{GW} .for the pre big bang model

To begin this inquiry, we will look at how additional dimensions affect gravitational potentials. Starting with this, we refer to O.V. Selyugin · O.V. Teryaev's [4] recent document as to a model of how additional dimensions may affect gravitational potentials and generalize it to its effect upon Ω_{GW} . Selvugin, and Teryaev [4] have, for Kaluza – Klein modification of a gravitational potential the expression: This is in tandem with Maarten's work with branes with a different emphasis [5]

$$V(r) \sim \frac{1}{r^3} \cdot \left[1 - \exp(-M_D r) - \left(M_D r \right) \cdot \exp(-M_D r) \right] \tag{3}$$

Here, if L is the size of the "additional dimensions', Maarsden [5] approximates the behavior of the mass, so that if d is the additional dimensions above our usual four dimensions, with d any where from 1 to 7, then

$$M_D \sim M_{4+d} \sim \left[M_P^2 / L^d \right]^{(1/2+d)} \tag{4}$$

This above, greatly simplifies, if we work with Planck scale, so that $L \sim M_P^{-1} \Rightarrow M_D \propto M_P$, so then at the Planck scale, one is obtaining [4]

$$V(r) \sim \frac{1}{r^3} \cdot \left[1 - \exp(-M_D r) - \left(M_D r \right) \cdot \exp(-M_D r) \right] \sim \frac{M_P^2}{r} \propto \frac{1}{r^3} \sim M_P^3 \tag{5}$$

One relationship to keep in mind, namely that according to brane world models as reported by Masrten's, there is a density variation according to [5]

$$\delta\rho^* = \frac{\delta C^*}{a^4} \tag{6}$$

Mind ., that in the beginning of inflation $a \sim 10^{-25}$, whereas δC^* is stated by Maarten [5] to be a constant. The upshot is that in a fluid approximation, that a change or a nucleation of density value, which may be implemented , are very approximately $\delta\rho^* \sim a^{-4} \propto r^{-4} \approx M_P^4$. Note that if one has a "constant" Hubble mass gap between the zeroth to the higher order KK modes, as given by $\Delta m = \frac{3}{2} \cdot H_0$, then Eq. (6) may be approximated by, an initial Hubble parameter as given by $H_{initial} = H_0$ with $\delta\rho^* \sim H_0^4$, so up to a point if one is looking at [6]

$$\Omega_{GW} = \frac{\rho}{\rho_{critical}} \sim 10^{-6} \tag{6a}$$

for certain base line models, one is referring, realistically to a re scaling of , if we look at what Saunders[*] put in about a temperature dependence of, if N(T) is the degrees of freedom specified at a given temperature, as stated by Kolb and Turner [7], and H the 'flat space' Hubble parameter, while making use of the flat space version of the Friedman equation, as given by Saunders [8],with $T_{initial}$ being an initial temperature value. Frequently, $T_{initial}$ is at to less than 10 to the 32 power , Kelvin.[8]

$$H = H_{initial} = \sqrt{\frac{4\pi G a N(T_{initial})}{3c^2}} \cdot T_{initial}^2 \tag{7}$$

We make reference to the Hubble parameter, with a temperature $H_{initial} = H_0$ with $\delta\rho^* \sim H_0^4$

$$\rho \approx \rho_{critical} \cdot 10^{-6} \cong \left[10^{-25} \right]^4 \cdot 10^{-6} \cdot \left\lfloor \delta\rho^* \sim \Lambda_{4-\dim} \Big|_{Planck-temp} \right\rfloor \tag{8}$$

We shall next describe the role of Vacuum energy as to contributions as to Eq. (8) above.

1.2 First, thermal input into the new universe. In terms of vacuum energyfor the pre big bang mode.

We will briefly allude to temperature drivers which may say something about how thermal energy

in contrast with the more traditional four-dimensional version of the same, minus the minus sign of the brane world theory version. as given by Park [9], [10]

$$\Lambda_{4-\dim} \approx c_2 \cdot T^{\beta} \tag{9}$$

If one looks at the range of allowed upper bounds of the cosmological constant, the difference between what Barvinsky [9] recently predicted, and Park [9], [10] is:

$$\Lambda_{4-\dim} \propto c_2 \cdot T^{\beta} \xrightarrow[graviton-production-as-time>t(Planck)]{} 360 \cdot m_P^2 << c_2 \cdot \left[T \approx 10^{32} K\right]^{\beta} \tag{10}$$

Right after the gravitons are released, one still sees a drop-off of temperature contributions to the cosmological constant .

We assume in this that we have, a discontinuity in the pre Planckian regime, for scale factors[8].

$$\left[\frac{a(t^* + \delta t)}{a(t^*)}\right] - 1 < (value) \approx \varepsilon^+ << 1 \tag{11}$$

Furthermore, in the transition for $0 \le t < t_P$ the following increase in degrees of freedom is driven by thermal energy from a prior universe Starting with [11] , [12]

$$E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \left[\Omega_0 \breve{T}\right] \sim \tilde{\beta} \tag{12}$$

The assumption is that there is an initial fixed entropy arising, with $\overline{N}$ as a nucleated structure in short time interval as temperature $T_{temperature} \varepsilon\left(0^+, 10^{19} GeV\right)$ arrives. Then by [11], [12]

$$[\Delta S] = [\hbar / T] \cdot \left[2k^2 - \frac{1}{\eta^2}\left[M_{Planck}^2 \cdot \left[\left[\frac{6}{4\pi} - \frac{12}{4\pi}\right] \cdot \left[\frac{1}{\phi}\right]^2 - \frac{6}{4\pi} \cdot \left[\frac{1}{\phi^2}\right]\right]\right]\right]^{1/2} \sim n_{Particle-Count} \tag{13}$$

If the inputs into the inflaton ϕ, as given by a random influx of thermal energy from temperature, we will see the particle count on the right hand side of Eq. (12) above a random creation of $n_{Particle-Count}$. The way to introduce the expansion of the degrees of freedom from nearly zero to having **N(T) ~ 10^3** is to define the classical and quantum regimes of gravity as to minimize the point of the bifurcation diagram affected by quantum processes.[5] Dynamical systems modeling is employed right 'after' evolution through the 'quantum dot' regime. The diagram, would look like an application of the Gauss mapping of [11].[12]

$$x_{i+1} = \exp\left[-\tilde{\alpha} \cdot x_i^2\right] + \tilde{\beta} \sim N(T_{initial}) \Big|_{Planck} \tag{14}$$

The inputs of change of iterated steps on the right hand side of Eq. (13) may indeed show increase in degrees of freedom. Change of temperature, as given , over a short distance, is [11],[12]

$$\frac{\Delta\tilde{\beta}}{dist} \cong \left(5 k_B \Delta T_{temp} / 2\right) \cdot \frac{\overline{N}}{dist} \sim qE_{net-electric-field} \sim \textbf{change in degrees of freedom} \tag{15}$$

We would regard this as being the regime in which we see a thermal increase in temperature, up to the Planckian physics regime. If so, then we can next look at what is the feeding in mechanism from the **end of a universe, or universes**, and inputs into Eq.(14) , Eq.(15)

1.3 A new idea extending Penrose's suggestion of cyclic universes, black hole evaporation, and the embedding structure our universe is contained within

Beckwith strongly suspects that there are no fewer than N universes undergoing Penrose 'infinite expansion' [13],[14] and all these are contained in a mega universe structure. Furthermore, each of the N universes has black hole evaporation, with the Hawking radiation from decaying black holes. If each of the N universes is defined by a partition function, we can call $\left\{\Xi_i\right\}_{i\ \equiv N}^{i\ \equiv 1}$, then there exist an information minimum ensemble of mixed minimum information roughly correlated as about $10^7 - 10^8$ bits of information per partition function in the set $\left.\left\{\Xi_i\right\}_{i\ \equiv N}^{i\ \equiv 1}\right|_{before}$, so minimum information is conserved between a set of partition functions per each universe [13], [14]

$$\left.\left\{\Xi_i\right\}_{i\ \equiv N}^{i\ \equiv 1}\right|_{before} \equiv \left.\left\{\Xi_i\right\}_{i\ \equiv N}^{i\ \equiv 1}\right|_{after} \tag{16}$$

However, that there is non uniqueness of information put into each partition function $\left\{\Xi_i\right\}_{i\ \equiv N}^{i\ \equiv 1}$. Furthermore Hawking radiation from the black holes is collated via a strange attractor collection in the mega universe structure to form a new big bang for each of the N universes as represented by $\left\{\Xi_i\right\}_{i\ \equiv N}^{i\ \equiv 1}$. Verification of this mega structure compression and expansion of information with a non unique venue of information placed in each of the N universes favors Ergodic mixing treatments of initial values for each of N universes expanding from a singularity beginning. The n_f value, will be used to algorithm of [14], [15]. $S_{entropy} \sim n_f$. . How to tie in this energy expression, as in Eq. (16) will be to look at the formation of a non trivial gravitational measure which we can state as a new big bang for each of the N universes as by [9], and $n(E_i)\cdot$ the density of states at a given energy E_i for a partition function. [16]

$$\left\{\Xi_i\right\}_{i\ \equiv 1}^{i\ \equiv N} \propto \left\{\int_0^\infty dE_i \cdot n(E_i)\cdot e^{-E_i}\right\}_{i\ \equiv 1}^{i\ \equiv N}. \tag{17}$$

Each of the terms E_i would be identified with Eq.(17) above, with the following iteration for N universes [13],[14]

$$\frac{1}{N}\cdot\sum_{j=1}^{N}\left.\Xi_j\right|_{j-before-nucleation-regime} \xrightarrow[vacuum-nucleation-tranfer]{} \left.\Xi_i\right|_{i-fixed-after-nucleation-regime} \tag{18}$$

For N number of universes, with each $\left.\Xi_j\right|_{j-before-nucleation-regime}$ for j = 1 to N being the partition function of each universe just before the blend into the RHS of Eq. (12) above for our present universe. Also, each of the independent universes given by $\left.\Xi_j\right|_{j-before-nucleation-regime}$ would be constructed by the absorption of one million black holes sucking in energy**. I.e. in the end [13],[14]**

$$\Xi_j \Big|_{j-before-nucleation-regime} \approx \sum_{k=1}^{Max} \tilde{\Xi}_k \Big|_{black-holes-jth-universe} \tag{19}$$

2.1 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 Institute of theoretical physics researchers in Chongquing University[17],[18] For a cavity containing electromagnetic energy, if Q is the quality factor of a cavity, ξ is the total energy in a cavity, $\hbar\omega_{e^-}$ is the energy of a photon in the cavity, then the minimum sensitivity to a stochastic HFGW would need a metric 'amplitude' of at least [19],[20],[21],[22]

$$h_{\min} \approx \frac{1}{\sqrt{Q}} \cdot \sqrt{\frac{\hbar\omega_{e^-}}{\xi}} \tag{20}$$

This can be a significant limitation in practice. For example, as quoted from a document being written up by F. Li et al, for publication [23] if Q $=10^{11}$, E = 10J, and ω_{e^-} is a frequency $=10^{12}$ Hz, then one will obtain $h_{\min} \sim 2:5 \times 10^{-17}$ for the stochastic HFGW. Therefore, we can conclude that advanced cavity detectors could be a promising way for the HFGW detection If much higher contained energies are developed. Similarly, if one has, instead, a coherent GW background, [19],[20],[21],[22],[24] then

$$h_{\min} \approx \frac{1}{Q} \cdot \sqrt{\frac{\hbar\omega_{e^-}}{\xi}} \tag{21}$$

It this case $h_{\min} \sim 8.1 \times 10^{-23}$ for the non - stochastic HFGW, even at a very low contained energy of 10 J. It is therefore quite plausible that such a detection cavity could be tuned over a range of HFGW frequencies to scan for detectible gravitational waves of either a coherent or stochastic nature. Given these figures, it is now time to consider what happens if one is looking for traces of gravitons which may have a small rest mass in four dimensions**.** What Li et a.l have shown in 2003 [18] which Beckwith commented [17] is to obtain a way to present first order perturbative electromagnetic power flux, i.e. what was called $\overset{(1)}{T^{uv}}$ in terms of a non zero graviton rest mass, in a detector , in an uniform magnetic field, i.e. [18] what if we have curved space time with say an energy momentum tensor of the electro magnetic fields in GW fields as

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

Li et al [23] [18] 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

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

The 1st term to the right hand side of Eq. (23) is the energy – momentum tensor of the back ground electro magnetic field, and the 2nd term to the right hand side of Eq. (22) is the first order perturbation of an electro magnetic field due to gravitational waves. The above Eq.(22) and Eq. (23) will lead to Maxwell equations as[18]

$$\frac{1}{\sqrt{-g}} \cdot \frac{\partial}{\partial x^\nu} \cdot \left(\sqrt{-g} \cdot g^{\mu\alpha} g^{\nu\beta} F_{\alpha\beta} \right) = \mu_0 J^\mu \tag{24}$$

as well as

$$F_{[\mu\nu,\alpha]} = 0 \tag{25}$$

Eventually, with GW affecting the above two equations, we have a way to isolate $\overset{(1)}{T}{}^{uv}$. If one looks at if a four dimensional graviton with a very small rest mass included [17] we can write

$$\frac{1}{\sqrt{-g}} \cdot \frac{\partial}{\partial x^{\nu}} \cdot \left(\sqrt{-g} \cdot g^{\mu\alpha} g^{\nu\beta} F_{\alpha\beta} \right) = \mu_0 J^{\mu} + J_{effective} \tag{26}$$

where for $\varepsilon^{+} \neq 0$ but very small

$$F_{[\mu\nu,\alpha]} \sim \varepsilon^{+} \tag{27}$$

The claim which A. Beckwith made [13],[14], [17] , is that

$$J_{effective} \cong n_{count} \cdot m_{4-D-Graviton} \tag{28}$$

As stated by Beckwith, in [17] $m_{4-D-Graviton} \sim 10^{-65}\, grams$, n_{count} is the number of gravitons which are in the detector. What Beckwith, and Li, intend to do is to try to isolate out an appropriate $\overset{(1)}{T}{}^{uv}$ assuming non zero graviton rest mass, and using Eq. (12), Eq. (13) and Eq. (14) . From there, the energy density contributions of $\overset{(1)}{T}{}^{uv}$, i.e. $\overset{(1)}{T}{}^{00}$ can be isolated, and reviewed in order to obtain traces of $\tilde{\beta}$, which can be used to interpret Eq. (15) . application of the Gauss mapping of [13],[14]. With the LHS being degrees of freedom, for $E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \left[\Omega_0 \breve{T} \right] \sim \tilde{\beta}$ I.e. use $\tilde{\beta} \cong |F|$ and make a linkage of sorts with $\overset{(1)}{T}{}^{00}$. The term $\overset{(1)}{T}{}^{00}$ isolated out from $\overset{(1)}{T}{}^{uv}$ present day data. The point here that the detected GW would help constrain and validate Eq. 14. Then, the next step will be making sense out of different GW measurement protocols.

2.2 : Working with NOTE TO TAME THE INCOMMESURATE METRICS, THE APPROXIMATION given below is used as a START to come up with how to make measurements.

$$h_0^2 \Omega_{GW} \sim 10^{-6} \tag{29a}$$

Next, we will commence to note the difference and the variances from using $h_0^2 \Omega_{GW} \sim 10^{-6}$ as a unified measurement which will be in the different models discussed right afterwards

2.3 : Wavelength, sensitivity and other such constructions from Maggiore, with our adaptations and comments

We will next give several of our considerations as to early universe geometry which we think are appropriate as treatment of both wavelength, strain, and Ω_{GW} . To begin with , look at Maggiore's [22] Ω_{GW} formulation, strain, and what we did with observations as from L. Crowell [25] which ties in with the ten to the tenth power increase as to wave length from pre Planckian physics to 1-10 GHz inflationary GW frequencies.. We will proceed to look at how the conclusions factor in with information exchange between different universes .We begin with the following , Table 1 and Table 2. What we have stated below in **Table 2 and Table 3** will have consequences of information flow from a prior to present universe, and fine tuning GW variance

Table 1: Managing GW generation from Pre Planckian physics [22]

$h_C \leq 2.82 \times 10^{-33}$	$f_{GW} \sim 10^{12}\, Hertz$	$\lambda_{GW} \sim 10^{-4}\, meters$
$h_C \leq 2.82 \times 10^{-31}$	$f_{GW} \sim 10^{10}\, Hertz$	$\lambda_{GW} \sim 10^{-2}\, meters$
$h_C \leq 2.82 \times 10^{-29}$	$f_{GW} \sim 10^{8}\, Hertz$	$\lambda_{GW} \sim 10^{0}\, meters$
$h_C \leq 2.82 \times 10^{-27}$	$f_{GW} \sim 10^{6}\, Hertz$	$\lambda_{GW} \sim 10^{2}\, meters$
$h_C \leq 2.82 \times 10^{-25}$	$f_{GW} \sim 10^{4}\, Hertz$	$\lambda_{GW} \sim 10^{1}\, kilometer$
$h_C \leq 2.82 \times 10^{-23}$	$f_{GW} \sim 10^{2}\, Hertz$	$\lambda_{GW} \sim 10^{3}\, kilometer$

What we are expecting, as given to us by L. Crowell,[25] is that initial waves, synthesized in the initial part of the Planckian regime would have about $\lambda_{GW} \sim 10^{-14}\, meters$ for $f_{GW} \sim 10^{22}\, Hertz$ which would turn into $\lambda_{GW} \sim 10^{-1}\, meters$, for $f_{GW} \sim 10^{9}\, Hertz$**,** and sensitivity of $h_C \leq 2.82 \times 10^{-30}$**.** This is assuming that $h_0^2 \Omega_{GW} \sim 10^{-6}$, using Maggiorie's [22] $h_0^2 \Omega_{GW}$ analytical expression.[22] It is important to note in all of this, that when we discuss the different models that the $h_0^2 \Omega_{GW} \sim 10^{-6}$ is the first measurement metric which is drastically altered. h_C should be also noted to be an upper bound. In reality, only the 2nd and 3rd columns in table 1 above escape being seriously off and very different. So for table 1, the first column is meant to be an upper bound which, even if using **Eq. (15.c)** may be off by an order of magnitude. More seriously, the number of gravitons per unit volume of phase space as estimated, is heavily dependent upon $h_0^2 \Omega_{GW} \sim 10^{-6}$. If that is changed, which shows up in the models discussed right afterwards, the degree of fidelity with **Eq. (29.b)** drops

Table 2: Managing GW count from Planckian physics/unit-phase-space[22]

$\lambda_{GW} \sim 10^{-4}\, meters \Rightarrow n_f \propto 10^{-6}\, graviton / unit - phase - space$;
$\lambda_{GW} \sim 10^{-2}\, meters \Rightarrow n_f \propto 10^{2}\, graviton / unit - phase - space$
$\lambda_{GW} \sim 10^{0}\, meters \Rightarrow n_f \propto 10^{10}\, graviton / unit - phase - space$
$\lambda_{GW} \sim 10^{2}\, meters \Rightarrow n_f \propto 10^{18}\, graviton / unit - phase - space$
$\lambda_{GW} \sim 10^{1}\, kilometer \Rightarrow n_f \propto 10^{26}\, graviton / unit - phase - space$
$\lambda_{GW} \sim 10^{3}\, kilometer \Rightarrow n_f \propto 10^{34}\, graviton / unit - phase - space$

The particle per phase state count will be given as, if $h_0^2 \Omega_{GW} \sim 10^{-6}$ [22]

$$n_f \sim h_0^2 \Omega_{GW} \cdot \frac{10^{37}}{3.6} \cdot \left[\frac{1000 Hz}{f} \right]^4 \tag{29b}$$

Secondly we have that a detector strain for device physics is given by [22]

$$h_C \le \left(2.82\times10^{-21}\right)\cdot\left(\frac{1Hz}{f}\right) \tag{29c}$$

These values of strain, the numerical count, and also of n_f give a bit count and entropy which will lead to possible limits as to how much information is transferred. Note that per unit space, if we have an entropy count of , after the start of inflation with having the following , namely at the beginning of relic inflation $\lambda_{GW} \sim 10^{-1} meters \Rightarrow n_f \propto 10^6 graviton/unit-phase-space$ for $f_{GW} \sim 10^9 Hertz$ This is to have, say a starting point in pre inflationary physics of $f_{GW} \sim 10^{22} Hertz$ when $\lambda_{GW} \sim 10^{-14} meters$, i.e. a change of $\sim 10^{13}$ orders of magnitude in about 10^{-25} seconds, or less. **The challenge, next will be to** come up with an input model which will justify a generation of data points , i.e. a new data model, since the pre inflationary models and their other related inferences are all ready being spelled out.[22]

Table 3, how to identify the commensurate metric models which are consistent with Eq. (40a) above as far as conventional cosmology models

To summarize, what we expect is that appropriate strain sensitivity values plus predictions as to frequencies may confirm or falsify each of these four inflationary candidates, and perhaps lead to completely new model insights. Note that in the following table, we assume that Ω_{GW} are essentially not measurable in the relic GW sense for the classic GR model.

TABLE 3: Variance of the Ω_{GW} parameters as given by the above mentioned cosmology models.[26], [27], [28],[29], [30], [31], [32],[33],[34]: paraphrasing Appendix A

Relic pre big bang	QIM	Cosmic String model	Ekpyrotic
$\Omega_{GW} \sim 6.9\times10^{-6}$ $when \quad f \ge 10^{-1} Hz$ $\Omega_{GW} << 10^{-6}$ $when \quad f < 10^{-1} Hz$	$\Omega_{GW} \sim 10^{-6}$ $1GH < f < 10GH$	$\Omega_{GW} \sim 4\times10^{-6}$ $f \propto 10^{-6} Hz$ $\Omega_{GW} \sim 0$ $otherwise$	$\Omega_{GW} \sim 10^{-15}$ $10^7 Hz < f < 10^8 Hz$ $\Omega_{GW} \sim 0$ $otherwise$

The best targets of opportunity, for viewing $\Omega_{GW} \sim 10^6$ are ***in*** the $1Hz < f < 10\ GHz$ range, with another possible target of opportunity in the $f \propto 10^{-6} Hz$ range. Other than that, it may be next to impossible to obtain relic GW signatures. Now that we have said it, it is time to consider the next issue. See **Appendix A** for a description of these cosmology models

3.0 : Providing a curve for the fifth cosmology model, as a modification / extension of the Penrose model talked about above

We can look now at the following approximate model for the discontinuity put in,due to the heating up implied in Table 1 above, namely This is adapted from a lecture at the ICGC-07 conference by Beckwith [9] We will start off with

$$\frac{\Lambda_{Max} V_4}{8 \cdot \pi \cdot G} \sim T^{00} V_4 \equiv \rho \cdot V_4 = E_{total} \tag{30}$$

The approximation we are making, in this treatment initially is that $E_{total} \propto V(\phi)$ where we are looking at a potential energy term.[11] What we are paying attention to, here is that for an exponential potential (effective potential energy) [33]

$$V(\phi) = g \cdot \phi^{\alpha} \tag{31}$$

De facto, what we come up with pre, and post Planckian space time regimes, when looking at consistency of the emergent structure is the following. Namely [33],[34]

$$V(\varphi) \propto \phi^{|\alpha|} \qquad \text{For } t < t_{PLanck} \tag{31a}$$

Also, we would have

$$V(\varphi) \propto 1/\phi^{|\alpha|} \qquad \text{for } t >> t_{PLanck} \tag{31b}$$

The switch between Eq. (31a) and Eq. (31b) is not justified analytically. I.e. it breaks down. Beckwith et al (2011) designated this as the boundary of a causal discontinuity. Now according to Weinberg [33], if

$\in = \frac{\lambda^2}{16\pi G}, H = 1/\in t$ so that one has a scale factor behaving as[33]

$$a(t) \propto t^{1/\in} \tag{32}$$

Then, if [33]

$$|V(\phi)| << (4\pi G)^{-2} \tag{33}$$

There are no quantum gravity effects worth speaking of. I.e., if one uses an exponential potential a scalar field could take the value of, when there is a drop in a field from ϕ_1 to ϕ_2 for flat space geometry and times t_1 to t_2 [33]

$$\phi(t) = \frac{1}{\lambda} \ln\left[\frac{8\pi G g \in^2 t^2}{3}\right] \tag{34}$$

Then the scale factors, from Planckian time scale as [33]

$$\frac{a(t_2)}{a(t_1)} = \left(\frac{t_2}{t_1}\right)^{1/\in} = \exp\left[\frac{(\phi_2 - \phi_1)\lambda}{2 \in}\right] \tag{35}$$

The more $\frac{a(t_2)}{a(t_1)} >> 1$, then the less likely there is a tie in with quantum gravity. Note those that the way this potential is defined is for a flat , Roberson-Walker geometry, and that if and when $t_1 < t_{Planck}$ then what is done in Eq. (35) no longer applies, and that one is no longer having any connection with even an octonionic Gravity regime.

3.1 We are then going to get the following expression for the energy / frequency spread in the Penrose alternation of the big 'crunch' model

Start with working with the expression given beforehand as [34] $E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \tilde{\beta}$

This is for having for a time $\breve{T} \sim 0^{+} \;\; to \;\; 10^{-44}$ seconds, $\Omega_{GW} \sim 10^{6}$ **,**and a variance of frequency of

$$\Omega_0 \varepsilon \left[1GHz, \;\; 10GHz \right] \tag{36}$$

This is due to $T_{temperature} \sim 10^{32}$ Kelvin at the point of generation of the discontinuity leading to a discontinuity for a signal generation as given by δ_0 at about $\breve{T} \sim 10^{-44}$ seconds. This is for inputs into the relatively constant

$$\left[\Omega_0 \breve{T}\right] \sim \tilde{\beta} \tag{37}$$

The assumption is that the discontinuity, as given by δ_0 will be as of about temperature $T_{temperature} \sim 10^{32}$ Kelvin , for $\Omega_{GW} \sim 10^{6}$ ***, meaning that the peak curve of frequency will be between 1 to 10 GHz for*** $\Omega_{GW} \sim 10^{6}$, with a rapidly falling value of Ω_{GW} ***for frequencies < 1 GHz***

4.1: 1st part of conclusion. Can we justify / Isolate out an appropriate $\overset{(1)}{T^{uv}}$ if one has non zero graviton rest mass?

It is difficult.. In (2001) Zimmermann and Voelcker [35] refer to a pure abstract mathematical self organized criticality structure... We assert that the mathematical self organized criticality structure is akin to a definition as to how Dp branes arise at the start of inflation. What is the emergent structure permitting $\oint p_i \, dx_k = \hbar \delta_{i,k}$ to hold? What is the self organized criticality structure leading to forming an appropriate $\overset{(1)}{T^{uv}}$ if one has non zero graviton rest mass? Answering such questions will permit us to understand how to link finding $\overset{(1)}{T^{uv}}$ in a GW detector, its full analytical linkage to $\tilde{\beta}$ in Eq. (13), and Eq. (14). The following construction is used to elucidate how a EM Gaussian sense beam can perhaps be used to eventually help in isolating $\overset{(1)}{T^{uv}}$ in a GW detector. This construction below is to be used to investigate 'massive gravitons'/ and also the initial structure of self organized criticality, in the aftermath of graviton/ gravitational wave generation. One of the main things which we may be able to obtain via investigation of what a suitably configured GW detector can give us is resolution of the following: Stephen Feeney at University College London and colleagues say they've found tentative evidence of four collisions with other universes in the form of circular patterns in the cosmic microwave background. In their model of the universe, called "eternal inflation," the universe we see is merely a bubble in a much larger cosmos. This cosmos is filled with other bubbles, all of which are other universes where the laws of physics may be dramatically different from ours. As seen in Figure 2. This also echos the ideas on the evolution of the universe as first put forth by Lee Smolin in [36].

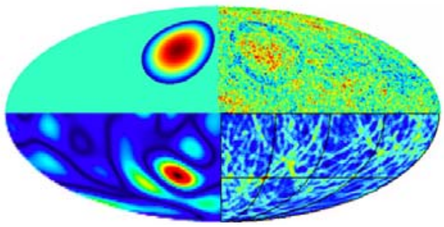

Fig 2, Based upon: First Observational Tests of Eternal Inflation[37]

We are attempting to add more information than **<u>Fig (2)</u>** above, via suitable analysis of $\overset{(1)}{T}{}^{uv}$, [38],[39]

4.2: 2nd part of conclusion : In terms of the Planckian evolution, as well as the feed into it from different universes

In particular, in order to verify the above one may have to make analogies with detection via the proposed and planned detection systems (SEMCS and SEMCS II), for frequency ranges centering on 10^9 to 10^{10} Hz uniquely corresponds to Ω_{gw} maxima for pre-big-bang and quintessential inflation models. This for $\Omega_{gw} \sim 10^5$ as the ratio of the density of GW radiation over $\rho_C =$ critical density. Theoretically, what Eq. (17) and Eq. (18) are to develop considerations based upon different initial conditions in phase space, requiring experimental input. If what the author suspects, i.e. ergodic characteristics, along the lines of [40]

$$
\begin{aligned}
&p_0(x) = \{1/\delta \cdot x_0\} \;\; when \;\; x\varepsilon \;\; [x_0, x_0 + \delta \cdot x] \\
&p_0(x) = 0, \;\; otherwise
\end{aligned}
\tag{38}
$$

We hope to get ergodic mapping structure to Eq. (12) and Eq. (13) corresponding to a probability density expression so Eq. (14) to Eq. (18) hold in the run up of pre Planckian to Planckian space time physics.

Appendix A, Establishing GW astronomy in terms of a choice between models

A change of $\sim 10^{13}$ orders of magnitude in about 10^{-25} seconds, or less in terms of one of the variants of inflation . As has been stated else where [26], [27], [28],[29], [30],[31], [32],[33],[34]: particularly in a publication under development, there are several models which may be affecting this change of magnitude. The following is a summary of what may be involved: We seek to keep the direction of time to be one directional. I.e.[35]

A1) The relic GWs in the pre-big-bang model.

Here, the relic GWs have a broad peak bandwidth from 1 Hz to 10 GHz We can refer to other such publications for equivalent information as in the pre big model [27],[28], In this spectral region the upper limit of energy density of relic GWs is almost a constant $\Omega_{gW} \sim 6.9 \times 10^{-6}$, but it will rapidly decline in the region from 1 Hz to 10^{-3} Hz. Thus direct detection of the relic GWs should be focused in intermediate and high-frequency bands. Amplitude upper limits of relic GWs range from $h \sim 10^{-23}$ at frequencies around 100 Hz to $h \sim 10^{-30}$ at frequencies around 2.9 GHz. This means that frequencies around 100 Hz and frequencies around 2.9 GHz would be two key detection windows

A2) The relic GWs in the quintessential inflationary model (QIM).

The peak and maximal signal of relic GWs in the QIM are localized in the GHz band, and the strength of relic GWs in both the QIM and the pre-big-bang model in the GHz band have almost the same magnitude (e.g., $h \sim 10^{-30}$ at 2.9GHz). But the peak bandwidth of the QIM (from 1GHz to 10GHz) (21) is less than that of the pre-big-bang model (from 1Hz to 10GHz) [27],[28]

A3) The relic GWs in the cosmic string model.

Unlike relic GWs in the pre-big-bang model and in the QIM, the peak energy density Ω_{gw} of relic GWs in the cosmic string model is in the low-frequency region of $\sim 10^{-7}$ Hz to 10^{-1} Hz, and the upper limit of Ω_{gw} may be $\sim 4\times10^{-6}$ at frequencies around 10^{-6} Hz. When $\nu < 10^{-7}$ Hz, the energy density decays quickly. Therefore, LISA and ASTROD will have sufficient sensitivity to detect low-frequency relic GWs in the region of $\sim 10^{-7}$ Hz $< \nu < 10^{-3}$ Hz predicted by the model [27],[28]. Moreover, the energy density of relic GWs is an almost constant $\Omega_{gw} \sim 10^{-8}$ from 10^{-1} Hz to 10^{10} Hz, and the relic GWs at frequencies around 100 Hz should be detectable by advanced LIGO, but the amplitude upper limit of relic GWs in the GHz band may be only $h \sim 10^{-31}$ to 10^{-32}, which cannot be directly detected by current technologies. We may be able to get better visibility on this front if [41] is true, ie semi classical embedding of quantum objects as a result of looking at ultra long wave lengths for gravitational waves.

A4) The relic GWs in the ekpyrotic scenario

Relic GWs in the ekpyrotic scenario [42] and in the pre-big-bang [27],[28] model have some common and similar features. The initial state of universe described by both is a large, cold, nearly empty universe, and there is no beginning of time in both, and they are faced with the difficult problem of making the transition between the pre- and post-big bang phase. However, the difference of physical behavior of relic GWs in both is obvious. First, the peak energy density of relic GWs in the ekpyrotic scenario is $\Omega_{gw} \sim 10^{-15}$, and localized in frequencies around 10^{7} Hz to 10^{8} Hz. Therefore the peak of Ω_{gw} is less than corresponding value in the latter.

A5) The relic GWs in the ordinary inflationary model

Also, for ordinary inflation [27][35] the energy density of relic GWs holds constant ($\Omega_{gW} \sim 10^{-14}$) in a broad bandwidth from 10^{-16} Hz to 10^{10} Hz, but the upper limit of the energy density is less than that in the pre-big-bang model from 10^{-3} Hz to 10^{10} Hz, in the cosmic string model from 10^{-7} Hz to 10^{10} Hz, and in the QIM from 10^{-1} Hz to 10^{10} Hz. For example, this model predicts $h_{max} \sim 10^{-27}$ at 100 Hz, $h_{max} \sim 10^{-33}$ at 100 MHz and $h_{max} \sim 10^{-35}$ at 2.9 GHz.

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