How to prove that the transition from pre Planckian to Planckian space time physics may allow Octonionic gravity conditions to form. And how to measure that transition from Pre Octionic to Octionic gravity, and check into conditions permitting possible multiple universes

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Abstract: We ask if Octonionic quantum gravity [1] is a relevant consideration near the Planck scale. Furthermore, we examine whether gravitational waves would be generated during the initial phase, δ_0 , of the universe when triggered by changes in spacetime geometry; i.e. what role would an increase in degrees of freedom have in setting the conditions during δ_0 , so that the result of these conditions can be observed and analyzed by a gravitational detector. Various initial scenarios are explored. We present how a Gaussian mapping, combined with what we hope to turn into a strange attractor for re cycling prior universe matter-energy may enable quantum gravity to form. And embed it in a larger- non linear theory. The key development to be worked upon would be turning into a strange attractor [2] the supposition R. Penrose made as to re cycling the 'history' of the universe without the necessity of a 'big crunch', i.e. a contracting universe. The nature of the attractor would be instrumental in helping us come up with conditions enabling the evolution of pre Planckian embedding of non linear ' analog reality' ('classical') physics meshing into, with an increase in degrees of freedom into 'digital reality' ('quantum mechanics') and de facto quantum gravity , at the start of Planckian space time. This Planckian space time would mark the beginning of inflation. We give conditions for detection of δ_0 if, for example, one can isolate an appropriate first-order perturbative electromagnetic power flux, $\overset{(1)}{T}{}^{uv}$ in scenarios where the graviton has a vanishingly small – but non-zero – rest mass. This paper assumes there is a non-zero 4-dimensional graviton mass since the solutions we are examining apparently contradict the correspondence principle. We contrast the above constructions with questions of when entropy and quantum mechanics fit together or agree, in the very early universe, and when and why such a fit no longer holds [3]. We hope to find traces of the breakdown of the Entropy/QM spacetime regime during δ_0 . As well as proof, one way or another if

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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 spacetime 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 spacetime geometry phase changes during the early universe. Each such phase change should produce gravitational waves. The geometry to be considered is introduced as given below. We attempt to address thereby some of the questions relating to how pre and post Planckian geometries may evolve. At the end of this paper, we will bring up an exciting comparison of how entropy, as in flat space geometry fits with quantum mechanics [4], and suggest that the regime of quantum mechanics as connected with space time geometry is in part due to a degree of freedom increase consistent with a topological construction first outlined in the abstract. The readers are also referred to appendix A which summarizes the relevant aspects of J.-W. Lee [4] 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 <1000s, or so, as outlined in an argument given in Eq. (16). One of the primary results of the paper is reconciling the difference in degrees of freedom versus a discussion of dimensions, per se. How and why the experimental degrees of freedom approach a maxima is something which the primary author, Beckwith, is investigating.

1.1 What we will propose is the following, i.e. reference applications of Appendix A.

1. That the degrees of freedom increase, with an increase in temperature, during a transition to a Rindler Geometry flat space regime of space time. As given in Eq (16), with increasing temperature, more degrees of freedom unfold from a topological transition. Degrees of freedom likely approach a maxima as temperature does, but this is a subject needing experimental exploration and verification.

2. That for low but non zero initial temperature, the so called cold universe model, in pre space time in the pre Planckian regime, one has initially a huge degree of generated entropy. At the same time, we have about 2 degrees of freedom, with complex geometry in each geometrical slot, geoinfometric instantiation, or "infometron" of space time, which large quantities of stored entropy enveloped in the 'crevices' between infometrons, or lattice points .

3. Low degrees of freedom for low temperature corresponds to a complex geometry storing large amounts of total entropy in a complex geometric structure, and that later the entropy is released, with a break down of this complex geometric structure, i.e. equivalent to having many lattices, highly ordered, with low degrees of freedom per 'lattice', to many degrees of freedom (DOF) as space time 'lattices' are broken, releasing entropy. The analogy is not perfect, but approximates what would happen as one goes from complex curved space geometry with many 'crevices' for storage of entropy, which are released, "apparently" leading to a lot of entropy, but in reality leading to a release of stored entropy on the way to a flat Rindler geometry spacetime in which flat space time is acting as part of an emergent structure. As suggested by G. Stephenson, there appears to be a trading of DOF for entropy in the early evolution of the universe.

Further elaboration of what is being brought up is tied in with a summary of properties of a mutually unbiased basis (MUB), [2] as seen in **Appendix B.** with one set of mutually unbiased basis at the start of cosmological evolution as will be referenced by Eq. (16) below, which is topologically adjusted to the properties of flat space Rindler geometry. We will call this a change in basis sets, and is another way to quantify and identify a different form of phase transition at the end of this article, and we assert the change involved could be identified by experimental detection of δ_0 .In **Appendix C**, [3] there is a way to quantify two different types of entropy, which in reality are linked to each other by the idea of MUB. The first is a simplified form of Renyi entropy [4] ,explicitly depending upon MUB ideas. The second is one which is discussed in [5] , is based upon a particle count version of entropy, i.e. S ~ <n>, with S an entropy per phase space volume, and <n> an emergent field contribution of particles per phase space volume. This will be built up using formalism appearing in Appendix C. The key point of the document will be in determining an inter relationship between a change in MUB, from initial highly complex geometric structure, to flat space time, a new way to quantify a phase transition so resulting , and experimentally verifiable detection of δ_0 .The values of δ_0 are set by the difference between Renyi entropy, and a particle count version of entropy, i.e. S ~ <n>. Are predictions also possible regarding signal strength of evolutionary artifacts of early universe HFGW? Again, yes. What we are talking about is the break down, due to thermal heat flux of an initial mutually unbiased basis set for a very complex initial geometry, and a reconstitution of space time geometry in flat Euclidian space time regime. The topological transition is due to a change in basis / geometry from the regime of Renyi entropy to entropy in a particle count version of entropy, i.e. S ~ <n>.. The choice of a Gaussian mapping, with two variable inputs, as given by Eq. (16) below is done as a simplest case model..Now, let us refer to the tools used to construct the initial space time geometry before we refer to Lee's article [4]. As brought up by Beckwith, and Glinka [6], (assuming a vacuum energy $\rho_{Vacuum} = [\Lambda/8\pi \cdot G]$ initially), with Λ part of a closed FRW Friedman Equation solution.

$$a(t) = \frac{1}{\sqrt{\Lambda/3}} \cosh\left[\sqrt{\Lambda/3} \cdot t\right] \quad (1)$$

to a flat space FRW equation of the form [6]

$$\left[\frac{\dot{a}}{a}\right]^2 + \frac{1}{a^2} = \frac{\Lambda}{3} \quad (2)$$

Which is so one forms a 1-dimensional Schrodinger equation [6],[7], [8]

$$\left[\frac{\partial^2}{\partial \cdot \tilde{a}^2} - \frac{9\pi^2}{4G^2}\left[\tilde{a}^2 - \frac{\Lambda}{3}\tilde{a}^4\right]\right]\psi = 0 \quad (3)$$

with $\tilde{a}_0$ a turning point to potential [5],[6],[7]

$$U(a) = \frac{9\pi^2}{4G^2}\left[\tilde{a}^2 - \frac{\Lambda}{3}\tilde{a}^4\right]. \quad (4)$$

What we are doing afterwards is refinement as to this initial statement of the problem in terms of giving further definition of the term $\rho_{Vacuum} = [\Lambda/8\pi \cdot G]$. Let us now consider a worm hole as a high energy, but zero temperature, virtual fluctuation conforming to the potential in (4). We will model inputs into the initial value of Λ as high energy fluctuations, and see if they contribute to examination of the formation of non commutative geometry in the beginning/ just before the inflationary era. This $\rho_{Vacuum} = [\Lambda/8\pi \cdot G]$ if stated correctly may enable tying in initial vacuum expectation value (VeV) behavior with the following diagram. Note that cosmology models have to be consistent with the following diagram.

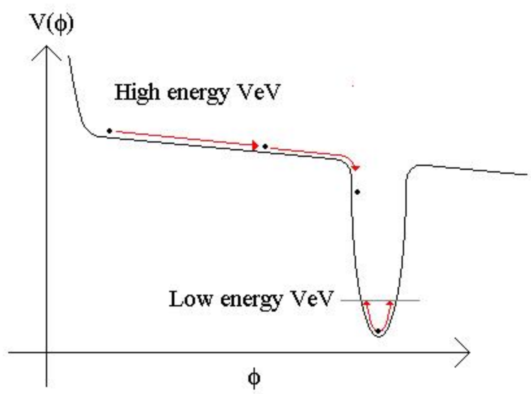

Figure 1, as supplied by L. Crowell, in correspondence to A. W. Beckwith, October 24, 2010 [8]

As stated by L. Crowell [8], 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 [9]:

> *"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 (5), as given by Poplawski [10]:

$$\rho_{\Lambda} = H\lambda_{QCD} \tag{5}$$

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. Here we consider that if there is a relationship between Eq. (5) above and $\rho_{Vacuum} = [\Lambda/8\pi \cdot G]$ then the formation of inputs into our vacuum expectation values $V \sim 3\langle H\rangle^4 / 16\pi^2$, and also equating $V \sim 3\langle H\rangle^4 / 16\pi^2$ with V(φ) ~ φ^2 would be consistent with an inflaton treatment of initial inflation This will be tandem with a treatment of gravitons and their generation we will comment upon later[11].. We can then equate vacuum potential with vacuum expectation values as follows:

$$\rho_{Vacuum} = [\Lambda/8\pi \cdot G] \approx \rho_{\Lambda} \approx H\lambda_{QCD} \Leftrightarrow V \sim 3\langle H\rangle^4 / 16\pi^2 \sim V_{\inf} \approx \phi^2 \tag{6}$$

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. (6) before, during, and after inflation. **Table** 1 **below**. is how to obtain inflation. We will examine scenarios as to how to feed inflation from a non standard cosmology model; next We present a Gaussian mapping as a way to increase degrees of freedom in pre Planckian physics to Planckian physics. In addition, in tandem to a suggestion made by Penrose, 2007.we investigate a dynamical systems mapping for re cycling matter "caught" by millions of black holes, in the universe, to be re cycled to the initial stages of a new big bang. The two mappings together may enable a description of how quantum gravity arises.

1.2 First, thermal input into the new universe. In terms of vacuum energy

We will briefly allude to temperature drivers which may say something about how thermal energy will be introduced into the onset of a universe. This will be the 'thermal driver' for the increase in degrees of freedom. Begin first with looking at different value of the cosmological vacuum energy parameters, in four and five dimensions [12]

$$|\Lambda_{5-\dim}| \approx c_1 \cdot (1/T^{\alpha}) \tag{7}$$

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 [12], [13]

$$\Lambda_{4-\dim} \approx c_2 \cdot T^{\beta} \tag{8}$$

If one looks at the range of allowed upper bounds of the cosmological constant, the difference between what Barvinsky [13] recently predicted, and Park [13], [14] is:

$$\Lambda_{4-\dim} \propto c_2 \cdot T^{\beta} \xrightarrow[graviton-production-as-time>t(Planck)]{} 360 \cdot m_P^2 << c_2 \cdot [T \approx 10^{32} K]^{\beta} \tag{9}$$

Right after the gravitons are released, one still sees a drop-off of temperature contributions to the cosmological constant .Then for time values $t \approx \delta^1 \cdot t_P$, $0 < \delta^1 \leq 1$ and integer n [12]

$$\frac{\Lambda_{4-\dim}}{|\Lambda_{5-\dim}|} - 1 \approx \frac{1}{n} \tag{10}$$

In terms of its import the following has been suggested in the initial phases of the big bang, with large vacuum energy $\neq \infty$ and $a(t^*) \neq 0, 0 < a(t^*) << 1$, the following relation, which violates (signal) causality, is obtained for small fluctuation $a(t^*) < l_P$ If we examine $|\Lambda_{5-\dim}| \sim c_2 T^{-\beta}$

Table 1: Cosmological Λ in 5 and 4 dimensions [12],[13]

Time $0 \le t << t_P$	**Time** $0 \le t < t_P$	**Time** $t \ge t_P$
$\lvert\Lambda_5\rvert$ undefined, $T \approx \varepsilon^+ \to T \approx 10^{32} K$ $\Lambda_{4-\dim} \approx$ almost ∞	$\lvert\Lambda_5\rvert \approx \varepsilon^+$, $\Lambda_{4-\dim} \approx$ extremely large $10^{32} K > T > 10^{12} K$	$\lvert\Lambda_5\rvert \approx \Lambda_{4-\dim}$, T much smaller than $T \approx 10^{12} K$

We assume in this that we have, a discontinuity in the pre Planckian regime, for scale factors[12].

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

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 [15] , [16]

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

The assumption is that there is an initial fixed entropy arising, with $\bar{N}$ as a nucleated structure in short time interval as temperature $T_{temperature} \varepsilon\left(0^+, 10^{19} GeV\right)$ arrives. Then by [15], [16]

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

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. (13) 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 [15].[16]

$$x_{i+1} = \exp\left[-\tilde{\alpha} \cdot x_i^2\right] + \tilde{\beta} \tag{14}$$

The inputs of change of iterated steps on the right hand side of Eq. (14) may indeed show increase in degrees of freedom. Change of temperature, as given , over a short distance, is [15],[16]

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

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' [16],[17] 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 [16],[17]

$$\left.\left\{\Xi_i\right\}_{i\equiv N}^{i\equiv 1}\right|_{before} \equiv \left.\left\{\Xi_i\right\}_{i\equiv N}^{i\equiv 1}\right|_{after} \tag{15}$$

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 [18]. $S_{entropy} \sim n_f$. . 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. [10],[19]**[9] , [10]**

$$\left\{\Xi_i\right\}_{i\equiv 1}^{i\equiv N} \propto \left\{\int_0^\infty dE_i \cdot n(E_i)\cdot e^{-E_i}\right\}_{i\equiv 1}^{i\equiv N}. \tag{16}$$

Each of the terms E_i would be identified with Eq.(17) above, with the following iteration for N universes [16],[17]

$$\frac{1}{N}\cdot\sum_{j=1}^{N}\left.\Xi_j\right|_{j-before-nucleation-regime} \xrightarrow[vacuum-nucleation-tranfer]{} \left.\Xi_i\right|_{i-fixed-after-nucleation-regime} \tag{17}$$

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[16], [17]**

$$\left.\Xi_j\right|_{j-before-nucleation-regime} \approx \sum_{k=1}^{Max}\left.\tilde{\tilde{\Xi}}_k\right|_{black-holes-jth-universe} \tag{18}$$

1.4 Analysis of the action of these two mappings on the formation of Quantum gravity

In particular, in the regime where there is a build up of temperature,[1] Eq. (19)

$$\oint [x_j, p_i] dx_k \approx -\oint p_i [x_j, dx_k] = -\beta \cdot l_P \cdot T_{j,k,l} \oint p_i dx_l \neq -\hbar\beta \cdot l_P \cdot T_{i,j,k} \tag{19}$$

Very likely, across a causal boundary, between $\pm l_P$ across the boundary due to the causal barrier, one gets [1]

$$\oint p_i \, dx_k \neq \hbar \delta_{i,k}, \oint p_i \, dx_k \equiv 0 \tag{20}$$

I.e.

$$\oint_{\pm l_P} p_i dx_k \bigg|_{i=k} \to 0 \tag{21}$$

If so,[1] the regime of space time, for the feed in of , prior to the introduction of QM, that [1]

$$[x_j, p_i] \neq -\beta \cdot (l_{Planck}/l) \cdot \hbar T_{ijk} x_k \quad and \quad does \quad not \to i\hbar \delta_{i,j} \tag{22}$$

Eq. (23) in itself would mean that in the pre Planckian physics regime, and in between $\pm l_P$, QM no longer applies. What we will do is determining where Eq. (23) no longer holds via experimental data.

1.5. Formal proof that increase in thermal temperatures as given in Table 1 leads to approaching quantum mechanics

To do this we look at the G. Ecker article [20] as to how to look at the way we may have , if temperatures increase, as stated in **Table 1** above, from a low point to a higher one, for there to be a flattening of space time and the end of non communative geometry. This non communative geometry due to rising temperatures signifies conditions for the emergence of Eq. (23) to become[1]

$$[x_j, p_i] \xrightarrow[Temp \to \infty]{} i\hbar \delta_{i,j} \tag{23}$$

In order to get conditions for Eq. (24) the following can be referred to about non commutative geometry [20]

$$[x_j, x_i] = i \cdot [\Theta_{ji}] \xrightarrow[Temp \to \infty]{} 0 \tag{24}$$

The essentials step is to say the anti symmetric real tensor is proportional to the square of 1 over the Parks representation of the "Planck constant" , which has a temperature dependence built in it.

$$\Theta_{ji} \sim \Lambda_{NC}^{-2} \sim [\Lambda_{4-Dim}]^{-2} \propto 1 / [T^{2\beta}] \xrightarrow[T \to \infty]{} 0 \tag{25}$$

When Eq. (26) goes to zero, leading to Eq. (24) going to zero, we submit that then Eq. (24) is recovering quantum / Octoinian gravity. The Eq. (24) above, according to the G. Ecker article [20] , page **79**, is linkable to initial violations of Lorentz invariance. We submit that the entire argument of Eq.(22) to Eq. (25) , as given by Eq. (25) with rising temperature is a way to understand the removal of non Euclidian space to approach Euclidian flat space. We shall next examine how this increasing temperature may lead to an explosion of the degrees of freedom present.

2.0 **Understanding how phase shift in Gravitational waves may be affected by the transition to and from a causal discontinuity, and different models of emergent structure cosmology**

We will outline research initiated by . Beckwith and Li, and Yang Nang, gives us details of gravitational wave generation by early universe conditions. In [21] as given by Li, and Yang, 2009, Beckwith [22] outlined in Chongquing the following representation of amplitude, i.e. as by reading [21] the following case for amplitude

$$A_{\otimes} = A_{\oplus} = \breve{A} \tag{26}$$

Furthermore, the first order perturbative (E and M) terms of an E&M field may have its components written as

$$\widetilde{F}^{(1)}_{0\ 2} = i\widetilde{F}^{(1)}_{0\ 1} \tag{27}$$

Secondly, there is a way to represent the" number" of transverse first order perturbative photon flux density as given by (in an earth bound high frequency GW detector).

$$n_r^{(1)} = \frac{c}{2\mu_0 \hbar \omega_{e^-}} \mathrm{Re}\{\ \} \tag{28}$$

$$\{\ \} = i(\exp[-i\theta]) \cdot \widetilde{F}^{(1)*}_{0\ 1} \cdot \left[\frac{i}{\omega_{e^-}} \cdot \left(\frac{\partial \Psi_x}{\partial y} - \frac{\partial \Psi_y}{\partial x} \right) \right] \tag{29}$$

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 to be 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 the $\widetilde{F}^{(1)}_{0\ 2} = i\widetilde{F}^{(1)}_{0\ 1}$ will lead to

$$\widetilde{F}^{(1)}_{0\ 1} = i2\breve{A}\hat{B}_y^{(0)} Q \cdot \left[\sin\left[\frac{n\pi z}{b} \right] \right] \cdot \exp[i(-\omega_g t + \delta_0)] \tag{30}$$

The formula $E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \widetilde{\beta}$ is a feed into ω_g provided that we pick time $t \propto$ Planck time, and set Eq. (30) with $\omega_g \sim \omega_g$ by setting up the $E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \approx \widetilde{\beta}$. In other words, for relic GW/ graviton production, a topological transformation and interrelationship between $\widetilde{\alpha}$ and $E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \widetilde{\beta}$ for increases in (topological) degrees of freedom , as a change in geometry, i.e. before quantum gravity.. Passing gravitons through to a new universe is not the same thing though as a pre Planckian geometry, for Octonian gravity conditions arise in early Planckian space time. 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 We will specify how to locate massive gravitons, via an experimental set up which may enable obtaining data for supporting a value for δ_0. The next discussion is on research done by Dr. F. Li, et al, 2003, [23], with commentar by A. Beckwith [22] as to obtaining criteria as to identify traces of massive gravitons, which play a role in DE models [24].[25]

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 [22],[23].Assuming that one was measuring stochastic HFGW using the disturbance of electromagnetic energy in a cavity, the minimum gravitational wave 'magnitude' to be measured is limited by the Standard Quantum Limit (SQL), which is a description of quantum backaction as described by Braginsky, Grischuk, et al., [26]. 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 [27], [28], [29], [30]

$$h_{\min} \approx \frac{1}{\sqrt{Q}} \cdot \sqrt{\frac{\hbar\omega_{e^-}}{\xi}} \tag{32}$$

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 [31] 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, [26], [27], [28], [29], [31] then

$$h_{\min} \approx \frac{1}{Q} \cdot \sqrt{\frac{\hbar\omega_{e^-}}{\xi}} \tag{33}$$

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 [23] which Beckwith commented upon and made an extension in [22] 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 four dimensional graviton rest mass, in a detector , in the presence of uniform magnetic field, when examining the following situation, i.e. [23] what if we have curved space time with say an energy momentum tensor of the electro magnetic fields in GW fields as given by

$$T^{uv} = \frac{1}{\mu_0} \cdot \left[- F^{\mu}_{\alpha} F^{\nu\alpha} + \frac{1}{4} \cdot g^{\mu\nu} F_{\alpha\beta} F^{\alpha\beta} \right] \tag{34}$$

Li et al [23] state that $F_{\mu\nu} = F^{(0)}_{\mu\nu} + \widetilde{F}^{(1)}_{\mu\nu}$, with $\left|\widetilde{F}^{(1)}_{\mu\nu}\right| << \left|F^{(0)}_{\mu\nu}\right|$ will lead to

$$T^{uv} = \overset{(0)}{T^{uv}} + \overset{(1)}{T^{uv}} + \overset{(2)}{T^{uv}} \tag{35}$$

The 1st term to the right hand side of Eq. (36) is the energy – momentum tensor of the back ground electro magnetic field, and the 2nd term to the right hand side of Eq. (36) is the first order perturbation of an electro magnetic field due to the presence of gravitational waves. The above Eq.(34) and Eq. (35) will eventually lead to a curved space version of the Maxwell equations as

$$\frac{1}{\sqrt{-g}} \cdot \frac{\partial}{\partial x^{\nu}} \cdot \left(\sqrt{-g} \cdot g^{\mu\alpha} g^{\nu\beta} F_{\alpha\beta} \right) = \mu_0 J^{\mu} \tag{36}$$

as well as

$$F_{[\mu\nu,\alpha]} = 0 \tag{37}$$

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 [22] we can write

$$\frac{1}{\sqrt{-g}} \cdot \frac{\partial}{\partial x^{\nu}} \cdot \left(\sqrt{-g} \cdot g^{\mu\alpha} g^{\nu\beta} F_{\alpha\beta} \right) = \mu_0 J^{\mu} + J_{effective} \tag{38}$$

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

$$F_{[\mu\nu,\alpha]} \sim \varepsilon^{+} \tag{39}$$

The claim which A. Beckwith made [16] , [22] is that

$$J_{effective} \cong n_{count} \cdot m_{4-D-Graviton} \tag{40}$$

As stated by Beckwith, in [16], [22] $m_{4-D-Graviton} \sim 10^{-65}\, grams$, while n_{count} is the number of gravitons which may be in the detector sample. What Beckwith, Li, and Chonquing university researchers intend to do is to try to isolate out an appropriate $\overset{(1)}{T}{}^{uv}$ assuming a non zero graviton rest mass, and using Eq. (38), Eq. (39) and Eq. (40) . From there, the energy density order 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. (14) . 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. If this is done, the next step will be to come up with a protocol as far as 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.**

$$h_0^2 \Omega_{GW} \sim 10^{-6} \tag{40a}$$

Next, after we tabulate results with this measurement standard, 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 basic considerations as to early universe geometry which we think are appropriate as to Maggiore's [30] treatment of both wavelength, strain, and Ω_{GW} among other things. As far as early universe geometry and what we may be able to observe, such considerations are make or break as to the role of early universe geometry and the generation of GW at the start of the universe. To begin with , we will look at Maggiore's [30] Ω_{GW} formulation, his ideas of strain, and what we did with observations as from L. Crowell [31] which may tie in with the ten to the tenth power increase as to wave length from pre Planckian physics to 1-10 GHz early inflationary GW frequencies. The idea will be to look at how the ten to the tenth stretch out of generated wave length may tie in with early universe models. We will from there proceed to look at, and speculate how the presented conclusions factor in with information exchange between different universes.

We begin with the following tables, Table 1 and Table 2. The idea will be to, if one has $h_0 = .51 \pm .14$, as a degree of measurement uncertainty begin as to understand what may be affecting an expansion of the wave lengths of pre Planckian GW / gravitons which are then increased up to ten orders of magnitude. What we have stated below in **Table 2 and Table 3** will have major consequences as far as not only information flow from a prior to present universe, but also fine tuning the degree of GW variance

Table 2: Managing GW generation from Pre Planckian physics [30], [32]

$h_C \le 2.82 \times 10^{-33}$	$f_{GW} \sim 10^{12}\, Hertz$	$\lambda_{GW} \sim 10^{-4}\, meters$
$h_C \le 2.82 \times 10^{-32}$	$f_{GW} \sim 10^{11}\, Hertz$	$\lambda_{GW} \sim 10^{-3}\, meters$
$h_C \le 2.82 \times 10^{-31}$	$f_{GW} \sim 10^{10}\, Hertz$	$\lambda_{GW} \sim 10^{-2}\, meters$
$h_C \le 2.82 \times 10^{-30}$	$f_{GW} \sim 10^{9}\, Hertz$	$\lambda_{GW} \sim 10^{-1}\, meters$
$h_C \le 2.82 \times 10^{-29}$	$f_{GW} \sim 10^{8}\, Hertz$	$\lambda_{GW} \sim 10^{0}\, meters$
$h_C \le 2.82 \times 10^{-28}$	$f_{GW} \sim 10^{7}\, Hertz$	$\lambda_{GW} \sim 10^{1}\, meters$
$h_C \le 2.82 \times 10^{-27}$	$f_{GW} \sim 10^{6}\, Hertz$	$\lambda_{GW} \sim 10^{2}\, meters$
$h_C \le 2.82 \times 10^{-26}$	$f_{GW} \sim 10^{5}\, Hertz$	$\lambda_{GW} \sim 10^{0}\, kilometer$
$h_C \le 2.82 \times 10^{-25}$	$f_{GW} \sim 10^{4}\, Hertz$	$\lambda_{GW} \sim 10^{1}\, kilometer$
$h_C \le 2.82 \times 10^{-24}$	$f_{GW} \sim 10^{3}\, Hertz$	$\lambda_{GW} \sim 10^{2}\, kilometer$
$h_C \le 2.82 \times 10^{-23}$	$f_{GW} \sim 10^{2}\, Hertz$	$\lambda_{GW} \sim 10^{3}\, kilometer$

What we are expecting, as given to us by L. Crowell,[31] 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 $h_C \le 2.82 \times 10^{-30}$**.** This is assuming that $h_0^2 \Omega_{GW} \sim 10^{-6}$, using Maggiorie's [30] $h_0^2 \Omega_{GW}$ analytical expression.[32]

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 which is mentioned in **Eq. (11c)** 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. , since the interactions of gravitational waves / gravitons with quark – gluon plasmas and even neutrinos would serve to deform by at least an order of magnitude h_C. So for table 1, the first column is meant to be an upper bound which, even if using **Eq. (40.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. (40.b)** drops. I.e. it makes for serious problems as to comparing and identifying the appropriate

Table 3: Managing GW count from Planckian physics/unit-phase-space[30],[32]

$\lambda_{GW} \sim 10^{-4}\, meters \Rightarrow n_f \propto 10^{-6}\, graviton/unit-phase-space$;
$\lambda_{GW} \sim 10^{-3}\, meters \Rightarrow n_f \propto 10^{-2}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{-2}\, meters \Rightarrow n_f \propto 10^{2}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{-1}\, meters \Rightarrow n_f \propto 10^{6}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{0}\, meters \Rightarrow n_f \propto 10^{10}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{1}\, meters \Rightarrow n_f \propto 10^{14}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{2}\, meters \Rightarrow n_f \propto 10^{18}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{0}\, kilometer \Rightarrow n_f \propto 10^{22}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{1}\, kilometer \Rightarrow n_f \propto 10^{26}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{2}\, kilometer \Rightarrow n_f \propto 10^{30}\, graviton/unit-phase-space$
$\lambda_{GW} \sim 10^{3}\, kilometer \Rightarrow n_f \propto 10^{34}\, graviton/unit-phase-space$

The particle per phase state count will be given as, if $h_0^2\Omega_{GW} \sim 10^{-6}$ [30], [32]

$$n_f \sim h_0^2\Omega_{GW} \cdot \frac{10^{37}}{3.6} \cdot \left[\frac{1000Hz}{f}\right]^4 \tag{40.b}$$

Secondly we have that a detector strain for device physics is given by [30],[32]

$$h_C \le \left(2.82 \times 10^{-21}\right) \cdot \left(\frac{1Hz}{f}\right) \tag{40.c}$$

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.[30],[32]

Table 4, 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. We hope that we can turn GW research into an actual experimental science.

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 4: Variance of the Ω_{GW} parameters as given by the above mentioned cosmology models. [33], [34],[35], [36], [37], [38],[39],[40]

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

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 D** 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 given at the ICGC-07 conference by Beckwith [12] We will start off with

$$\frac{\Lambda_{Max} V_4}{8 \cdot \pi \cdot G} \sim T^{00} V_4 \equiv \rho \cdot V_4 = E_{total} \tag{41}$$

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.[14] What we are paying attention to, here is the datum that for an exponential potential (effective potential energy) [39]

$$V(\phi) = g \cdot \phi^{\alpha} \tag{42}$$

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, [39], [40]

$$V(\varphi) \propto \phi^{|\alpha|} \qquad \text{For } t < t_{PLanck} \tag{43a}$$

Also, we would have

$$V(\varphi) \propto 1/\phi^{|\alpha|} \qquad \text{for } t >> t_{PLanck} \tag{43b}$$

The switch between Eq. (43a) and Eq. (43b) 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 [39], if $\in = \frac{\lambda^2}{16\pi G}, H = 1/\in t$ so that one has a scale factor behaving as[39]

$$a(t) \propto t^{1/\in} \tag{44}$$

Then, if [39]

$$|V(\phi)| << (4\pi G)^{-2} \tag{45}$$

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 [39]

$$\phi(t) = \frac{1}{\lambda} \ln\left[\frac{8\pi Gg \in^2 t^2}{3}\right] \tag{46}$$

Then the scale factors, from Planckian time scale as [39]

$$\frac{a(t_2)}{a(t_1)} = \left(\frac{t_2}{t_1}\right)^{1/\in} = \exp\left[\frac{(\phi_2 - \phi_1)\lambda}{2 \in}\right] \tag{47}$$

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. (47) 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 [15],[40]

$$E_{thermal} \approx \frac{1}{2} k_B T_{temperature} \propto \tilde{\beta} \tag{48}$$

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

$$\Omega_0 \varepsilon \left[1GHz,\ 10GHz \right] \tag{49}$$

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

$$\left[\Omega_0 \breve{T} \right] \sim \tilde{\beta} \tag{50}$$

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. It depends upon understanding what is meant by emergent structure, as a way to generalize what is known in mathematics as the concept of "self-organized criticality" put forward by the Santa Fe school. [41] as well as the concept of negator algebra referring to topos-theoretic results. In (2001) Zimmermann and Voelcker [42] 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. Further details can be accessed in Appendix F as to a GW detection system which may be able to help us isolate $\overset{(1)}{T}{}^{uv}$. 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 3. This also echos the ideas on the evolution of the universe as first put forth by Lee Smolin in [43].

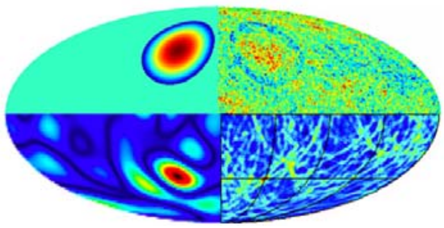

Fig 3, Based upon: First Observational Tests of Eternal Inflation [44]

We are attempting to add more information than Fig (3) above, via suitable analysis of $\overset{(1)}{T}^{uv}$, [45]

3.2: 2nd part of conclusion : In terms of the Planckian evolution, as well as the feed into it from different universes

We wish to summarize what we have presented in an orderly fashion. Doing so is a way of stating that Analog, reality is the driving force behind the evolution of inflationary physics

- **a)** Pre Octonian gravity physics (analog regime of reality) features a break down of the Octonian gravity commutation relationships when one has curved space time. This corresponds, as brought up in the Jacobi iterated mapping for the evolution of degrees of freedom to a build up of temperature for an increase in degrees of freedom from 2 to over 1000. Per unit volume of space time. The peak regime of where the degrees of freedom maximize is where the Octonian regime holds.
- **b)** Analog physics, prior to the build up of temperature can be represented by Eq. (17) and Eq. (18). The first of these mappings is an ergotic mapping, a perfect mixing regime from many universes into our own present universe. This mapping requires a deterministic quantum limit as similar to what tHooft included in his embedding of Quantum physics in a larger, non linear theory [46]. This is approximated by current Pilot model build up of an embedding of QM within a more elaborate super structure**.**

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 [47]

$$
\begin{aligned}
&p_0(x) = \{1/\delta \cdot x_0\} \;\; when \;\; x\varepsilon \;\; [x_0, x_0 + \delta \cdot x] \\
&p_0(x) = 0, \;\; otherwise
\end{aligned}
\tag{41}
$$

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

Appendix A: Highlights of J.-W. Lee's paper as used by the authors

The following formulation is to highlight how entropy generation blends in with quantum mechanics, and how the break down of some of the assumptions used in Lee's paper coincide with the growth of degrees of freedom. What is crucial to Lee's formulation, is Rindler geometry, which is flat space time geometry, not the curved space formulation of initial universe conditions. To enable these ideas, the following formulas are used from [3]. First of all. quoting from [48] , *"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. If gravity and Newton mechanics can be derived by considering information at Rindler horizons, it is natural to think quantum mechanics might have a similar origin. In this paper, along this line, it is suggested that quantum field theory (QFT) and quantum mechanics can be obtained from information theory applied to causal (Rindler) horizons, and that quantum randomness arises from information blocking by the horizons*

To start this program, we look at the Rindler partition function, as given by[48]

$$Z_R = \sum_{i=1}^{n} \exp[-\beta H(x_i)] = Trace \cdot (\exp[-\beta H]) \tag{A.1}$$

As stated by Lee [48] , *..we expect Z_R to be equal to the quantum mechanical partition function of a particle with mass m in Minkowski space time.* Furthermore, there exists the datum that: Lee made an equivalence between Eq. (A1) and [48]

$$Z_Q = N_1 \int \wp x \cdot \exp\left[\frac{-i}{\hbar} \cdot I(x_i)\right] \tag{A2}$$

Where $I(x_i)$ is the action 'integral' for each path x_i, leading to a wave function for each path x_i

$$\psi \sim \exp\left[\frac{-i}{\hbar} \cdot I(x_i)\right] \tag{A3}$$

If we do a rescale $\hbar = 1$, then the above wave equation can lead to a Schrodinger equation,

The example given by Lee [48] is that there is a Hamiltonian for which

$$H(\phi) = \int d^3x \cdot \left\{ \frac{1}{2} \cdot \left(\frac{\partial \phi}{\partial t}\right)^2 + \frac{1}{2} \cdot (\nabla \phi)^2 + V(\phi) \right\} \tag{A4}$$

Here, V is a potential, and ϕ can have arbitrary values before measurement, and to a degree, Z represent uncertainty in measurement. In Rindler co-ordinates, $H \to H_R$, in co-ordinates (η, r, x_2, x_3) with proper time variance $ard\eta$ then

$$H_R(\phi) = \int dr dx_\perp ar \cdot \left\{ \frac{1}{2} \cdot \left(\frac{\partial \phi}{\partial r}\right)^2 + \frac{1}{2} \cdot \left(\frac{\partial \phi}{ar \partial \eta}\right)^2 + \frac{1}{2} \cdot (\nabla_\perp \phi)^2 + V(\phi) \right\} \tag{A5}$$

Here, the $\perp$ is a plane orthogonal to the (η, r) plane. If so then

$$Z = tr \exp[-\beta H] \mapsto Z_R = tr \exp[-\beta H_R] \tag{A6}$$

Now, for the above situation, the following are equivalent

1. Z_R thermal partition function is from information loss about field beyond the Rindler Horizon
2. QFT formation is equivalent to purely information based statistical treatment suggested in this paper
3. QM emerges from information theory emerging from Rindler co-ordinate

Lee also forms a Euclidian version for the following partition function, if $I_E(x_i)$ is the Euclidian action for the scalar field in the initial frame. I.e.

$$Z_Q^E = N_1 \int \wp x \cdot \exp\left[\frac{-i}{\hbar} \cdot I_E(x_i)\right] \tag{A7}$$

There exist analytic continuation of $\tilde{t} \mapsto it$ leading to $Z_Q^E \mapsto Z_Q =$ Usual zero temperature QM partition function of Z_Q for ϕ fields.

Important Claim: The following are equivalent

1. Z_R and Z_Q are obtained by analytic continuation from Z_Q^E
2. Z_R and Z_Q are equivalent .

Question: Can one transcribe Rindler co – ordinates to the ' origin ' of the big bang ?
Provisional Answer: No. Need to have flat space geometry, and ORIGIN of big bang is curved space. I.e. pre Planckian regime is curved space. Also, Rindler co ordinates can be as good a description of present geometry. Note Free energy, corresponds to

$$F = -\frac{1}{\beta} \cdot \ln Z_R \cong F_{Classical} \approx \left(I_E \left(x_i \right) \right) \qquad \text{(A8)}$$

Here, $F_{Classical} \approx \left(I_E \left(x_i \right) \right)$ **minimized**, means that change in entropy is **maximized**. If we look at Verlinde entropy as associated with lost particle information, it means, if $F = -k_B T \cdot \ln Z(T,V,\overline{N}) \equiv -k_B TN \left[\ln(V/\lambda^3) + 5/2 \right]$, with $\lambda^3 \geq V$, with V an initial space time volume, and λ the 'wave length, of say a graviton or equivalent space time particle at/about the origin, then one would have up to a point,

$$F = -\frac{1}{\beta} \cdot \ln Z_R \cong F_{Classical} \approx \left(I_E \left(x_i \right) \right) \sim -k_B TN \left[\ln(V/\lambda^3) + 5/2 \right] \propto k_B TN \qquad \text{(A9)}$$

Low temperature mean high entropy, and eventually, when one would get to the Planckian regime of space time, with the squeezing of space time geometry to a flat space Rindler geometry , the particle count algorithm would be along the lines of having all the entropy squeezed to

$$\Delta S \sim n(relic) \sim \text{\# of initial relic particles} \qquad \text{(A10)}$$

Here, having $\lambda^3 \geq V$, with V the initial Planckian regime sized 'volume' would be equivalent to the causal discontinuity relationship of **a certain amount of 'information' as given above above**. Also, having $\lambda^3 \geq V$ corresponds to having a filter for the creation of $J_{effective} \cong n_{count} \cdot m_{4-D-Graviton}$, for "massive" gravitons.

Appendix B: Highlights of S. Chaturvedi paper (about MUB) as used

Based upon [49] we will go through an accounting of what are Mutually Unbiased Bases, so as to lead up to their application in early universe geometry. When going through this, we should keep in mind that what will be done in the application will be making an accounting as to how much information and structure is implied by an initial geometry, as well as what happens when the initial mutually unbiased basis is 'dissolved' by an increase in temperature as outlined via Eq. (14) **in the main text**. To begin with, we go to [49]'s key definition. In a Hilbert space, of dimension N, by a set of mutually unbiased basis, we mean a set of N+1 orthormal basis, , the modus squared if any scalar product of one basis with any member of any other basis = 1/N. Now for his generalization, which has important implications we will elaborate in the text, namely. Let $e^{(\alpha,k)}$ be the k th vector in the α th orthornormal bis. Let $\alpha = 1,......, N-1$. There $\exists$ N(N+1) Nth dimensional vectors satisfying

$$\left| \left\langle e^{(\alpha,k)}, e^{(\alpha',k')} \right\rangle \right|^2 = \delta^{\alpha,\alpha'} \delta^{k,k'} + \frac{1}{N} \cdot \left(1 - \delta^{\alpha,\alpha'} \right) \qquad \text{(B.1)}$$

Here, we have that $\alpha, \alpha' = 0,1,.........., N$ Also, we have that $e_l^{(\alpha,k)}$ is the l th component of k vector of α orthornormal basis, where

$$\left| \left\langle e^{(\alpha,k)}, e^{(\alpha',k')} \right\rangle \right|^2 = \left| \sum_{l=0}^{N-1} \left\langle e_l^{(\alpha,k)}, e_l^{(\alpha',k')} \right\rangle \right|^2 \qquad \text{(B.2)}$$

For our early universe purposes, the main benefit of MUB would be in 'encryption' of information [50], a point which has direct relevance to highly complex geometry before the transition to quantum mechanics, where the geometry is, in part simplified to 'flat space " , where the rules of quantum Octonian gravity formulation hold.

Appendix C: Renyi Entropy (using MUB) versus Y. Ng particle count entropy

This section is to high light the similarities and differences in entropy, in the pre Planckian regime, Planckian space time, and then in doing so, suggest inputs into experimentally detecting δ_0 .in a gravitational wave detector. [51]. We start off with the description from[51] as to what Renyi Entropy, for a MUB , and from there set up a protocol as to compare the difference in entropy between MUB Renyi Entropy, and Ng entropy [18] . Let us begin as to what is known as Entropic relations

C1. Basics of Entropic relations

Let $|\psi\rangle \varepsilon \mathrm{H}_n$ be a quantum state of $n = LogN$ qubits. Set $B \equiv \{|b_i\rangle\}_{i=1,\ldots,n}$ be an orthonormal basis in H_n

So, using the construction of an MUB as given in Appendix B, we can refer to $|\langle b \| b' \rangle|^2 = 1/N, for \forall b \varepsilon B, b' \varepsilon B', B \neq B' \varepsilon \beta, \beta$ a set of N+1 MUB for H_n Here we have the

C2 Theorem [Maasen-Uffink88]

For any pair of mutually unbiased basis P and Q for H_n, and $|\psi\rangle \varepsilon \mathrm{H}_n$, then , $\exists$ a probability distribution for

$$B_{\psi(i)} = \| \langle b_i | \psi \rangle \|^2 \tag{C1}$$

$$H(B_{\psi(i)}) = -B_{\psi(i)} \log B_{\psi(i)} \tag{C2}$$

So now we go to the definition of Renyi entropy, i.e. for $-1 < \alpha < \infty$ defining the ‘Renyi entropy of order α

$$H_\alpha(B_{\psi(i)}) = -\log\left(\sum_i B_{\psi(i)}{}^{1+\alpha} \right)^{1/\alpha} \tag{C3}$$

$$\begin{aligned} &H_0(B_{\psi(i)}) = H(B_{\psi(i)}), \\ &H_\infty(B_{\psi(i)}) = -\log(\max_i B_{\psi(i)}) \end{aligned} \tag{C4}$$

And now for the main result, i.e. the [Maasen-Uffink88] theorem

For any pair of mutually unbiased basis, P and Q for H_n, and any state $|\psi\rangle \varepsilon \mathrm{H}_n$ then one has for Log N=n quidbits

$$H(P_n) + H(Q_n) \geq \log N \tag{C5}$$

(C5)This inequality involving zeroth order Renyi entropy as given by Eq(C4) should be contrasted with Y. Jack Ng [20] entropy , i.e. S ~ <n>

Appendix D, 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 [34],[35],[36],[37],[38],[39], 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: The only thing which we seek is to keep the direction of time to be one directional. I.e.[52]

D1) 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 [35],[36] 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 . If the relic GWs in the pre-big-bang model (or other similar models such as the cyclic model of the universe (41) [53] can be detectable, then its contribution to contemporary cosmological perspectives would be substantial

D2) 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) [37],[38]

D3) 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 $\sim 4\times 10^{-6}$ 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 [37],[38]. 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.

D4) The relic GWs in the ekpyrotic scenario

Relic GWs in the ekpyrotic scenario [54] and in the pre-big-bang [37], [38] 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 it is localized in frequencies around 10^{7} Hz to 10^{8} Hz. Therefore the peak of Ω_{gw} in the former is less than corresponding value in the latter.

D5) The relic GWs in the ordinary inflationary model

Also, for ordinary inflation [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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