For GRACO, Luxor EGYPT, Feb 7 2011

Is Octonionic Quantum Gravity Relevant near the Planck Scale? Measurement and Evaluation Re-Considered

continuation and elaboration of themes from Christ Church, New Zealand, 2009, Capetown, SA, 2010, with new developments

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Abstract

A thought experiment: Does Octonionic Gravity exist in pre Inflationary cosmology?

- To what degree are the fundamental constants of nature preserved between different cosmological cycles?
- To what degree is gravity an emergent field that is partly/largely classical with extreme nonlinearity, or a QM/quantum field theory phenomenon?
- How does the existence of a small 4 dimensional rest graviton mass affect cosmology ?
- Does **Octonionic** (quantum) geometry break down prior to inflation ?

Math – Physics representation of core issues of higher dimensional contribution

- **Start off with a basic statement of strength of matter - graviton interaction, assuming KK graviton**

$$\Im = -\frac{\kappa}{2} \cdot \sum_n \int d^4 x h_{uv}^n \cdot T^{uv} \sim 1/M_{PL}^2$$

The stress energy tensor comes from the standard model, and the h term is from using a KK graviton interactions model , up to the n th mode.

Has some similarity with graviton-neutrino interaction issues talked about in this PPT

Does the last slide hold if we make the following modification of a KK tower of gravitons ?

- Modification put in, as seen in later to mimic DE
- Suggestion to look at, here, is to consider what if
- $m_n(Graviton) = \frac{n}{L} + 10^{-65}$ grams? i.e.

$$m_n(graviton) = \sqrt{\left(\frac{n}{L}\right)^2 + \left(10^{-65}\, grams\right)^2}$$

$$m_n(Graviton) = \frac{n}{L} + 10^{-65} \quad \text{Grams}$$

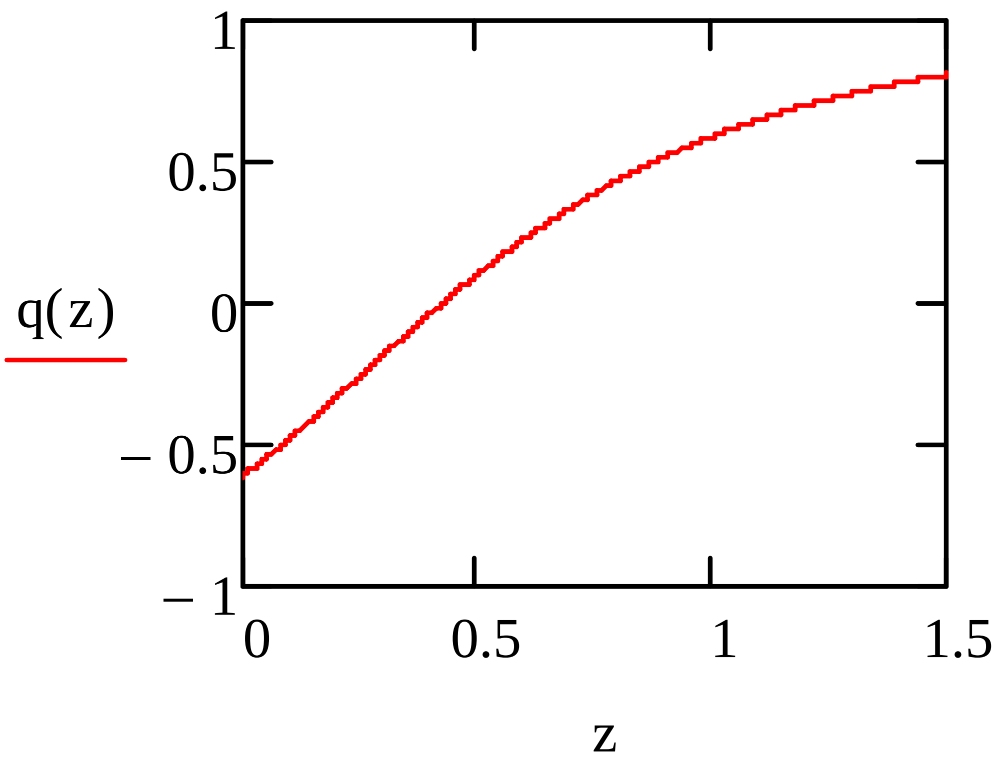
KK graviton~ effective DM+ effective DE

In Christ Church, and in Capetown, the following case was made. This with regards to re acceleration of the universe

- If we are in the regime for which for red shift values z between zero to 1.0-1.5 As given by Beckwith
-
- $$q = -\frac{\ddot{a}a}{\dot{a}^2} \equiv -1 + \frac{2}{1 + \tilde{\kappa}^2 \left[\rho / m\right] \cdot (1+z)^4 \cdot \left(1 + \rho \ \ /2\lambda\right)}$$

Jerk calculation leads to

- If we define the jerk $q = -\frac{\ddot{a}a}{\dot{a}^2}$



Assuming a brane world

Z (red shift value). Change in sign for Z = ~.42 is almost one billion years ago, corresponding to reacceleration of the universe, i.e

Basic results of Alves, et al. (2009), using their parameter values, with an additional term of C for "dark flow" added, corresponding to one KK additional dimensions.

For brane world, use these evolution equations

Friedman equation, subsequently modified

$$\dot{a}^2 = \left[\left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{\rho^2}{36 M_{Planck}^2} \right) a^2 - \kappa + \frac{C}{a^2} \right]$$

Density equation, with non-zero graviton mass

$$\rho \equiv \rho_0 \cdot \left(\frac{a_0}{a} \right)^3 - \left[\frac{m_g c^6}{8\pi G \hbar^2} \right] \cdot \left(\frac{a^4}{14} + \frac{2a^2}{5} - \frac{1}{2} \right)$$

This is the end of the re acceleration of the universe part, now want about the beginning? First structure formation

- **Structure formation from entropy generation**
- Starting with what Beckwith used in 2008 and also in Rencontres De Blois

$$\left|S_{Total}\right|_{Initial-\inf-condt} \sim \left|k_B \cdot \ln 2\right| \cdot \left[\# operations\right]^{3/4}$$

$$\approx N\left|-\log\frac{N}{10} + \log V_4^3 + \log E^{3/'2}\right| \sim 10^5$$

Issues about Octonionic gravity, before structure formation

- That the degrees of freedom increase, with an increase in temperature, during a transition to a Rindler Geometry flat space regime of space time. With increasing temperature, more degrees of freedom unfold from a topological transition. Degrees of freedom likely approach a maxima as temperature does.

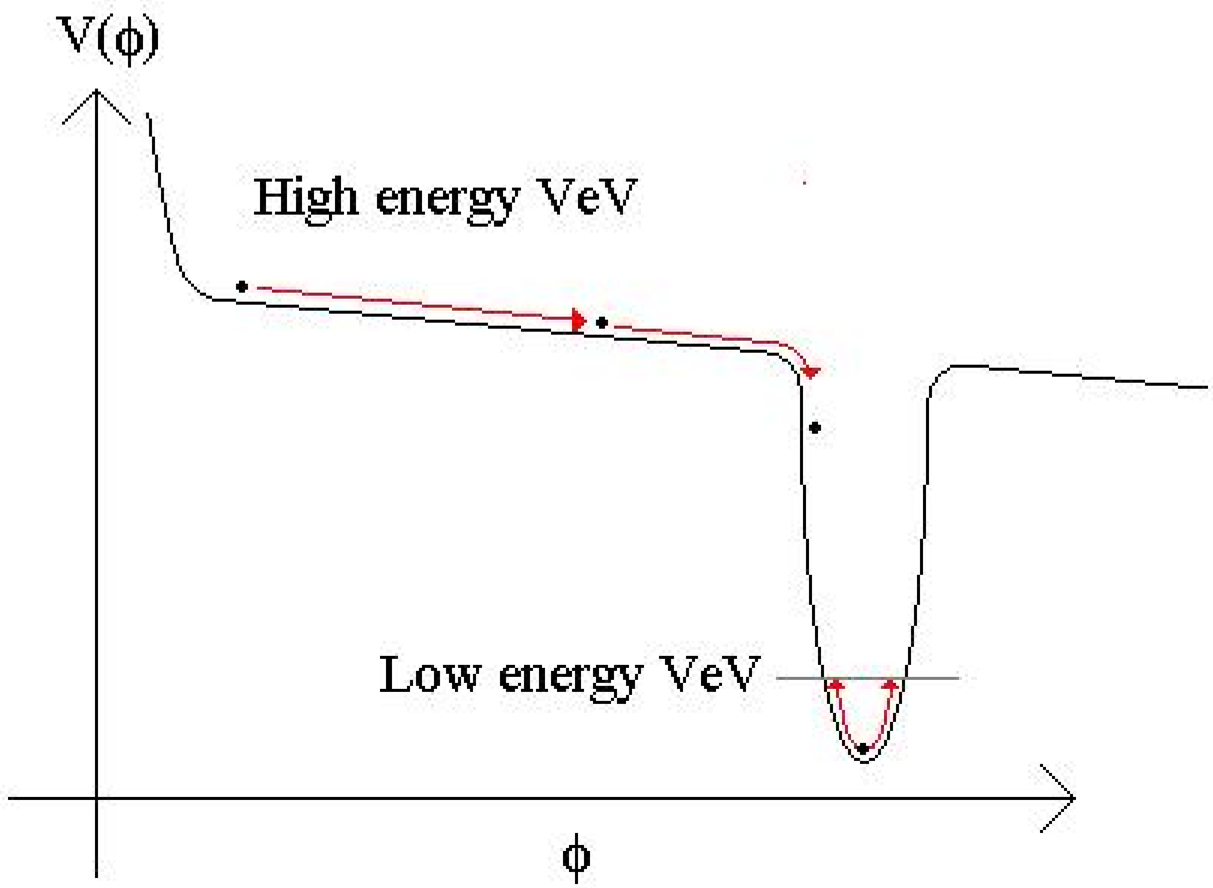
Issues about Octonionic gravity, before structure formation, Contd.

- That for low but non zero initial (pre inflation) temperature, one has a huge degree of generated entropy. At the same time, we have initially about 2 degrees of freedom, with complex geometry in each geometrical slot, so called geoinfometric instantiation, or “infometron” of space time, which large quantities of stored entropy enveloped in the ‘crevices’ between the infometrons, or lattice points .

Issues about Octonionic gravity, before structure formation, Contd.

- 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 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.

Defining Octonionic gravity, before structure formation. First, potential diagram



Defining what Octonionic gravity is, before structure formation

- **As stated by L. Crowell**

- ***"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 $V(\varphi) \sim \varphi^2$. The enormous VeV at the start is about 14 orders of magnitude smaller than the Planck energy density $\sim (1/L_p)^4$ 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 $\lambda = \lambda(\varphi, \partial\varphi)$, 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."***

Defining what Octonionic gravity is, before structure formation

- Now for how to define Octonionic structure

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

$$\lfloor x_j , p_i \rfloor \cong -\beta \cdot (l_{Planck} / l) \cdot \hbar T_{ijk} x_k \rightarrow i\hbar \delta_{i,j}$$

Defining how Octonionic gravity breaks down , before structure formation

- Octonionic structure is retrieved when curved space time is flat, i.e. when the right hand side of the following equation goes to zero. Octonionic structure does not exist beforehand.

$$\left\lfloor x_j , p_i \right\rfloor \cong -\beta \cdot \left(l_{Planck} / l \right) \cdot \hbar T_{ijk} x_k \to i\hbar \delta_{i,j}$$

Defining how Octonionic gravity breaks down , before structure formation, Continued

- Our contention is that once a QCD style condensate breaks up there will be NO equivalent structure to

$$\left[x_j , p_i\right] \cong -\beta \cdot \left(l_{Planck} / l\right) \cdot \hbar T_{ijk} x_k \to i\hbar \delta_{i,j}$$

- Once that condensate structure is not possible then as quantified by Eq. (8.140) of Crowell , the following will not hold

$$\oint p_i \, dx_k = \hbar \delta_{i,k}$$

Defining how Octonionic gravity breaks down , before structure formation

What no longer works,
due to causal break down

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

Defining how Octonionic gravity breaks down , before structure formation

-
- Now for the problem

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

How to measure causal discontinuity

- First the change in entropy, as given from Beckwith, Dice 2010

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

How to measure causal discontinuity, continued

- NEXT application of the Gauss mapping , to measure increase in degrees of freedom from 2 to over 1000

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

$$\frac{\Delta\tilde{\beta}}{dist} \cong \left(5k_B \Delta T_{temp} / 2\right) \cdot \frac{\overline{N}}{dist} \sim qE_{net-electric-field} \sim \left[T\Delta S / dist\right]$$

How to measure causal discontinuity, continued

- Now for temperature increase

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

How to measure causal discontinuity, continued

- As far as information transferred

$$n_{Bit} \approx \frac{3\cdot(1.66)^2 g^*}{\left[\Delta x \cong l_p\right]} \cdot \frac{c^2 \cdot T^2}{\pi \cdot k_B^2} \sim 3\cdot\left[1.66\cdot\sqrt{\tilde{g}_*}\right]^2 T^3$$

How to measure causal discontinuity, continued

- Now, in a detector, the contribution of a small graviton mass would lead to a massive graviton current looking like
-

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

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

1st set of optional slides, next. Answering some questions about massive gravitons,entropy

- Should there be time in the question, the next set of slides will be to answer some questions about the nature of gravitons which the author thinks are worth looking at and investigating.

Semi-classical interpretation of giant graviton waves?

Brought up as a way to interpret the existence of a small graviton mass, which appears to violate the QM correspondence principle (shown later)

Main motivation: a field theory limit demo that shows problems with **massive graviton field theories, and the limit**

$$m_{graviton} \rightarrow 0$$

How to measure a graviton/ GW ?

- Look at the normalized gravitational wave density function

$$\Omega_{gw} \equiv \frac{\rho_{gw}}{\rho_c} \equiv \int_{f=0}^{f=\infty} d(\log f) \cdot \Omega_{gw}(f) \Rightarrow h_0^2 \Omega_{gw}(f) \cong 3.6 \cdot \left[\frac{n_f}{10^{37}} \right] \cdot \left(\frac{f}{1kHz} \right)^4$$

- Note that n depends upon frequency and is stated to be part of the unit phase space

Infinite Quantum statistics. From the work presented in the Paris observatory, July 2009 Start with

$$Z_N \sim \left(\frac{1}{N!}\right)\cdot\left(\frac{V}{\lambda^3}\right)^N \qquad S \approx N\cdot\left(\log\left[V/N\lambda^3\right]+5/2\right)$$

$$S \approx N\cdot\left(\log\left[V/\lambda^3\right]+5/2\right) \qquad V \approx R_H^3 \approx \lambda^3$$

V stands for volume of nucleation regime space. "particles" nucleate from 'vacuum' in QM

For DM. V for nucleation is HUGE. Graviton space

V for nucleation is tiny , well inside inflation/ Therefore, the log factor drops OUT of entropy S if V chosen properly. For small V, then

$$\Delta S \approx \Delta N_{gravitons}$$

Breakdown of field theory with respect to massive gravitons in limit

$$m_{graviton} \rightarrow 0$$

The massless equation of the graviton evolution equation takes the form

$$\partial_{\mu}\partial^{\mu} h_{\mu\nu} = \sqrt{32\pi G} \cdot \left(T_{\mu\nu} - \frac{1}{2}\eta_{\mu\nu} T^{\mu}_{\mu} \right)$$

Consider what happens with a graviton mass

$$m_{graviton} \neq 0$$

From Maggiore (2008):

$$\left(\partial_\mu \partial^\mu - m_{graviton}\right) \cdot h_{\mu\nu} = \left[\sqrt{32\pi G} + \delta^+\right] \cdot \left(T_{\mu\nu} - \frac{1}{3}\eta_{\mu\nu} T^\mu_\mu + \frac{\partial_\mu \partial_\nu T^\mu_\mu}{3m_{graviton}} \right)$$

The mismatch between these two equations when

$$m_{graviton} \to 0$$

Is largely due to, even if graviton mass goes to zero

$$m_{graviton} h_{\mu}^{\mu} \neq 0$$

$$m_{graviton} \cdot h_{\mu}^{\mu} = -\left\lfloor \sqrt{32\pi G} + \delta^{+} \right\rfloor \cdot T_{\mu}^{\mu}$$

Try semi - classical model of graviton, as kink-anti kink pair

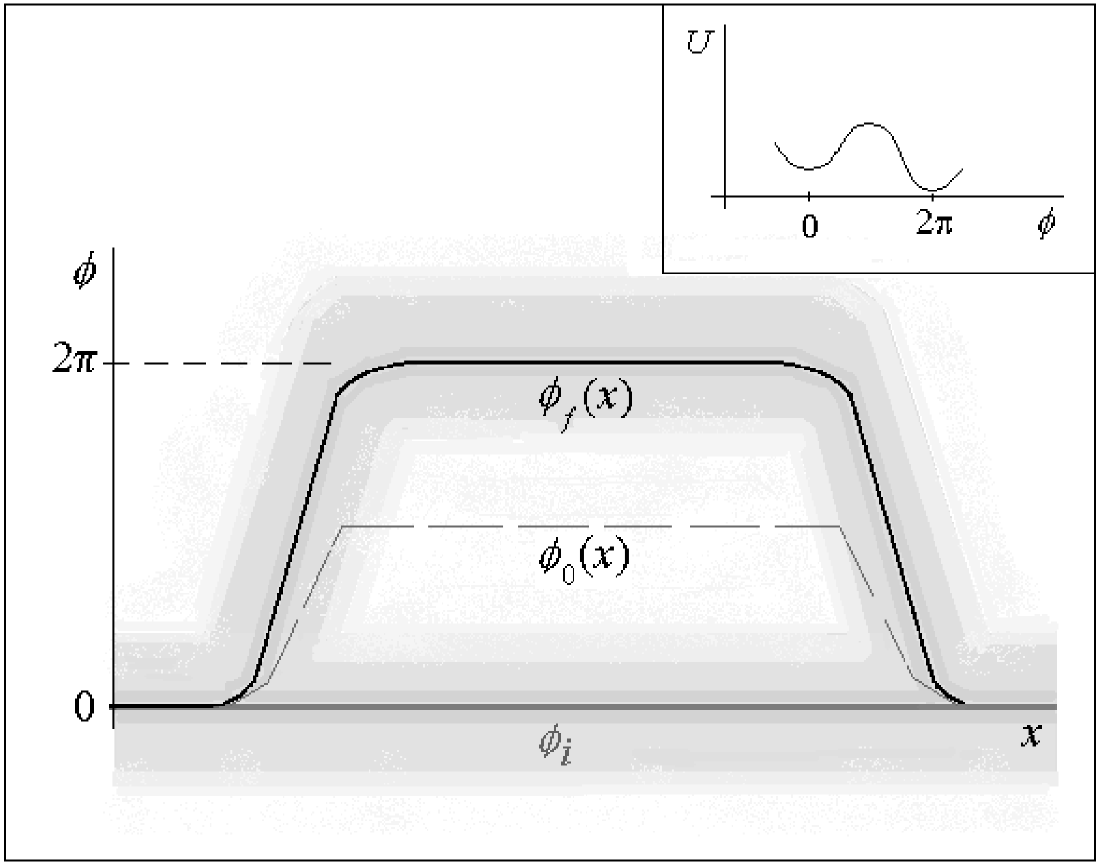
- How does this fit in with t'Hooft's deterministic QM?

- From a 1+ dimensional kink-antikink

$$\Psi_{i,f}\ \left[\phi(\mathbf{x})\right]\Big|_{\phi\equiv\phi_{ci,cf}} = c_{i,f}\cdot\exp\left\{-\int d\mathbf{x}\ \alpha\left[\phi_{C_{i,f}}(\mathbf{x})-\phi_0(\mathbf{x})\right]^2\right\},$$

From density wave physics, 1+ dimensions

Kink-antikinks lead to a vacuum wave function. The LHS is a kink; the RHS is an antikink.



The wave functional should have t'Hooft equivalence class structure added, in 4 to 5 dimensions

- T'Hooft used in 2006 an equivalence class argument as an embedding space for simple harmonic oscillators, as given in his Figure 2, on page 8 of his 2006 article.
- "Beneath Quantum Mechanics, there may be a deterministic theory with (local) information loss. This may lead to a sufficiently complex vacuum state." - t'Hooft
- The author submits, that a kink-anti kink formulation of the graviton, when sufficiently refined, may indeed create such a vacuum state, as a generalization of Fig 2.

One to four-five dimensions in instanton, anti-instaton construction

For one dimension, the semiclassical treatment has (CDW) a kink given by Beckwith(2001) as

$$\phi_{+}(z,\tau) = 4 \cdot \arctan\left(\exp\left\{ \frac{z + \beta \cdot \tau}{\sqrt{1-\beta^2}} \right\} \right)$$

$$\frac{\partial^2 \phi(z,\tau)}{\partial \tau^2} - \frac{\partial^2 \phi(z,\tau)}{\partial z^2} + \sin\phi(z,\tau) = 0$$

In five dimensions, M. Giovannini (2006) has constructed

For a five dimensional line element,

$$dS^2 = a(w) \cdot \left[\eta_{uv} dx^u dx^v - dw^2 \right]$$

$$\phi = \tilde{v} + \arctan\left((bw)^v \right)$$

Supposition to get about the singularity in 4 dimensions, in early universe models

- Dropping in of ‘information’ to form an instanton-anti-instanton pair, and avoiding the cosmological singularity via the 5th dimension?

- This lead to the author presenting in Chongqing, 11/15/2009 the region about the GR singularity is definable via a ring of space-time about the origin, but not overlapping it, with a time dimension defined

$$\Delta t \equiv 10^{\beta} \cdot t_{Planck}$$

The small mass of the graviton would be for energy in

$$\Delta E \Delta t \geq \hbar$$

- Having said this, the author is fully aware of the String theory HUP variant

$$\Delta x \geq \frac{\hbar}{\Delta p} + \frac{l_s^2}{\hbar} \Delta p$$

- The idea would be to possibly obtain a way to look at counting for GW detectors

$$h_0^2 \Omega_{gw}(f) \cong \frac{3.6}{2} \cdot \left[\frac{n_f [graviton] + n_f [neutrino]}{10^{37}} \right] \cdot \left(\frac{\langle f \rangle}{1kHz} \right)^4$$

End of 1st set of optional slides, back to core part of lecture

- Back to the matter of how to look at Gravitons, and information.

The following is claimed:

If n (graviton) is obtained, then higher dimensional geometry may be relevant to transmitting information via gravitons from prior to present universes

- How much information can be carried by an individual graviton?
- Assume $\Delta S \approx \Delta N_{gravitons}$
- Use Seth Lloyd's

$$I = S_{total} / k_B \ln 2 = [\# operations]^{3/4} = \left[\rho \cdot c^5 \cdot t^4 / \hbar\right]^{3/4}$$

10^{20} relic gravitons yields almost 10^{27} operations!

This value implies that per graviton, as nucleated at least 4 dimensions, there is at least **one unit** of information associated with the graviton (assuming there is at least **some relationship** between an operation and information)

$\Delta S \approx \Delta N_{gravitons} \approx 10^{20} \Leftrightarrow 10^{20}$ or higher amounts of prior universe information transmitted to our cosmos?

Cosmological parameters and information from prior to present cosmos ?

- The fine structure constant would probably be a place to start, in terms of information

$$\tilde{\alpha} \equiv e^2 / \hbar \cdot c \equiv \frac{e^2}{d} \times \frac{\lambda}{hc}$$

What the author thinks, is that <u>higher dimensional models</u> of gravity need to be developed, investigated, which may allow for such a counting algorithm.

2nd set of optional slides, next. Extension of Penrose hypothesis

- First, statement of Penrose hypothesis

- A) Initial standard inflation, but with no contraction phase
- B) Up to a million black holes “suck up” space time ‘material’
- C) Space time material so collated is recycled into a new big bang. No particular mapping specified as to how this happens.

2nd set of optional slides, next. Extension of Penrose hypothesis, Continued

- **Beckwith strongly suspects that there are no fewer than N (a large number) of universes under going Penrose 'infinite expansion' and all these are contained within a mega universe structure**.

- **Furthermore, that each of the N universes has black hole evaporation commencing, with the Hawking radiation from decaying black holes**.

2nd set of optional slides, next. Extension of Penrose hypothesis, Continued

- If each of the N universes is definable 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

$$10^7 - 10^8$$

-
- bits of information per each partition function in the set

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

- ,

2nd set of optional slides, next. Extension of Penrose hypothesis, Continued

- so minimum information is conserved between a set of partition functions per each universe

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

2nd set of optional slides, next. Extension of Penrose hypothesis, Continued

- However, that there is non uniqueness of information put into each partition function
.

$$\left\{ \Xi_i \right\}_{i \equiv N}^{i \equiv 1}$$

2nd set of optional slides, next. Extension of Penrose hypothesis, Continued

- Representation to think about

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

2nd set of optional slides, next. Extension of Penrose hypothesis, Continued

- Mapping to be defined is

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

End of 2nd set of optional slides: Extension of Penrose hypothesis,

- This hypothesis is being investigated

Resolutions of questions about cosmological constants ?

- **<u>1st Conclusion</u>, one needs a reliable information packing algorithm! I.e. for a wave length , as input into the fine structure constant, we need spatial / information limits defined for geometry**
- $\Delta S \approx \Delta N_{gravitons} \approx 10^{20}$ **is only a beginning**

<u>2nd Conclusion</u>, assumed GW detector sensitivity limits need a comprehensive look over, re do

Final inquiry, making sense of the supposed "radius of the Universe" calculation

- Matt Roos, has put in a foundational way of testing, via experiment, how to calculate a supposed 'radius of the universe'

$$r_U \equiv \frac{1}{H \cdot \sqrt{|\Omega - 1|}}$$

Tweaking parameters of *H*, and $\Omega \equiv \rho(t)/\rho_{critical}$ from our inquiry

- The choice of ***H***, and of density , as in the
- equation below will allow the dynamics of
- how the universe expands mesh with a fuller
- understanding of structure formation.

$$\Omega \equiv \rho(t)/\rho_{critical}$$

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