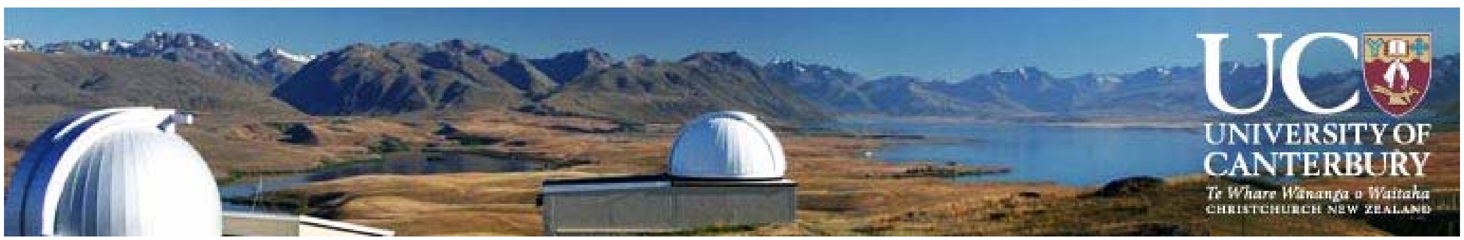
Applications of Euclidian Snyder geometry to the foundations of space-time physics

For ACGRG5



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Abstract

A thought experiment: LQG or string theory as an initial space-time template for emergent gravity?

- Applications of deformed Euclidian space to questions about the role of string theory and/or LQG
- 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?

Snyder formulation of HUP

1st Basic relation

$$\left[q, p\right] = i \cdot \sqrt{1-\alpha \cdot p^2} \Leftrightarrow \Delta q \Delta p \geq \frac{1}{2} \cdot \left| \left\langle \sqrt{1-\alpha \cdot p^2} \right\rangle \right|$$

2nd Basic relation

$$\Delta q \geq \left[(1/\Delta p) + l_s^2 \cdot \Delta p \right] \equiv (1/\Delta p) - \alpha \cdot \Delta p$$

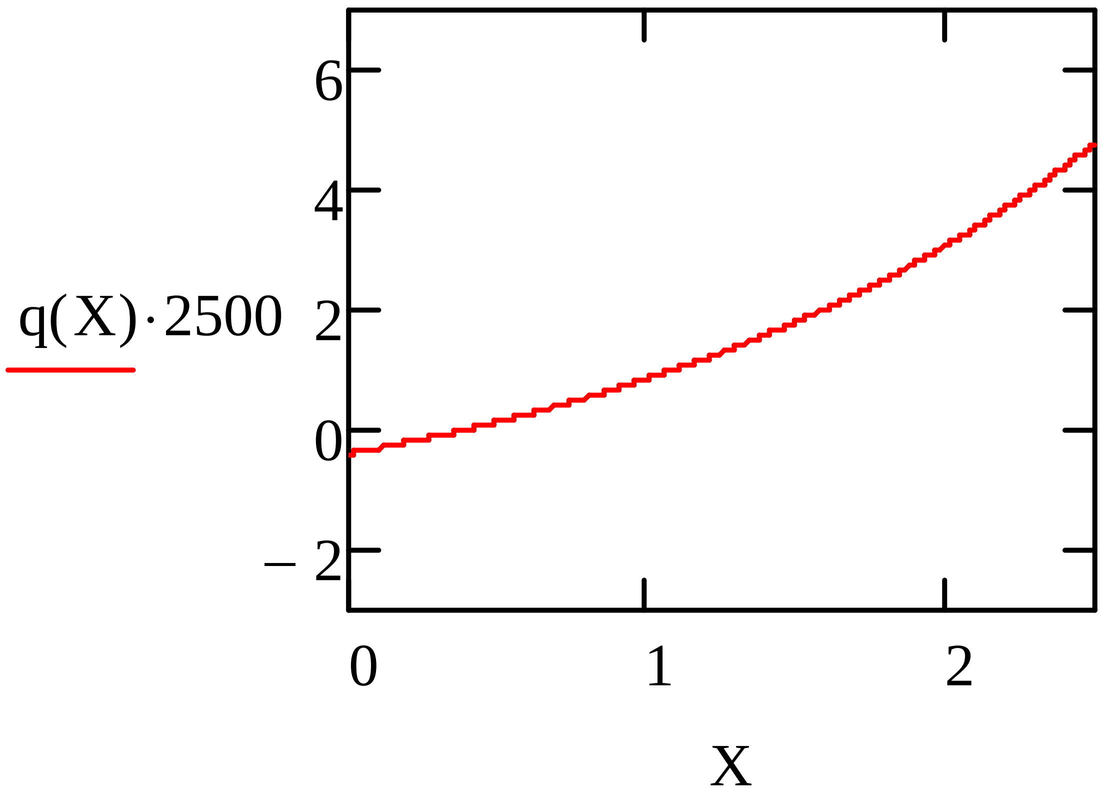
3rd Basic relation

LQG has $\alpha > 0$

Braneworld $\alpha < 0$

Jerk calculation in common for LQG, Braneword, and graphics, for figure 1 below

Using a non-zero graviton mass, $q = -\frac{\ddot{a}a}{\dot{a}^2}$



Assuming a brane world

X is Z (red shift value). Change in sign for Z = ~.40-.55 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, the following modification of Roy Maarsten's

- KK tower assumed to have a small non-zero mass added, i.e. no zero order value for the graviton

4 – D graviton ~ 10^{-65} grams

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

For brane world, use these evolution equations

Friedman equation, subsequently modified

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

Density equation, with non-zero graviton mass

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

For LQG, use these evolution equations

Friedman equations, assuming 'constant' momentum

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{\kappa}{3} \cdot \rho \qquad \left(\frac{\dot{a}}{a}\right)^2 \equiv \frac{\kappa}{6} \cdot \frac{p_\phi^2}{a^6} \qquad \left(\frac{\ddot{a}}{a}\right) = -\frac{2 \cdot \kappa}{3} \cdot \rho$$

Density equation

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

Can neutrinos interact with Gravitons? Part 1

Bashinsky states that the density of gravitons interacting with neutrinos causes an alteration of overall GR density via

$$\left[1 - 5 \cdot \left(\rho_{neutrino} / \rho\right) + \vartheta\left(\left[\rho_{neutrino} / \rho\right]^2\right)\right]$$

Can neutrinos interact with Gravitons? Part 2

- **George Fuller and Chad Kishimoto's PRL stretched neutrino hypothesis: a neutrino could be stretched 'across the universe' leading to (if there is an interaction with gravitons):**

  A few select gravitons, coupled to almost infinite wavelength stretched neutrinos would lead to at least the following stretched graviton wave

$$\lambda_{graviton} \equiv \frac{\hbar}{m_{graviton} \cdot c} < 10^{4}\, meters$$

Semiclassical 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

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

Some considerations about the partition function

Glinka (2007): if we identify $$\Omega = \frac{1}{2|u|^2 - 1}$$

- as a partition function (with u part of a Bogoliubov transformation) due to a graviton-quintessence gas, to get information theory-based entropy $S \equiv \ln \Omega$

1. Derivation by Glinka explicitly uses the Wheeler De Witt equation
2. 2. Is there in any sense a linkage of Wheeler De Witt equation with String theory results ?

PROBLEM TO CONSIDER:

Ng's result quantum counting algorithm is a **STRING theory** result.Glinka is **Wheeler De Witt equation**. **Equivalent ?**

Questions to raise.

Can we make a linkage between Glinka's quantum gas argument, and a small space version/ application of Ng's Quantum infinite statistics ?

In addition, if the quantum graviton gas is correct, can we model emergent structure of gravity via linkage between Ng particle count, and Q.G.G argument?

LQG , while using WdW up to a point, does not admit higher dimensions above 4 dimensions . String-Brane theory does

- Why is this relevant to a discussion of the LQG vs Brane theory discussion ?

Breakdown of field theory with respect to massive gravitons in limit

$$m_{graviton} \to 0$$

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

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

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

Try semiclassical model of graviton, as kink-anti kink pair

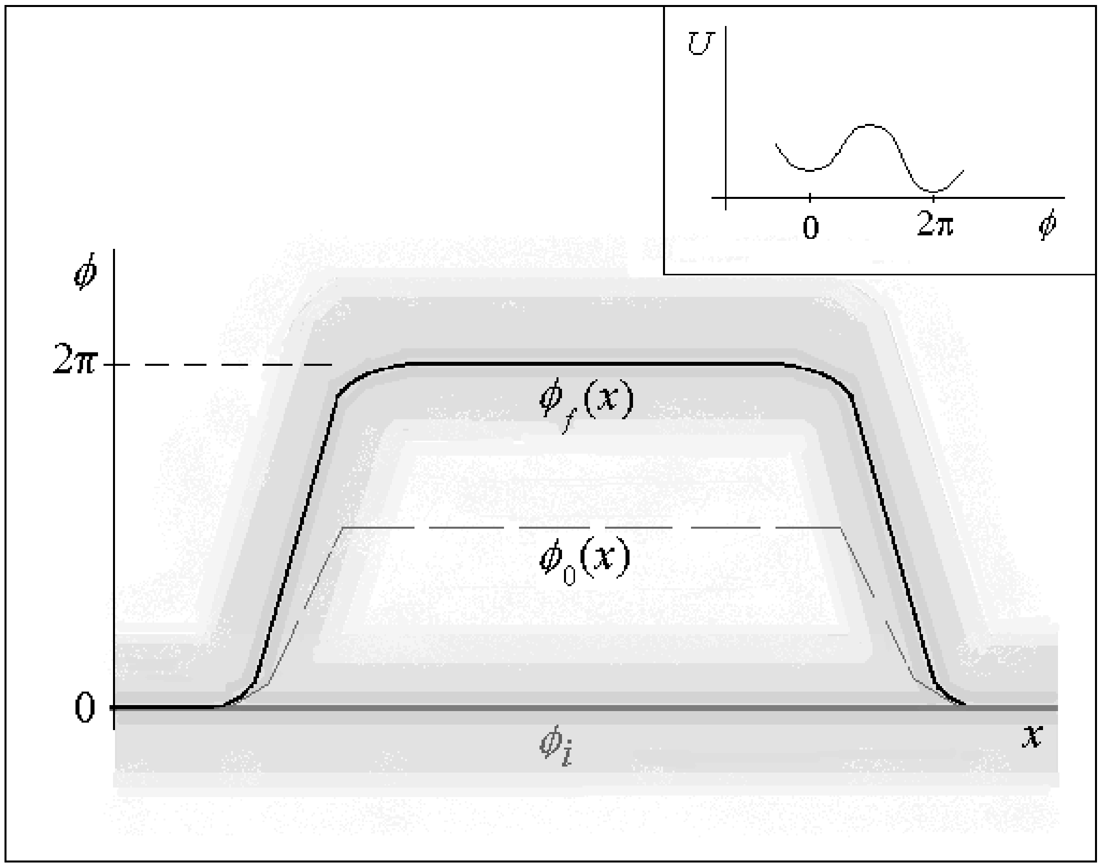
- How does this fit in with t'Hooft's deterministic QM?

- From a 1+ dimensional kink-antikink

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

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

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

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.

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

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