<u>COSMOLOGY</u>: The nature of semi-classical nature of gravity reviewed, and can we use a graviton entanglement version of the EPR experiment to answer if the graviton is classical or quantum in origin?

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Actual affiliation of speaker information.

- Detailing Coherent, Minimum Uncertainty States of Gravitons, as Semi Classical Components of Gravity Waves, and How Squeezed States Affect Upper Limits to Graviton Mass / Implications for a Graviton version of the EPR experiment ?

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First part of abstract, i.e. part I

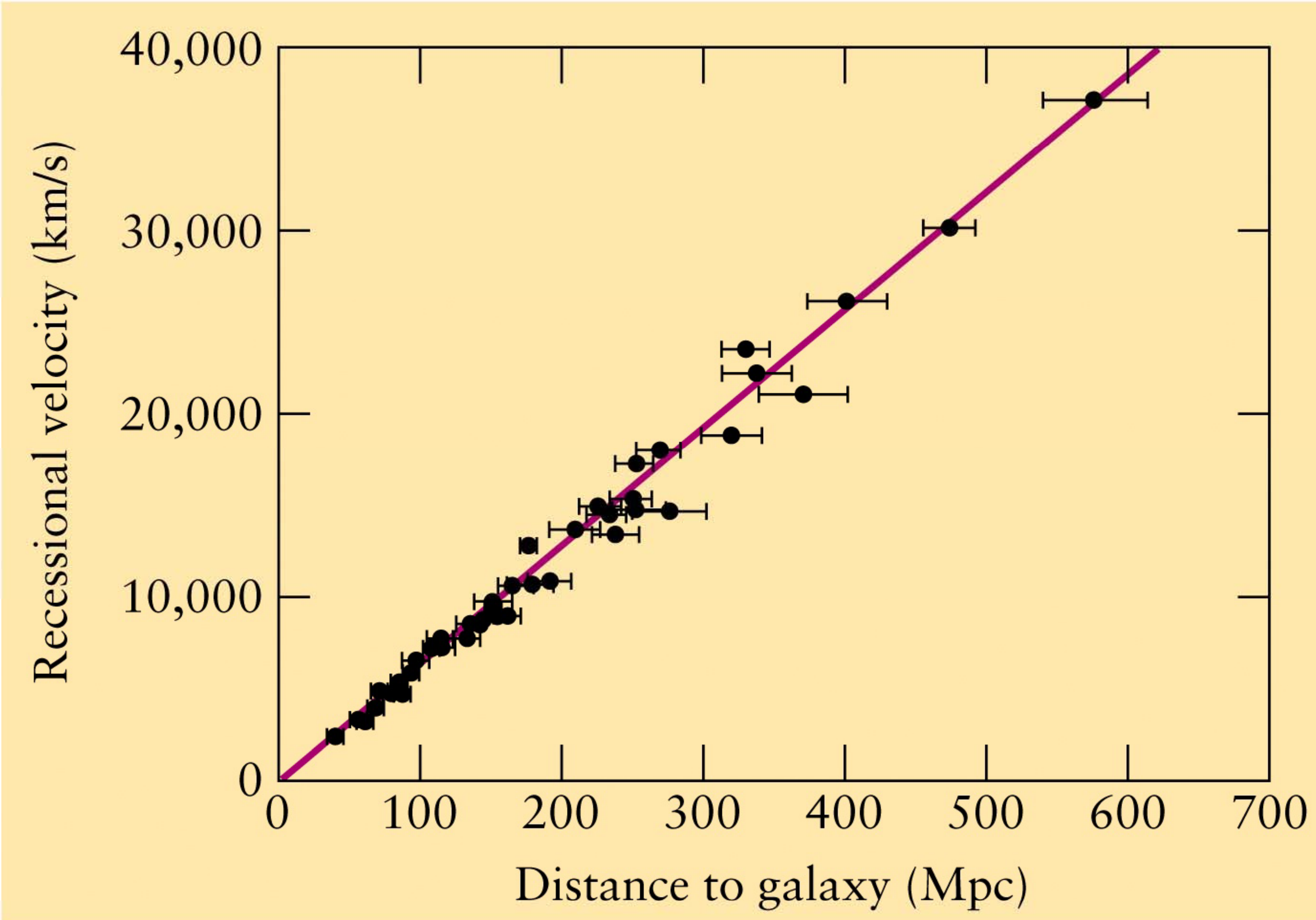
- Detailing Coherent, Minimum Uncertainty States of Gravitons, as Semi Classical Components of Gravity Waves, and How Squeezed States Affect Upper Limits to Graviton Mass /
- ***We present what is relevant to squeezed states of initial space time and how that affects both the composition of relic GW, and also gravitons. A side issue to consider is if gravitons can be configured as semi classical "particles", which is akin to the Pilot model of Quantum Mechanics as embedded in a larger non linear "deterministic" background.***

What can be used as a rule stick for measurement?
Velocity used as a surrogate for distance –
km/s for v<<c, otherwise red shift, *z*, where

$$1 + z \equiv \frac{\lambda}{\lambda_0} = \frac{\lambda_0 + \Delta\lambda}{\lambda_0} = 1 + \frac{\Delta\lambda}{\lambda_0}$$

$$1 + z = \frac{\lambda}{\lambda_o} \simeq 1 + \frac{v}{c}$$

$$1 + z = \frac{\lambda}{\lambda_o} = \frac{1 + v/c}{\sqrt{1 - v^2/c^2}}.$$



Hubble's Law (published 1929): H_0 = 72 (+/-5) km/s per Mpc

<u>DYNAMICS OF THE UNIVERSE</u>

The Friedmann Equation:

$$\dot{R}^2(t) = \frac{8\pi G\rho R^2(t)}{3} - kc^2 + \frac{\Lambda}{3}R^2(t).$$

R is the 'scale factor'
Λ is the 'cosmological constant' term
k is the 'curvature': -1 corresponds to an open universe
+1 corresponds to a closed universe
0 corresponds to a critical universe

This has a simple but limited ***dynamical interpretation****,*
and a complex but general geometrical interpretation

Dynamics of the Hubble parameter and scale factor

- Using the standard substitution of R = a for a scale factor, we can write, if φ 'scalar field' is an inflaton, and say

$$\frac{\dot{a}}{a} \equiv H \approx -m \cdot \frac{\varphi}{3 \cdot \dot{\varphi}}$$

Now to determine if there is a semi classical input from pre universe

- Viscosity of initial space time can be modeled via viscosity over entropy , **s ,** as given by

$$\left|\frac{\eta}{s} \approx \varepsilon^{+}\right| << \frac{1}{4\pi} < 1-\varepsilon$$

Two cases to consider for prior equation

- "Infinite" or very large values of entropy means information from a pre universe construction will be transferred

$$s \rightarrow \infty$$

- Viscosity vanishing , on the other hand means possible data compression and/ or cut off of data transfer

$$\eta \rightarrow 0^{+}$$

Do quantum processes play a role in Gravity? The Weinberg answer

- If $\in = \frac{\lambda^2}{16\pi G}, H = 1/\in t \Leftrightarrow a(t) \propto t^{1/\in}$

Weinberg states there is no actual quantum connection with gravity if $|V(\varphi)| = (4\pi G)^{-2}$

Furthermore, if $\varphi(t) = \frac{1}{\lambda}\ln\left[\frac{8\pi G g \in^2 t^2}{3}\right]$

and $\frac{a(t_2)}{a(t_1)} = \left(\frac{t_2}{t_1}\right)^{1/\in} = \exp\left[\frac{(\varphi_2 - \varphi_1)\lambda}{2\in}\right]$

The connection with Quantum gravity is lost if $\frac{a(t_2)}{a(t_1)} > 1$

Now for magnitude of the potential in early universe

- Scaled, growing potentials, including inflaton physics for φ

$$V(\phi) \propto \varphi^{|\alpha|} \text{for} \quad t < t_{PLanck},$$

$$V(\phi) \propto \varphi^{-|\alpha|} \text{for} \quad t > t_{PLanck}$$

Now how to possibly link gravity/ gravitons to entropy, in the early universe

- Try this for a start. I.e. what if the holographic suggestion as to entropy, Hogan, is combined with the Beckwith Modification of Y.J. Ng's

  infinite quantum statistics

$$S_{\max - initially} = \pi / H^2 \sim 10^5 \sim \Delta S_{gravitons} \propto N_{Jack-Ng}$$

What to compare, which version of

- To keep in mind what was written before

$$\left|\frac{\eta}{s} \approx \varepsilon^{+}\right| \ll \frac{1}{4\pi} < 1-\varepsilon$$

- Compare this with the statement made as to

early entropy. If Entropy very large, then does

$$S_{\max - initially} = \pi / H^{2} \sim 10^{5} \sim \Delta S_{gravitons}$$

mean large scale entropy, and transfer of information from a prior universe ? This would be at/about Planck time, when either $V(\phi) \propto \varphi^{|\alpha|} \text{for} \quad t < t_{PLanck}$ holds,

or $V(\phi) \propto \varphi^{-|\alpha|} \text{for} \quad t > t_{PLanck}$

Different Scenarios for Entropy Growth Depending Upon if or Not We Have Low to High Frequency GW from the Big Bang

- This means that we have to assume, initially, for a maximum transfer of entropy and also information from a prior universe, that *H* is extremely small. From Hogan, note that if we look at Hogan's holographic model, this is consistent with a non finite event horizon for black holes

$$r_0 = H^{-1} \quad \Leftrightarrow T_{black-hole} = \left(2\pi \cdot r_0\right)^{-1}$$

We assume an early universe generalization

$$H_{early-universe} \sim r_{early-universe}^{-1}$$

$$\sim \left[T_{early-universe} / 2\pi \right] \approx T_{early-universe}$$

Large or small initial Temperature? Answers dependent upon large higher dimensions?

- Number of “holographically induced states” is

$$N = \exp\left(\pi H^{-2}\right)_{early-universe} \sim (?)\Delta N_{gravitons} \sim 10^{5} - 10^{20}$$

Question, how does this relate to temperature ?

IF the temperature of start of pre –to present universe before expansion is nearly zero, and the following holds

$$r_{starting}(very-l\arg e) \propto H_{starting}^{-1} \propto T_{starting}^{-1} \sim \varepsilon^{-1}$$

Does this mean we have large higher dimensions? Very low initial Temp?

Why issue is so relevant? Temperature dependence in GW frequency? If HFGW are dominant?

- From Grishchuck , M = mass of 'universe' initially, and R = radius of initial dimensions, T=initial temperature. (What if the T is initially low ?)

$$f_{Peak} \approx \left(10^{-3}\ \mathrm{Hz}\right) \cdot \left[\frac{T}{T\mathrm{eV}}\right] \sim 10^{10}\,\mathrm{Hz}$$

$$\approx \sqrt{\frac{M}{M_{solar-mass}}} \cdot \sqrt{\frac{90\ \mathrm{km}}{R}}$$

What if the T is initially low ?

- This means that the initial temperature leads to string theory values of the GW

$$f_{Peak} \approx \left(10^{-3}\ \mathrm{Hz}\right) \cdot \left[\frac{T \sim T_{Very-Low}}{T\mathrm{eV}} \right] \sim 10^{-18}\text{-}10^{-10}\mathrm{Hz}$$

- Question we ask the audience, can we go from initially almost absolute zero temperature to much higher temperatures? What would allow up to even entertain such a notion ?

Low temperature for Holographic Treatment of N being non zero, if H ~ T, while High Temperature for high frequency GW ? How can this be possibly justified ?

- Claim # 1, If the above happens, it argues in favor of Tegmarks Multiverse as a 'container' of the present universe. I.e. the dim of the Multiverse container which could be a setting for initially low temperatures for N forming, especially if the Multiverse container is very 'large'

Claim # 2, If the above happens, Grishchuck's 10^{10}Hz arises later in 4 dimensions for very small initial 4 Dim .

Claim # 3 : To answer Claim 2, we need to consider the minimum grid size (?) $\Delta x \approx h_{rms} \sim 10^{-39} / \sqrt{Hz}$

Optimal Quantum Estimation for Gravitation. True so long as a metric exists

- The standard time-energy uncertainty relation and the Heisenberg uncertainty relation are special cases of the uncertainty relation for the space-time metric. The uncertainty relation takes a particularly simple and revealing form when the measurement region is made sufficiently small **.** **From :**
- Optimal Quantum Estimation for Gravitation
- T. G. Downes, G. J. Milburn
- http://xxx.lanl.gov/abs/1108.5220

$$\left\langle \left(\delta g_{uv}\right)^2 \left(\hat{T}^{uv}\right)^2 \right\rangle \geq \frac{\hbar^2}{{V_{vol}}^2}$$

Limits of applicability of uncertainty relationship

- Traditionally, minimum length for space-time benchmarking has been via the quantum gravity modification of a minimum Planck length for a grid of space-time of Planck length, whereas this grid is changed to something bigger

$$l_P \sim 10^{-33}\,\mathrm{cm}$$

$$\xrightarrow[\text{Quantum-Gravity-threshold}]{} \tilde{N}^{\alpha} \cdot l_P \propto 10^{-30}\,\mathrm{cm}$$

Re scaling of Units makes it plain

- Make the substitution

$$\text{Units } \hbar \equiv \text{c} \equiv l_p = 1$$

$$\left\langle \left(\delta g_{uv}\right)^2 \left(\hat{T}^{uv}\right)^2 \right\rangle \geq \left(10^{-6} - 1\right)$$

Upshot, for small volume

- Almost no initial energy density via means enormous metric fluctuations, and vice versa i.e. very large energy density then means vanishingly small metric perturbations δg_{00} using

$\hbar \equiv \mathrm{c} \equiv l_p = 1$

$$\Rightarrow \left\langle \left(\hat{T}^{uv} \right)^2 \right\rangle \geq \left[\frac{\left(10^{-6} - 1\right)}{\left(\delta g_{uv}\right)^2} \sim \left(\delta g_{uv}\right)^{-2} \right]$$

$$\Rightarrow \left\langle \left(\hat{T}^{00} \right)^2 \right\rangle \geq \left[\left(\delta g_{00}\right)^{-2} \right]$$

Minimizing uncertainty relations means a regime when QM may not apply initially?

- If the metric fluctuation δg_{00} no longer applies, does this tend to a regime of where QM no longer applies directly ? In initial conditions?

Notes on the vacuum energy idea and also the cosmological constant (Quintessence)

- Penrose (2010) writes as of p163 of his book that:

$$\Lambda\Big|_{Today}\,[vacuum-energy]$$

$$\sim \frac{c^3}{N^6 G\hbar} \equiv N^{-6}\Big|_{Today} \approx 10^{-90} - 10^{-120}$$

$$\sim 1/S_{Today}$$

One can perhaps write as of the beginning that

$$\Lambda\Big|_{initial-Planck\,time}\,[vacuum-energy]$$

$$\sim \frac{c^3}{N^6 G\hbar} \equiv N^{-6}\Big|_{Planck-time} \approx 10^{-6} - 10^{-24}$$

$$\sim 1/S_{initial-Planck-time}$$

Notes on the vacuum energy idea and also the cosmological constant (Not Quintessence); Continued.

- Super massive black holes in one million galaxies, vastly more entropy than gravitons

$$S_{universe} \approx \sum_{i=1}^{10^6} S_{Super-massive-Black-Holes-center-of-galaxies}$$

$$\sim \frac{1}{4}\sum_{i=1}^{10^6} A_i \propto 10^{120} - 10^{124}$$

Temperature dependence of quintessence (Park , 2002?)

- High temperature, high vacuum energy, and then low temperature, present vacuum energy?

$$\Lambda\left[Park, 2002\right] \equiv$$

$$\Lambda_{General-Value} T^{\beta}_{Temperature} \sim$$

$$\frac{10^{-120} \cdot T^{\beta=115/31}_{Temperature}}{\left[2.73 Kelvin\right]}$$

Quintessence, Park formula, continued

- High and low values as roughly tabulated

$$\Lambda\left[Park, 2002\right]\Big|_{\substack{Planck-Time \\ T_{temp}=10^{32}\,Kelvin}} \sim 10^{-5} \propto \frac{1}{S_{initial}}$$

$$\Lambda\left[Park, 2002\right]\Big|_{\substack{Today \\ T_{temp}=2.73\,Kelvin}} \sim 10^{-120} - 10^{-124} \propto \frac{1}{S_{Today}}$$

What would happen if gravitons as a particle count algorithm defined Today's Entropy ?

- **From Giovannini (2008- World Scientific)**

$$S_{Graviton-Today's.era} \propto V \int_{10^{-19}\,Hertz}^{10^{11}\,Hertz} r(v) \cdot v^2 dv$$

$$\cong \left(10^{30}\right)^3 \cdot \left(\frac{H_1}{M_{Planck-mass}} \right) \propto 10^{90}$$

$$\sim (difference \quad of \quad 10^{11} \quad to \quad 10^{-19}\,Hertz)^3$$

Difference in final entropy values, black holes versus gravitons may be proof of higher dimensions. How to reconcile 5th dimension, black holes and all that with value of entropy due to Gravitons?

- Use, perhaps a slightly modified version of cyclic conformal cosmology ? Review first of the Penrose ideas behind CCC, starting first with phase space volumes assumed by the Formula of phase space which comes from the Penrose book, 2010 directly

Phase space, BH in galaxies entropy, and all that, 5 D

- Much larger than 4 D Graviton induced entropy and resulting phase space due
  to super massive BH in center of galaxies

$$10^{10^{124}} \approx 10^{Final-entropy-Galactic-Black-Holes=S_{FINAL-BL}}$$

$$\sim Phase \quad space \quad Super-Massive-BH-in-Galaxies$$

Phase space , entropy and final number of gravitons in 4 D ?

- Phase space value assuming number of gravitons much smaller than phase space due to super massive black holes in center of galaxies: 4 D model for phase space as opposed to 5 D model for phase space

$$10^{10^{90}} \approx 10^{Final-entropy-Gravitons=S_{FINAL-GRAVITONS}}$$

$$\sim Phase \quad space \quad due \quad to \quad Gravitons$$

Looking at the contribution from super massive black holes in Galaxies in phase space leads to consider how to contain 4 D in 5 D

- We use Wesson's book (1999) directly in terms of defining a 5 D line metric in terms of an additional 5^{th} dimension put in with 4 dimensional space

Actual Wesson 5 D line element

- L is the length of the dimension in 5 dim.
- The other 'lengths' are from 4D contained dimension in the line element in 5D. j=1,2,3 corresponds to x,y,z , while t is for the time

$$dS_{5-Dim}^{2} = l^{2}\left[dt^{2} - \sum_{j=1}^{3}\left(\exp\left[i\left(\omega \cdot t + k_{j}x_{j} \right) \right] \right) \cdot dx_{j} \right] - L^{2}dl^{2}$$

Actual Wesson 5 D line element, continued

$$R = 12 \big/ l^2 L^2 = radius \quad of \quad curvature \xrightarrow[L\to\infty]{} 0$$

$$8\pi T_{00} = -\frac{3\cdot\omega^2}{4}$$

$$8\pi T_{jj} = \frac{3\omega^2}{4}\cdot\exp\left[i\cdot\left(\omega\cdot t + k_j x_j\right)\right]$$

$$8\pi p = -8\pi\rho = \frac{3\cdot\omega^2}{4l^2}$$

Main difference in Wesson 5 D cosmology from 4 D, negative cosmological constant

- Cosmological constant in 5 dimensions has negative value, similar to negative value in string theory. Note , vacuum waves exist in 5D

$$\Lambda_{5-D} = -\frac{3 \cdot \omega^2}{4l^2}$$

Main assertion is that black holes may be in 5 D, whereas our observable universe is 4 D

What does this say about a source for a gravitational field ?

- From Penrose, Page 130 (his 2010 book)

$$E = 8\pi \cdot T + \Lambda \cdot g$$

$$E = source \quad for \quad gravitational \quad field$$

$$T = mass \quad energy \quad density$$

$$g = gravitational \quad metric$$

$$\Lambda = vacuum \quad energy, rescaled \quad as \quad follows$$

- From cyclic conformal cyclic cosmology cycle per cycle

$$g \xrightarrow[ccc]{} \hat{g} = \Omega^2 g$$

Conformal invariance of Maxwell's theory

- Write, generally

$$\nabla F = 4\pi J$$

$$F = Field$$

$$J = Current \xrightarrow[set-to]{} 0$$

If a field is massless, Then for the Maxwell Field (with no current)

- Set a 'field' as $\phi_{ABC..E}$
- Then the following holds. True for almost massless fields as well (i.e. the ultra light graviton)

$$\hat{\phi}_{ABC..E} = \Omega^{-1}\phi_{ABC..E}$$

$$\hat{\nabla}^{AA'}\hat{\phi}_{ABC..E} = \Omega^{-3}\nabla^{AA'}\phi_{ABC..E}$$

$$Ideally, we \quad have$$

$$\hat{\nabla}\hat{F} = 0 \Leftrightarrow \nabla F = 0$$

For CCC theory, Penrose(2010) the cross over from Cycle to Cycle is given by mapping $\Omega \xrightarrow[CCC]{} \Omega^{-1}$

- If C is the Weyl tensor, then one has from Penrose, page 159 (2010 Penrose book). And we see figure 3.6 of Penrose book what if

$$\Omega \xrightarrow[CCC]{} \Omega^{-1}$$

Cross over to a new universe zone, if we use the Penrose $\Omega \xrightarrow[CCC]{} \Omega^{-1}$

$$\hat{K} = \Omega^{-1}\hat{C}$$

$$\hat{\nabla}\hat{K} = 0,$$

and before crossover to new universe zone

$C \to 0$ *just before crossover*, $\Omega \to$ *tiny*, "''", *and*
K *remains finite just before crossover*,

as well as

$$\Pi = \frac{d\Omega}{\Omega^2 - 1} \xrightarrow[\Omega \xrightarrow[CCC]{} \Omega^{-1}]{} SAME \quad \frac{d\Omega}{\Omega^2 - 1}$$

Difference of opinion with Penrose. I.e. 5th dimension inevitable, containing black holes, and there are many , not just one universe undergoing collection of material into black holes for recycling of Matter-energy material

- Penrose has ' large Ω' become small
- This information is fed into $\hat{g} = \Omega^2 g$
- The following transformation would happen for many universes, not just our own. And Ω changes

$$\Pi = \frac{d\Omega}{\Omega^2 - 1} \xrightarrow[\Omega \xrightarrow[CCC]{} \Omega^{-1}]{} SAME \quad \frac{d\Omega}{\Omega^2 - 1}$$

Experimentally tracking the GW and Gravitons from other 'universes'? As input into our own? This appears impossible; i.e. Causal discontinuities? And what is means of information transfer ? From other universes?

- Claim that an elaboration of the mapping across the boundary as given by $\Omega \xrightarrow[CCC]{} \Omega^{-1}$

becomes more nuanced, and complex. i.e. not just inverting a large Ω to become small for

$$\hat{g} = \Omega^2 g$$

What still remains the same, what changes

- The mapping $\Omega \xrightarrow[CCC]{} \Omega^{-1}$ should be refined from cycle to cycle, not just being one universe
- The mapping $\hat{g} = \Omega^2 g$ does not change
- The gravitational source E 'mapping' as given
- $E = 8\pi T + g\Lambda$ does not really change

Classical representation of Gravitons? Is it possible ?

- Now what could be said about forming states close to classical representations of gravitons?
- Venkatartnam, and Suresh [39], built up a coherent state via use of a displacement operator , applied to a vacuum state , where α is a complex number, and
- a, a^{+} as annihilation & creation operations , $\left[a, a^{+}\right] = 1$ where one has the displacement operator as set by

$$D(\alpha) \equiv \exp\left(\alpha \cdot a^{+} - \alpha^{*} \cdot a\right)$$

So that $$|\alpha\rangle = D(\alpha) \cdot |0\rangle$$

Have a situation where a vacuum state as a template for graviton nucleation is built out of an initial 'vacuum state' (The initial 'vacuum state' is not necessarily purely quantum mechanical, if it has a tiny rest mass)

- To do this though, as Venkatartnam, and Suresh [39] did, involved using a squeezing operator as given by

$$Z\left[r,\vartheta\right]=\exp\left[\frac{r}{2}\cdot\left(\left[\exp(-i\vartheta)\right]\cdot a^{2}-\left[\exp(i\vartheta)\right]\cdot a^{+2}\right)\right]$$

Furthermore, the squeezing operator hits a ground state, presumably classical for a graviton via $\left|\varsigma\right\rangle =$

$$Z\left[r,\vartheta\right]\left|\alpha\right\rangle=Z\left[r,\vartheta\right]D\left(\alpha\right)\cdot\left|0\right\rangle\xrightarrow[\alpha\to0]{}Z\left[r,\vartheta\right]\cdot\left|0\right\rangle$$

$$\left|\varsigma\right\rangle\xrightarrow[\alpha\to0]{}Z\left[r,\vartheta\right]\cdot\left|0\right\rangle\quad 0\le r\le\infty,-\pi\le\vartheta\le\pi$$

Could Final form of Graviton as squeezed vacuum states start off with semi classical representation for graviton?

- Begin looking at super position of states given as

$$\left|\varsigma\right\rangle \xrightarrow[\alpha \to 0]{} Z\left[r,\vartheta\right]\cdot\left|0\right\rangle$$

Being a super position of vacuum states, means that classical analog is extremely difficult to recover in the case of squeezing, and general non classical behavior of squeezed states

- **As an example of how muddled the quantum representation gets**
- *Note L. Grishchuk [40] wrote in "On the quantum state of relic gravitons", where he claimed in his abstract that "It is shown that relic gravitons created from zero-point quantum fluctuations in the course of cosmological expansion should now exist in the squeezed quantum state".* **Who says that the starting point for the graviton is purely QM ? Not necessarily true if rest mass for Graviton does not equal zero!**

Simple representation of an un squeezed GW/Graviton (?) state/states?

$$y(\eta) = \frac{\mu(\eta)}{a(\eta)} \equiv C(\eta) \cdot \exp(-B \cdot y)$$

$$B\Big|_{\eta} \xrightarrow[\eta \to \eta_b]{} B(\eta_b) \equiv \omega_b / 2$$

Simple representation of an squeezed GW/Graviton (?) state/states?

- The 2nd equation becomes very complicated:

$$y(\eta) = \frac{\mu(\eta)}{a(\eta)} \equiv C(\eta) \cdot \exp(-B \cdot y)$$

$$B\Big|_{\eta} \xrightarrow[\eta \neq \eta_b]{} B(\omega, \eta \neq \eta_b) \equiv$$

$$\frac{i}{2} \cdot \frac{\left(\mu/a(\eta)\right)'}{\left(\mu/a(\eta)\right)} \equiv \frac{\omega}{2} \cdot \frac{\cosh r + \left[\exp(2i\vartheta)\right] \cdot \sinh r}{\cosh r - \left[\exp(2i\vartheta)\right] \cdot \sinh r}$$

“ Massive” Gravitons ?

- One of the first tasks to consider if we look for imprint of complex embedding arguments for nucleation of gravitons ? Look at if the actual conformal time, η , is such that does the following hold ?

$$\eta \neq \eta_b \Rightarrow \omega \neq \omega_b \Rightarrow B(\omega, \eta \neq \eta_b) \equiv \frac{i}{2} \cdot \frac{\left(\mu/a(\eta)\right)'}{\left(\mu/a(\eta)\right)} \neq \frac{\omega_b}{2}$$

“Massive Graviton”, Continued?

- To answer these questions, not only is the stability of the graviton very important, with its connotations of either time dependence or time independence of DE, the other question it touches upon is how we can infer the existence of the speed up of acceleration of the universe.

<u>"Massive Graviton", Continued?</u>

- After the big bang, we might expect the rate of expansion to slow down under the influence of gravity. This anticipated deceleration is characterized by the 'deceleration parameter', q_0, which is evidently related to the total mass content of the universe. This mass content is conventionally expressed as Ω_M, a fraction of the mass required to bring the universe to a halt after infinite time; if it dominates the dynamics of the universe, then $q_0 = \Omega_M/2$.

“Massive Graviton”, Continued?

- Modified KK version of Graviton ? Non zero Graviton mass plays role of DE ? ***DM + DE joint model?*** This is from Beckwith’s (2011) Journal of cosmology article Here, L is ‘size’ of 5th Dimension, n is KK ‘node’.

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

$$= \frac{n}{L} + 10^{-65}\, grams$$

$$m_{graviton}(4 - Dim \quad GR) \sim 10^{-48}\, eV$$

$$M_X \sim M_{KK-Graviton} \sim .5 \times 10^9\, eV$$

“Massive Graviton”, Continued? Formulas from Maarten’s applied

- De - celeration parameter is now described

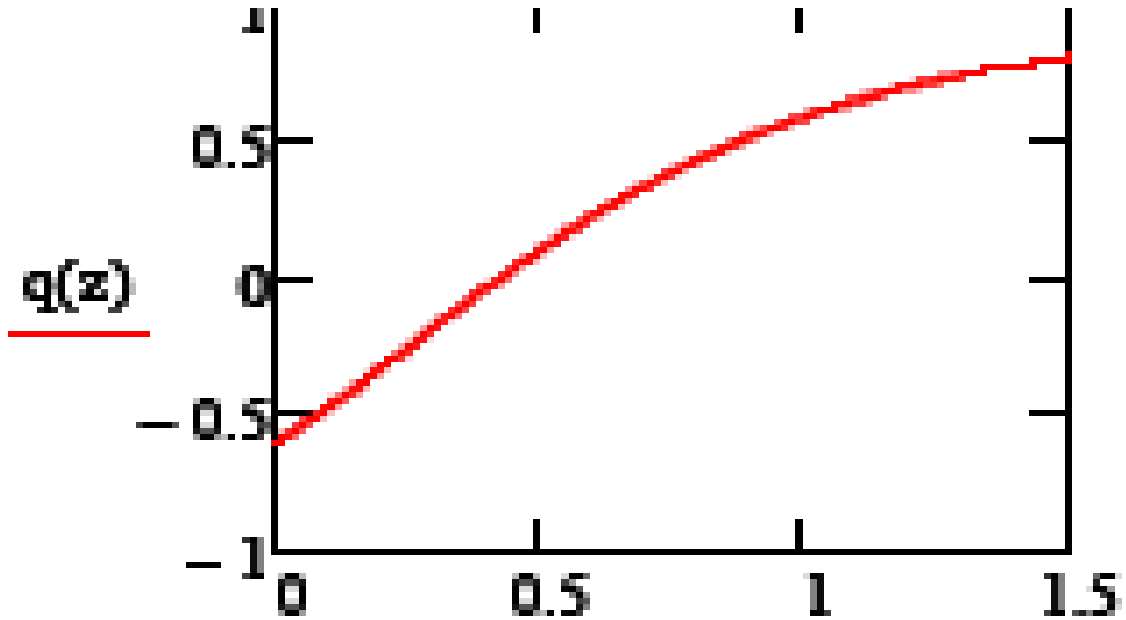
$$\dot{a}^2 = \left[\left(\frac{\tilde{\kappa}^2}{3} \left[\rho + \frac{\rho^2}{2\lambda} \right] \right) a^2 + \frac{\Lambda \cdot a^2}{3} + \frac{m}{a^2} - K \right]$$

$$\dot{H}^2 = \left[-\left(\frac{\tilde{\kappa}^2}{2} \cdot [p + \rho] \cdot \left[1 + \frac{\rho^2}{\lambda} \right] \right) + \frac{\Lambda \cdot a^2}{3} - 2\frac{m}{a^4} + \frac{K}{a^2} \right]$$

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

$$q = -\frac{\ddot{a}a}{\dot{a}^2} = -1 + \frac{2}{1 + \tilde{\kappa}^2 [\rho / m] \cdot (1 + z)^4 \cdot (1 + \rho \ /2\lambda)} \approx -1 + \frac{2}{2 + \delta(z)}$$

"Massive Graviton", Continued? Formulas from Maarten's applied



Z

$\Omega_M < 1$ – ($q_0 < 0.5$) matter will stop universal expansion after finite time (followed by recollapse, and a 'Big Crunch'); a closed universe

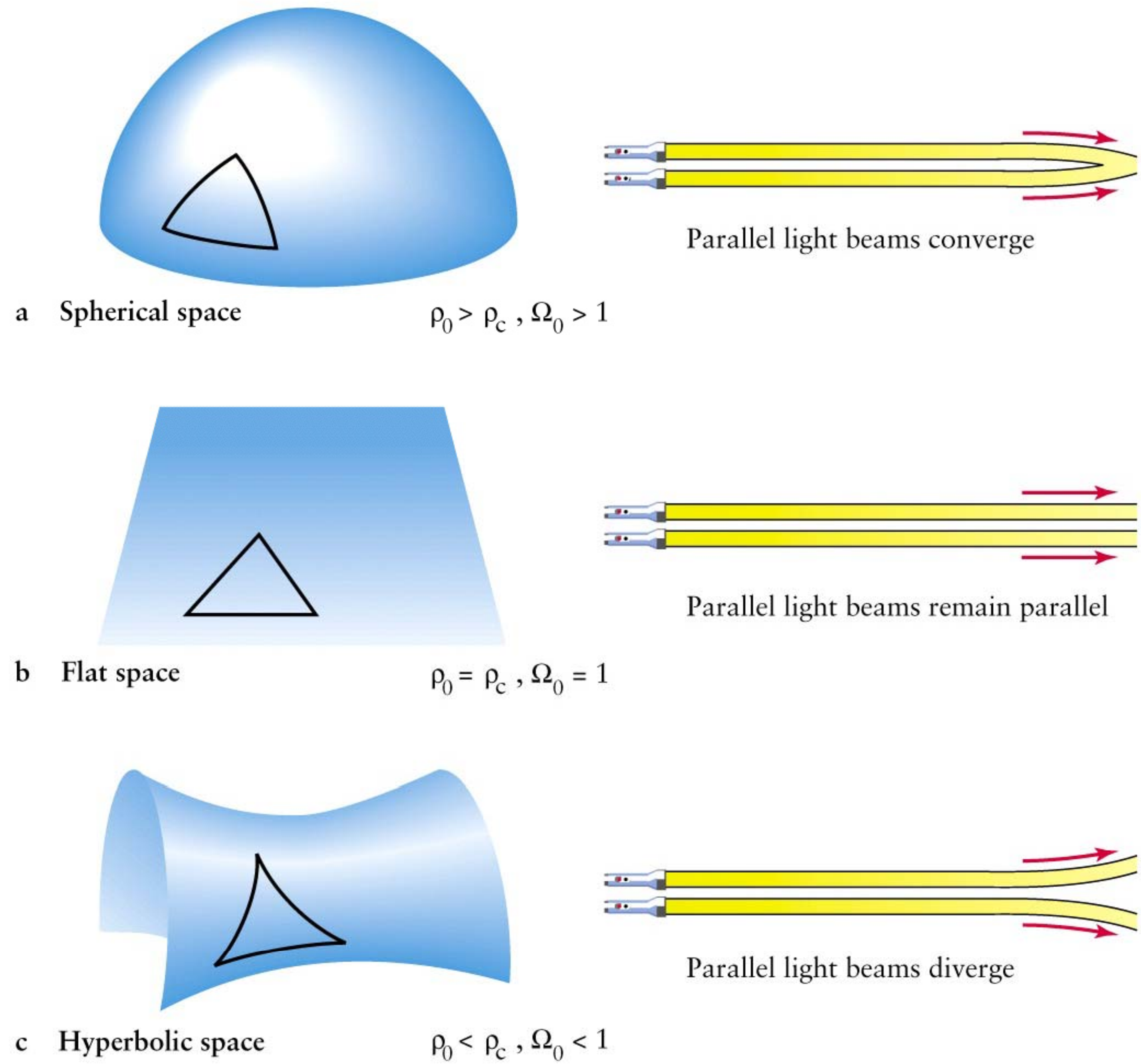
Geometry: positive curvature, $k = +1$

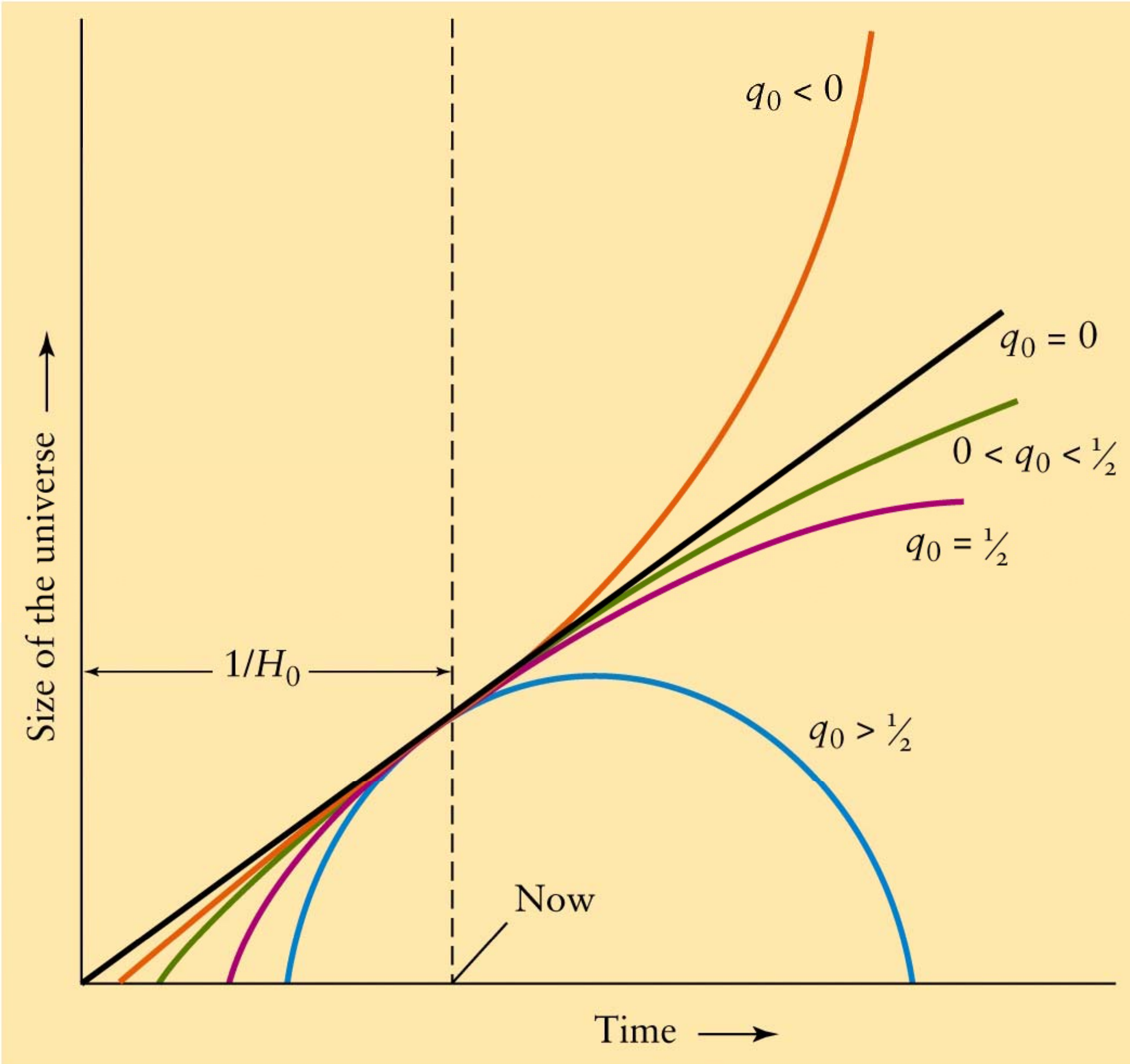
$\Omega_M > 1$ – ($q_0 > 0.5$) gravity will never stop the expansion (an open universe)

Geometry: negative curvature, $k = -1$

$\Omega_M = 1$ – ($q_0 = 0.5$) a critical universe

Geometry: flat (Euclidean), $k = 0$


Parallel light beams converge
a Spherical space
$\rho_0 > \rho_c$, $\Omega_0 > 1$
Parallel light beams remain parallel
b Flat space
$\rho_0 = \rho_c$, $\Omega_0 = 1$
Parallel light beams diverge
c Hyperbolic space
$\rho_0 < \rho_c$, $\Omega_0 < 1$



$q_0 < 0$
$q_0 = 0$
$0 < q_0 < ½$
$q_0 = ½$
$1/H_0$
$q_0 > ½$
Now
Size of the universe
Time

In seeking to determine the deceleration of the universe, it turns out that it's not decelerating at all;

the universe is accelerating!

So what is Ω_M? Well, whatever it is, there has to be something else involved in the dynamics of the universe?

We generalize Ω to include not just matter, but all forms of mass/energy:

$\Omega_M = \Omega_B + \Omega_{DM}$ $(+ \Omega_\nu ....)$

Ω_Λ $(+ \Omega_{starlight}, \Omega_{CMB} ...)$

What is the geometry (i.e., what is Ω_{total}?)

- Bridge between the two parts of this talk. “necessary” reason for introducing ‘massive’ graviton in terms of reacceleration of universe,etc.
- I.e. **we presented so far a scheme as to how to use a ‘massive’ graviton as a way to bench mark how the rate of acceleration of the universe actually is increasing**. *This is vital for the work at hand, I.e. being able to show a macro view as to how this re acceleration has a large scale, macroscopic consequence. No where did we give a proof that the graviton could have a non zero rest mass.* **Next we look at the rest mass of the graviton itself as experimentally inferred.**
- “SUFFICIENT” REASON For introducing the ‘massive’ graviton given next , i.e. altering the EPR experiment ?

2^{nd} part of abstract, i.e. part II

- / Implications for a Graviton version of the EPR experiment ?
- *The final part of the talk will be to examine practical testing of the EPR hypothesis, as given by B. Cocciaro, S. Faetti, L. Fronzoni, as to a lower bound for a superluminal communication signal propagating in space time, with a similar argument made between Graviton entangled states as what is done for photons. If Gravitons have a small rest mass, then we expect a slightly lower bound for a superluminal communication signal propagating in space time between entangled Gravitons , than would be true for such superluminal communication between entangled photons. Our supposition is that massive Gravitons would be no longer purely quantum mechanical objects and that alteration of the propagation speed for a superluminal communication signal from v_{t}~0.6*10^4 c reflects deviation from purely quantum mechanical origins for Gravitons and by extension that gravity is actually a classical physics 'force' in its origin and foundation.*

<u>2^{nd} part of abstract, i.e. part II, continued</u>

- **A Graviton re write of the following paper(?)**
- ***"A lower bound for the velocity of quantum communications in the preferred frame"***
- **B. Cocciaro, S. Faetti, L. Fronzoni**
- http://arxiv.org/abs/1006.2697
- *Idea will be to try to confirm, by a experiment, if entanglement of (semi classical ?) gravitons is possible, if there exists a way to confirm if there is something equivalent, namely for Photons, an entanglement super signaling would have a lower velocity for "instantaneous" signaling (the EPR idea, again) for transmission of information between the "centers" of entangled Graviton states*

Main goal of re doing EPR with regards to entangled Gravitons:

Slower speed of faster than light “tachyons” in a graviton generated setting , than the case of entangled photons implies increasing deviation from QM, according to the main point of the 2nd part of the abstract

- **“*deviation from purely quantum mechanical origins for Gravitons and by extension that gravity is actually a classical physics 'force' in its origin and foundation”.***

Key passage in EPR paper to keep in mind. Relevance to EPR & QM is stated

- *"An EPR experiment with polarized entangled photons is performed to test the Eberhard model. According to the Eberhard model, quantum correlations between space-like separated events are due to a superluminal communication signal propagating in a preferred frame"*

What shows deviation from QM if Gravitons generate 'FTL' Tachyons?

- The 'slower' the FTL counter part to the Tachyon of entangled photon , EPR frame is, according to the *Eberhard model, the greater the deviation from QM.*
- ***I.e. having "infinite" speed between entangled states of Photons would imply 100% fidelity to QM.***
- *Having a 'lower speed' to the 'Graviton' Tachyons (their Graviton equivalent) would mean more deviation from QM.* ***Allowing for "massive" gravitons ? This is my supposition***

From the entangled photon picture

http://arxiv.org/abs/1006.2697

The main features of the experimental method are schematically drawn in fig.1. Two entangled photons are generated at a point P and meet two polarizers at points A and B at distance $d_{AB} = x_B - x_A > 0$ along a x-axis of the laboratory frame oriented along the East-West direction.

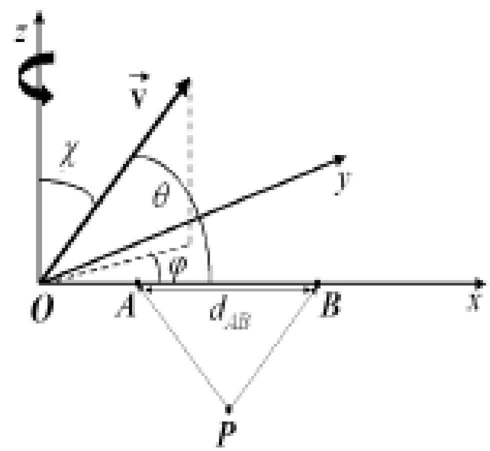


Figure 1: P: position of the source of the entangled photons; A,B: positions of the polarizers; $\vec{v}$: velocity of the tachyons preferred frame (PF); x: East-West axis in the laboratory; z: rotation axis of the Earth.

Comment. We need to revisit our ideas of how mass forms in particle physics. I.e. the Higgs Boson

- Beckwith, in the recent FXQI competition brought this up; i.e. a replacement to the Higgs boson may be necessary and badly over due. Doing so may allow for investigating how quantum mechanics may be part of a larger non linear theory

From Vixra.org, what Beckwith brought up about this issue

- **Relativity and Cosmology**
- http://vixra.org/abs/1102.0019
- **Is Nature Fundamentally Continuous or Discrete, and How Can These Two Different But Very Useful Conceptions be Fully Reconciled? Queries from L. Crowell and J. Dickau FXQI Contest , 2011, Presented and Partly Answered**
- **Authors:** A. Beckwith
- Our contention, is that reality is actually analog, but that at a critical limit, as when the Octonionic gravity condition kicks in,
- < S N I P > . **I.e. reality is far nastier than what people think!**

Beckwith raises the issue of the Higgs, and replacements for it.

Brief review of Higgs Boson

http://www.astroengine.com/2008/08/what-is-the-higgs-boson/

I.e. the Mexican hat potential and symmetry breaking, i.e. a broken symmetry leads to the formation of mass ? Here is what is mentioned as far as CERN

http://www.symmetrymagazine.org/breaking/2011/03/02/lhc-publishes-first-higgs-measurements/

“Houston, we have a problem”

- **LHC publishes first Higgs measurements**
- March 2, 2011 | 1:20 pm
- The CMS collaboration at CERN has published its first results about the search for the Higgs boson. The paper concludes that CMS found no evidence of the Higgs in their dataset from 2010. The latest result explores a version of the Higgs in a world that has an extra generation of fundamental particles.

What if we do not have the Higgs?

- This is the topic of physics which is beyond the standard model, and which has been referred to in this conference, and else where.
- Abandoning the Higgs may permit an understanding of the inter relation ship of quantum mechanics , and a larger non linear theory, which may permit gravitons with a small rest mass

t'Hooft and others as to a future embedding/ expansion of QM and Quantum Gravity

- http://arxiv.org/PS_cache/gr-qc/pdf/9903/9903084v3.pdf
- **QUANTUM GRAVITY AS A DISSIPATIVE DETERMINISTIC SYSTEM**

- **Gerard 't Hooft**
- **Institute for Theoretical Physics**
- **University of Utrecht, Princetonplein 5**
- **3508 TD Utrecht, the Netherlands**
- **e-mail: g.thooft@phys.uu.nl**
- **internet: http://www.phys.uu.nl/~thooft/**

http://arxiv.org/PS_cache/gr-qc/pdf/9903/9903084v3.pdf

- Abstract
- **It is argued that the so-called holographic principle will obstruct attempts to produce physically realistic models for the unification of general relativity with quantum mechanics, unless determinism in the latter is restored**
- **<< S N I P >>;** Beckwith is in full agreement!

Mexican hat potential and mass formation, if symmetry broken

- http://en.wikipedia.org/wiki/File:Mexican_hat_potential_polar.svg#file

- This is the sort of physics which may have to be revised to permit gravitons with a small rest mass, and also to restore determinism to the search for Quantum Gravity along the lines brought up by t'Hooft in the last slide.

Mexican hat potential and mass formation, if symmetry broken. continued

- http://t3.gstatic.com/images?q=tbn:ANd9GcRFZ32DpcE8rYjGz_TsgW_VQ7IiLS6CxQlTwmbUNJZMa4v0wnIHpA
- Now let us get out there and explore new physics ! This topic and others being explored by A. Beckwith, and Fangyu Li, in Chongquing University. **Thank you for your attention**!

Final comment from L. Crowell

http://www.fqxi.org/community/forum/topic/979

- Quote:
- *In a hypothetical universe devoid of the Higgs field, all particles would have zero rest mass; the universe would be space-time and energy. That's odd enough to picture—14 billion light years with nothing massive in it, from neutrons to neutron stars. But something weirder seems to follow. It strikes me that, without the Higgs, there would be no perspective by which time is moving*. < **PUNCH LINE, do we understand TIME ?** > >
- **My answer : NO ! Not at all !**

Explanation as to comment on Time

- *Time evolution is usually connected with the "Arrow of time" hypothesis. i.e. that changes in Entropy are directly linked to time flow. I.e. the usual idea is that entropy dramatically increases with the evolution of the universe.*

Bluntly stated, as put in this talk, we do NOT understand at all Entropy in cosmology Until we do, it is misleading to say we understand time evolution.

Here is an attempt by the author, and L. Glinka to talk about the issue of unidirectionality of time flow. ***It needs considerable elaboration and improvement. But it gets a start in the right direction. For your enjoyment.***

http://www.scribd.com/doc/44438498/PSTJ-Focus-Issue-V1-9-Cosmology-Gravity-Part-II

- **Prespacetime Journal | November 2010 | Vol. 1 | Issue 9 | pp. 1358-1454**
- **Table of Contents**
- **ISSN: 2153-8301 Prespacetime Journal Published by QuantumDream, Inc.www.prespacetime.com**

- ***The Arrow of Time Problem: Answering if Time Flow Initially Favouritizes One Direction Blatantly*** **by Andrew W. Beckwith & Lukasz A. Glinka, pp 1358-1375**

T hank you section to those who helped the presenter as of the last six months

- 1. Christian Corda is thanked for introducing the author to non Quantum ideas of the origins of Gravity and Cosmology. As of 2009, he gave the author a document which has been followed up on through this presentation, as to a replacement for DE via Gravitons.
- 2. Fangyu Li, of Chongquing University extended his hospitality to the author in numerous stays and work sessions in Chongquing university.
- 3. Amara Angelica edited the authors tortured English and writing phrases for several years and demanded logical presentation when it was necessary. Also, the generalized uncertainty principle involving g(metric) and T(u,v) is from her directly, August 2011. Her personal intervention as of August , 2011 saved the author from possible ruin.
- 4. Myron Stokes motivated the author to arrive at San Marino through his own well done example of personal courage . What he has done as from June, 2011 is courage personified. Thank you Myron for the conversations and your show of guts!

Thank you section for those who helped the presenter, continued

- **5. <u>Stuart Allen</u> provided a sounding board for the authors wildest suppositions as to the last eight months. He also reminded the author that things are not what they appear to be. A lesson the author has applied not only to physics, but to other issues as well.**
- **6. <u>Sharyn Beers</u> provided a means to renewing the authors connection to scientific inquiry when the author thought his involvement with science was not to be continued.**
- **7. <u>Jonathan Dickau</u> argued with the author repeatedly about non standard physics beyond the standard model. That was priceless, Jonathan. Thank you!**
- **8. Not to also forget <u>Thomas Elze</u>, who allowed the author to go to DICE. 2009. The genesis of many of the ideas here came from Beckwith's DICE 2009 article**.

First 5 references in a recent Journal of Modern physics article, by A.W. Beckwith

- Website: http://www.scirp.org/journal/jmp
- **JMP >> Vol.2 No.7, July 2011**
- **Detailing Coherent, Minimum Uncertainty States of Gravitons, as Semi Classical Components of Gravity Waves, and How Squeezed States Affect Upper Limits To Graviton Mass**
- Full Text(PDF, 399KB) PP.730-751
- **DOI**: 10.4236/jmp.2011.27086
- **Author(s)**Andrew Beckwith
- **KEYWORDS** Squeezed State, Graviton, GW, Pilot Model
- **ABSTRACT** We present what is relevant to squeezed states of initial space time and how that affects both the composition of relic GW, and also gravitons. A side issue to consider is if gravitons can be configured as semi classical "particles", which is akin to the Pilot model of Quantum Mechanics as embedded in a larger non linear "deterministic" background.

- **1st 5 References of the above article. Look them up at the web site. Very revealing**

- [1]M. Y. Kuchiev, “Can Gravity Appear Due to Polarization of Instantons in SO(4) Gauge Theory?” Classical and Quantum Gravity, Vol. 15, No. 7, 1998, pp. 1895-1913. doi:10.1088/0264-9381/15/7/008
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- **< < S N I P >>. The rest of the 77 references are helpful**.

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- S. Carroll, *An Introduction to General Relativity, Spacetime and Geometry* Addison and Wesley, San Francisco, California, USA, 2004

- ***Now from DICE 2010, which has some interesting speculations . See next slide.***
- ***Re print of letter from IOP as to DICE conference proceedings 306***

E mail received as to DICE 2010 conference proceedings and Beckwith paper in the proceedings, see last link as to how to access author's contribution; Kudos to Dr. Elze and that great conference. A step in the right direction.

- ***5th International Workshop DICE2010: Space-Time-Matter - Current Issues in Quantum Mechanics and Beyond proceedings now available online***
- Monday, July 11, 2011 5:02 PM
- **From:**
- This sender is DomainKeys verified"Graham Douglas" <jpcs@iop.org>
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- beckwith@iibep.org
- Dear Author

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IOP Publishing would like to express its thanks to the many authors and referees who have all contributed their time and expertise to write and review the papers and so make the 5th International Workshop DICE2010 proceedings rapidly become a widely known and valuable research resource.

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http://dx.doi.org/10.1088/1742-6596/306/1/012064