Entropy, GW, and the question of the degree of classical physics contribution to early GW waves

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with material added for Dr. Christian Corda's GW symposium

Below is a link to the presentations

as given in chonquing, Oct 2008-April 2009.

- **http://sites.google.com/site/abeckwithdocuments/**
- **Down load the following PDF as given**

- **Chongquing - tabulated results 1a.pdf**

- **We will present a question about infinite statistics as compared to Glinka's version of graviton quantum gas involving the Wheeler De Witt equation directly**
- **Ng's quantum infinite statistics**

- **Question1** : Is each "particle count unit" as brought up by Ng, equivalent to a brane-antibrane unit in brane treatments of entropy?

- **Question 2** : Is $$\Delta S \approx \Delta N_{gravitons}$$

1^{st} Does DM get perturbed via non Gaussian **perturbations** due to entropy and GW ?

- **As presented in COMO Italy in July 2009 by Dr. Sabino Matarrese. Our discussion puts up candidates for**
- $f_{NL} \equiv$ **non –Gaussian perturbations, we suggest what they , the perturbations, should be:**

- **Note** $\Phi_L \equiv$ **linear Gaussian Gravitational potential**

- **DM perturbations are from the overall gravitational potential** $\Phi \equiv \Phi_L + f_{NL} \cdot \left[\Phi_L^2 + \left\langle \Phi_L^2 \right\rangle\right] + g_{NL} \cdot \Phi_L^3$
- **DM perturbed by**

$$\delta \equiv -\left[\frac{3}{2} \cdot \Omega_m \cdot H^2\right]^{-1} \cdot \nabla^2 \Phi$$

From PRD article by Fangyu Li, et al, (2009). Important for relic entropy generation

- **HFGW in Quintessence inflationary models** leads to

$$h_{rms} \sim 10^{-30} - 10^{-32} \Big/ \sqrt{Hz}$$

$$\nu \sim 10^{9} - 10^{10}\, Hz$$

- Next, we will refer to perturbations resulting due to the high frequency gravitational waves

Infinite Quantum statistics. Start with

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

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

We wish to understand the linkage between dark matter and gravitons

To consider just that, we look at the “size” of the nucleation space, V

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 both 1 and 2. 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:

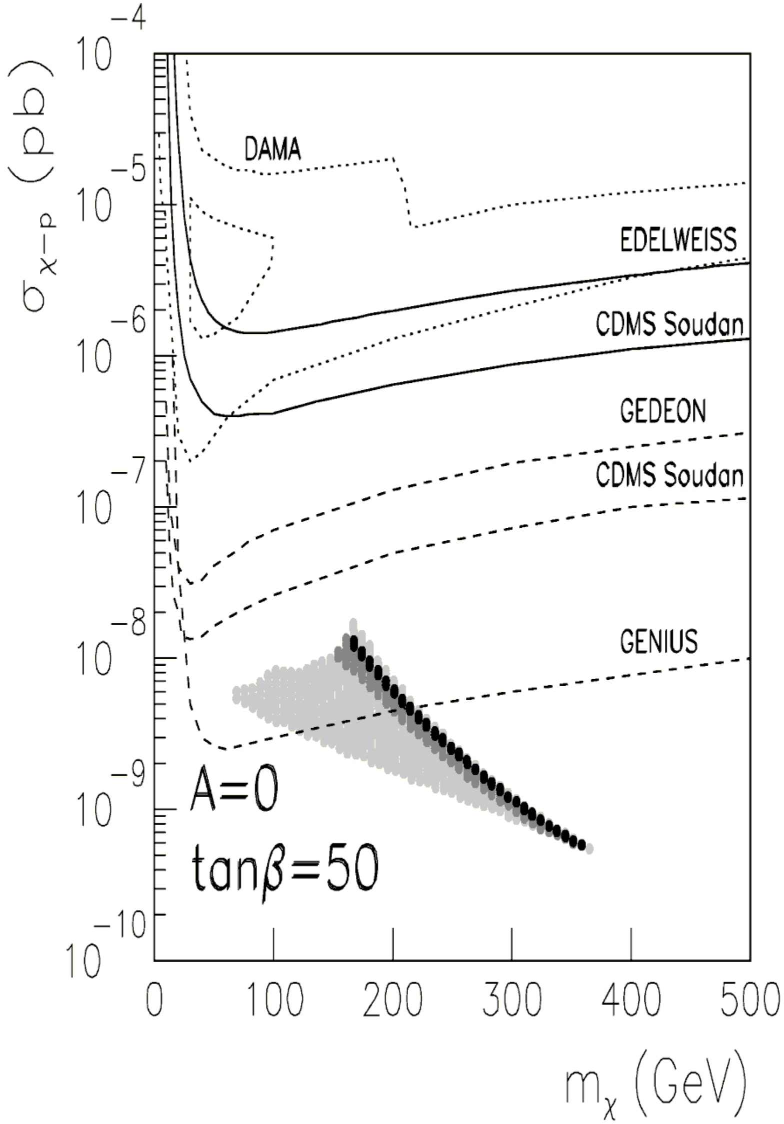
Ng's result quantum counting algorithm is a **STRING theory** result.Glinka is **Wheeler De Witt equation**. **Equivalent ?**

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 LQG argument?

Issue, detection vs assumed mass of the DM



Consequences of this DM density variation, as brought up above. Partly due to damping due to GW and entropy as well as GW / neutrino interactions. i.e. the halo merging tree for galaxy formation breaks down. The following figure no longer works out so well

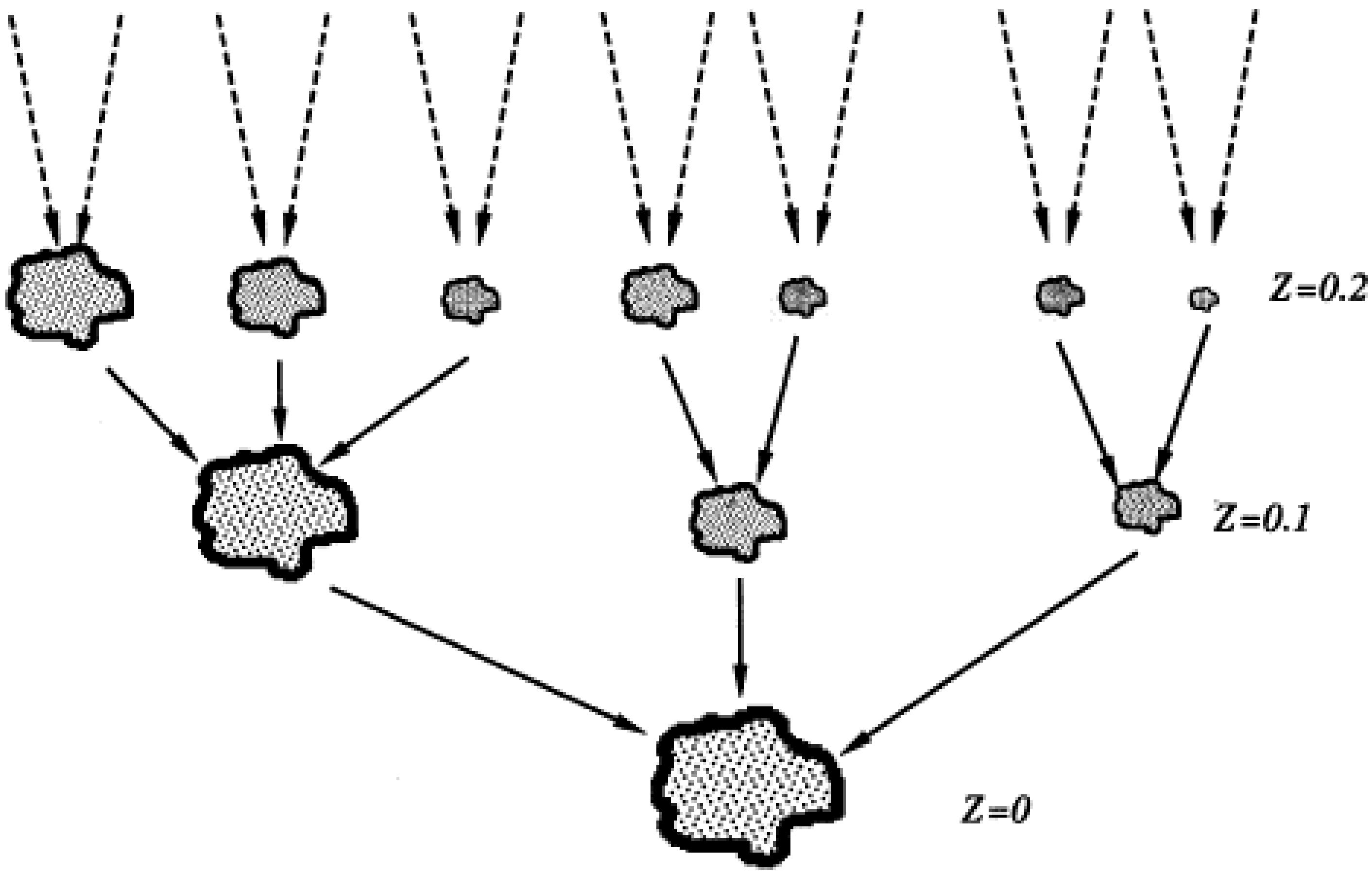


Figure 1. A schematic representation of a halo merging history 'tree'.

What is actually observed, contradicts this halo emerging history 'tree',we claim it is due to gw/ entropy/ perturbations on DM

- DM appears to be fattening up young galaxies, allowing for far-earlier-than-expected creation of early galaxies. "A clutch of massive galaxies that seem to be almost fully-formed just 5 billion years after the big bang challenge models that suggest galaxies can only form slowly. Tendrils of dark matter that fed the young galaxies on gas could be to blame (NASA/CXC/ESO/P Rosati et al)"

- http://www.newscientist.com/article/dn16912-overweight-galaxies-forcefed-by-dark-matter-tendrils.html.

- Needless, to say though, an analysis of the influence of DM on structure formation takes into consideration the datum as to the relative super abundance of DM in early universe conditions. The following is a KK tower model for gravitons, with the zeroth KK mode being approximately the 4 dimensional graviton.

2nd , what about relative degree of squeezing of initial relic vacuum states, and GW ? We claim lack of squeezing implies classical physics interpretation of relic GW / Gravitons

- **Start with : Issues about Coherent state of Gravitons (linking gravitons with GW)**
- . So what is appropriate for presenting gravitons as coherent states ? Coherent states , to first approximation are retrievable as minimum uncertainty states. If one takes string theory as a reference, the minimum value of uncertainty becomes part of a minimum uncertainty which can be written as given by Venziano (1993), where , with and centimeters

$$\Delta x \Delta p = \frac{\hbar}{2} + \frac{l_s^2}{2 \cdot \hbar} \cdot \left(\Delta p\right)^2$$

- **To put it mildly, if we are looking at a solution to minimize graviton position uncertainty, we will likely be out of luck if string theory is the only tool we have for early universe conditions**.

- **The condition of Gaussianity is how to obtain semi classical , minimal uncertainty wave states**, in this case de rigor for coherent wave function states to form. Ford uses gravitons in a so called ‘squeezed vacuum state’ as a natural template for relic gravitons. I.e. the squeezed vacuum state (a **squeezed coherent state**) is any state such that the uncertainty principle is saturated.:

Can any detector measure $h_{rms} \sim 10^{-39} \Big/ \sqrt{Hz}$?

<u>How squeezed state conditions at the onset of inflation affects usual attempts at measurement of coherent relic graviton states.</u>

- Venkatartnam, and Suresh, 2007 built up a coherent state via use of a displacement operator $D(\alpha) \equiv \exp\left(\alpha \cdot a^{+} - \alpha^{*} \cdot a\right)$

We now look at coherent state $\left|\alpha\right\rangle = D(\alpha)\left|0\right\rangle$

Now for squeezing, operator is

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

<u>Squeezed coherent state, is then</u>

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

What happens in early universe

- <u>Coherent state from shift operator is CLASSICAL in behavior.</u> Gravitons as coherent states can form GW, from superposition arguments

HOWEVER, SQUEEZED COHERENT are no LONGER classical.

. Gruishchuk created in 1989, one a non squeezed state, and another a squeezed state.

- Begin with his general wave function

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

- When $B\big|_{\eta} \xrightarrow[\eta \to \eta_b]{} B(\eta_b) \equiv \omega_b / 2$ we have no super position of vacuum states, no squeezing
- When

$$B\big|_{\eta} \xrightarrow[\eta \neq \eta_b]{} B(\omega, \eta \neq \eta_b) \equiv \frac{i}{2} \cdot \frac{(\mu/a)'}{(\mu/a)} \equiv \frac{\omega}{2} \cdot \frac{\cosh r + [\exp(2i\vartheta)] \cdot \sinh r}{\cosh r - [\exp(2i\vartheta)] \cdot \sinh r}$$

we then have multiple super postion of relic early vacuum states, squeezing & non classical behavior

Are initially un squeezed states in beginning of inflation possible ?

- Taking Grishchuck's formalism literally, a state for a graviton/ GW is not affected by squeezing when we are looking at an initial frequency, so that initially corresponds to a non squeezed state which may have coherence, but then right afterwards, may become squeezed

- A reasonable research task would be to try to determine, whether or not the following on the next page would correspond to a vacuum state being initially formed, un squeezed, but then becomes squeezed IMMEDIATELY afterwards.

Is the following possible?

- After an initial formation of an un squeezed state , at WHAT time interval after the big bang DOES THIS HAPPEN?

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

My claim.

- Consider a worm hole, from a Wheeler De Witt eqn with pseudo time component added. If from a prior universe, this may introduce an unsqueezed state, which would be gone after $t \approx t_{Planck} \propto 10^{-44}$

3rd big question, about GW, Gravitons: Importance/ affect of higher dimensions on evolution of universe

- **First part of 3rd big question:**

- Begin with de celeration parameter, $q(Z)$ will show that if Gravitons have mass, that adding dimensions does NOT mean that $q(Z)$ will cease to have NEGATIVE values for $Z < .55$ to $Z \sim 0$ today

Deriving 1st part of 3rd big question:

- Starting with setting curvature, and cosmological constant in higher dim

  Friedman equation as ZERO

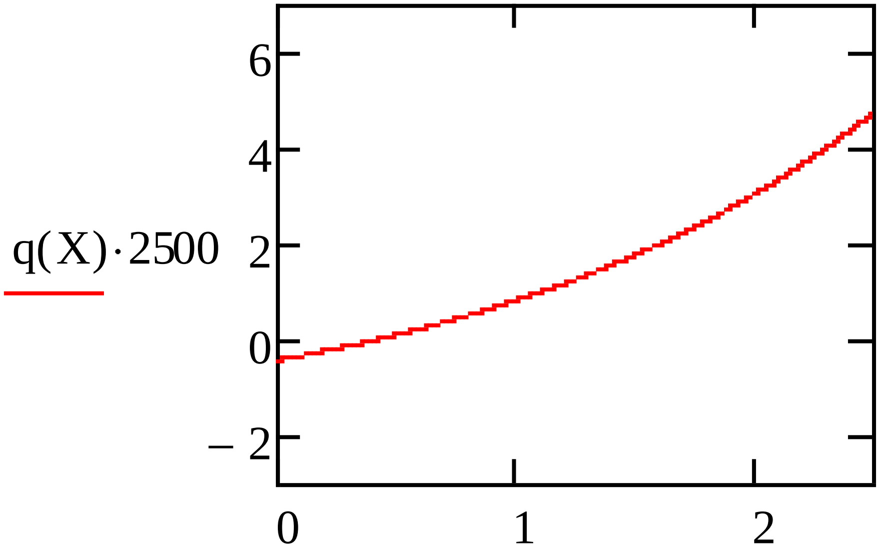
$$\dot{a}^2 = \left[\left(\frac{\rho}{3M_4^2} + \frac{\Lambda_4}{3} + \frac{\rho^2}{36M_{Planck}^2} \right) a^2 - \kappa + \frac{C}{a^2} \right]$$

Then, add the following DENSITY, with non zero graviton mass

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

Get Alves et al’s (2009) result

q(Z) gets negative about a billion years ago



- **Figure 4 b: re duplication of basic results of [Marcio E. S. Alves](), [Oswaldo D. Miranda](), [Jose C. N. de Araujo](), 2009, using their parameter values, with an additional term of C for‘Dark flow’ added,**

- **Figures 4a, and 4b suggest that additional dimensions are permissible. They do not state that the initial states of GW/ initial vaccum states have to form explicitly due to either quatum or semi classical processes.**

2nd part of 3rd question

: Higher dimensions do not create problems, but GIANT higher dimensions lead to low relic GW frequencies

- R. Brustein, M. Gasperini, M. Giovannini, and G. Veneziano,"Relic Gravitational waves from String Cosmology", http://cdsweb.cern.ch/record/284281/files/9507017.pdf; Physics Letters B 361(1995) 45-51

- **NO LIMITS to higher dimensional GW frequencies. Also small COMPACTIFIED higher dimensions**

What if huge higher dimensions are specified?

- ~ 1 Hertz predicted RELIC big bang GW frequencies. **A matter of post modern physics .**

  See : Enqvist, K., Mazumdar, A., Perez--Lorenzana, A., “ Dumping inflaton energy out of this world”,Phys Rev D, Volume 70, 103508

  See : Arkani – Hamid …

4th big question : **Classical vs Quantum over lap?**

- If high degree of over lap, then WdW quantum gas formalism may give similar partition function values as Y.J. Ng and Beckwith(2008,9) values for ENTROPY.

BOJOWALD's (2008) KEY result in his article about quantum bounce

- ***Note, also that Bojowald as of 2008 has left the degree of squeezing of initial vacuum states in the region of space as an open problem.***

- ***In Bojowald's model of a cosmological bounce, the degree of squeezing is a measure of what strength the 'bounce' from an initial configuration of the universe takes, and how strongly quantum effects contribute to the evolution of the LQG cosmos, after inflation commences***

What is known

Experimental constraints:

-- masses of the Higgs and superpartners,

e.g. ***mh >***114 GeV

$$\sigma\big|_{Neutralino-DM} < 3\times10^{-8}\ \text{pb}$$

Supposition to investigate consider a clump model of DM, as a profile density

- as given by <u>**Berezinsky, Dokuchaev, and Eroshenko**</u>**,** there is a power law for clumps of DM given, for galactic structure
- using
- $\tilde{\rho}$ as the mean clump density,

  R as mean radius of a clump , and r is spatial regions within the DM halo

- and

$$\beta \cong 1.8 - 2.0$$

- as a power law coefficient. This could be for MACHOS, which usually are ruled out via gravitational lensing. We are asking if the DM clump is composed of neutralinos. This would be a way of inferring an observational way of confirming

$$\rho_{\text{int}}(r) \equiv \frac{3-\beta}{\beta} \cdot \tilde{\rho} \cdot \left(\frac{r}{R}\right)^{-\beta}$$

Known

The lithium problem, i.e. why early stars may NOT have lithium suggests that a confluence of GW/Graviton/ Neutrino flux inter mixtures may affect the actual foundations of element nucleosynthesis.

May necessitate re writing the BIG bang mechanism itself.

5^{th} big question : Neutrinos interacting with Gravitons

- The coupling of neutrinos to gravitions would be enhanced as their wave lengths would initially be quite similar, i.e. very short..
- Consequences for the Lithium problem in stars, due to stellar formation, and gravitational perturbation on DM and will be discussed toward the end of this document.
- The neutrino / gravitational wave interaction leads to a damping factor in the intensity of GW of as far as relic GW as could be shown up in the CMBR data sets.

So what is the damping factor due to neutrinos interacting with GW, in CMBR perturbations?

- According to Barvinsky, (2005) it is a change to the order of:

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

1st set of Open questions? Assume existence of SUSY neutralinos

- If a certain number of neutralinos of mass of at least 28 to 100 GeV is produced, as implied by G. Belanger (2004), the following needs to be investigated:

- Is there roughly a one-to-one correspondence between gravitinos, neutralinos , and relic gravitons, leading to in the first 1000 seconds ? $\Delta S \approx \Delta N_{gravitons} \approx 10^{20}$

  And if true, are there enough gravitinos and neutralinos to account for Jedamzik's (2008) data, indicating suppression of Lithium 6 and 7?

2nd set of Open questions?

- Alejandro Jenkens, 2009, the author makes the same dimensional identification that of energy, and energy variation as carried by a graviton and as a way to show how gravitons are linkable to possible order of the Lorentz gravitational Lorentz violation.

$$p^0 \sim \overline{L} \cdot \mu \qquad \Delta E \sim \overline{L} \cdot \mu$$

$$\overline{L} \sim (c - v)/c$$

-
- Note that for the degree of Lorentz violation which involve gravitons with a dispersion relationship of , where is a speed of propagation of the graviton. Note that the linkage of dispersion relationships of the graviton specifically are linked to a non relativistic treatment of the graviton. Also, left unsaid as a variance is how the strength of the energy interaction,occurs, and is set . Can the Lorentz gravitational
- Violation , as given below, lead to at high speeds,

$$\mu / M_{Planck} \sim \overline{L}$$

- and for physics approaching SM

$$\overline{L} \xrightarrow[approach-to-s\tan dard-\mathrm{mod}el-physics]{} 0$$

When graviton velocity does not = c

- For low speeds, L bar does not go to zero
- Meaning that one is not required to have flat space

$$\bar{L} \neq 0$$

- Does this mean that initial emergence of gravitons was low energy, and then picked up **ENERGY** due to massive projection of emergent space time at the beginning of a new universe ?

UNKNOWN !

When neutrinos and gravitons inter mix in higher velocities, part 1

- The graviton wave length shrinks to actual Neutrino wave length values, perhaps aiding in inter mixture / interplay between neutrinos/GW/gravitons

$$m_{graviton}\Big|_{NON-RELATIVISTIC} \leq 4.4\times10^{-22}\,h^{-1}eV/c^{2} \Leftrightarrow \lambda_{graviton} \equiv \frac{\hbar}{m_{graviton}\cdot c} \sim 2.8\times10^{15}\,meters$$

$$m_{graviton}\Big|_{RELATIVISTIC} < 4.4\times10^{-22}\,h^{-1}eV/c^{2} \Leftrightarrow \lambda_{graviton} \equiv \frac{\hbar}{m_{graviton}\cdot c} < 2.8\times10^{-8}\,meters$$

Leading to asking

- Does higher velocity mean less graviton Lorentz invariance break down and

$$\bullet \bar{L} \sim \left[(c - v)/c \right] \approx \left[\frac{\mu}{M_{Planck}} \right] \xrightarrow[\mu \to 0]{relativistic-conditions-for-graviton-speed,} 0$$

When neutrinos and gravitons inter mix in higher velocities, part 2

- As the wavelength of a graviton shrinks…

$$m_{graviton}\Big|_{RELATIVISTIC} < 4.4 \times 10^{-22} h^{-1} eV / c^2 \Leftrightarrow \lambda_{graviton} \equiv \frac{\hbar}{m_{graviton} \cdot c} < 2.8 \times 10^{-8} meters$$

- The wave lengths of gravitons, neutrinos in early relic conditions when they mix during the matter-radiation era may be approximately the same. Leading to actual **<u>DAMPING</u>** of perturbations, and also more structural complexity, which may lead to asking and answering the following question

why DO some of the first stars <u>have no lithium</u>?

????????

Changing Neucleosynthesis ?

MAIN QUESTION

DO WE REALLY UNDERSTAND THE BIG BANG?

What the speaker is investigating graviton – neutrino mixing may affect

- In addition, lithium free stars were referenced earlier, namely in Astronomy & *Astrophysics* (Vol 388(3), L53: June IV, 2002). **...** *LITHIUM-FREE STARS PLUG HOLE IN BIG BANG.* T

- The question remains though what can be made of traditional nucleosynthesis theory and the big bang. . Usually at a few MeV values for de creasing temperature, after the big bang, it is expected, according to Matt Roos (2003), that fusion reactions begin to build up light elements.

- Note that Big Bang Nucleosynthesis (BBN) is the synthesis of the light nuclei, Deuterium, 3He, 4He and 7Li during the first few minutes of the universe. This review concentrates on recent improvements in the measurement of the primordial (after BBN, and prior to modification) abundances of these nuclei.

About dimensions

- Higher dimensions are NOT ruled out.

- Higher dimensions leading to practically NON existent to ultra low relic GW need to **not be taken as gospel**. I.e. QUIET experiment, plus Li- Baker detector, if built, i.e. both systems may get to early relic condition measurements of HFGW.

Bibliography

- Sergei Bashinsky,” Coupled Evolution of Primordial Gravity Waves and Relic Neutrinos”, http://arxiv.org/abs/astro-ph/0505502, 4 May 2005

Bibliography, contd.

- Birgit Eberle , Andreas Ringwald, Liguo Song , Thomas J. Weiler , "Relic neutrino absorption spectroscopy", Phys. Rev. D 70, 023007 (2004) [17 pages], http://arxiv.org/abs/hep-ph/0401203

- Andrew Beckwith," **Entropy, neutrino physics, and the lithium problem; why stars with no lithium in early universe exist?",**
- **viXra:0909.0031 [pdf]** ***submitted on 11 Sep 2009***

- Andrew Beckwith, **Entropy growth in the early universe, and the search for determining if gravity is classical or quantum, part III (Is gravity a classical or quantum phenomenon at its genesis 13.7 billion years ago?) viXra:0909.0010 [pdf]** *replaced on 4 Sep 2009*

Bibliography, contd

- Andrew Beckwith," **How Can Gw/graviton Generation Has Semi Classical Features, and What the Implications Are for Cosmological re Acceleration of the Universe, and Initial Relic Entropy Generation in Term of the Importance of Dimensions"**

  viXra:0909.0028 [pdf] ***submitted on 10 Sep 2009***

- Andrew Beckwith." **Entropy Growth in the Early Universe, and the Search for Determining if Gravity is Classical or Quantum, Part I (confirmation of Initial Big Bang Conditions?)",**

  viXra:0909.0016 [pdf] ***submitted on 5 Sep 2009***

Bibliography, contd

- **L.** Grishchuck," Discovering Relic Gravitational Waves in Cosmic Microwave Background Radiation", Proceedings of the School, Eds. I. Ciufolini and R. Matzner, Springer 2008. v3: 52 pages, additional references and improvements; http://arxiv.org/abs/0707.3319

- Alejandro Jenkens, "Constraints on emergent gravity", Submitted to the Gravity Research Foundation 2009 Awards for Essays on Gravitation; Report number MIT-CTP-4025; http://arxiv.org/abs/0904.0453

- Fangyu Li, Nan Yang, Zhenyun Fang, Robert M. Baker, Gary V. Stephenson, and Hao Wen, "Signal photon flux and background noise in a coupling electromagnetic detecting system for high-frequency gravitational waves ",[Phys. Rev. D 80, 064013] Published Wed Sep 9, 2009 ; http://vixra.org/abs/0907.0030

Bibliography, contd

- M. Marklund, G. Brodin, and P.K. Shukla,”Interaction of Gravitons and Neutrinos with Plasmas in the Universe”, Physica Scripta . Volume T 82, pages 130-132, 1999

- M. Marklund, G. Brodin, and P.K. Shukla Phys. Rev. Lett. 98, 125001 (2007)

- Dimitar Valev,” Neutrino and graviton rest mass estimations by a phenomenological approach”, Aerospace Res. Bulg. 22:68-82, 2008; http://arxiv.org/abs/hep-ph/0507255