Entropy growth in the early universe and confirmation of initial big bang conditions

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Abstract

This paper shows how increased entropy values from an initially low big bang level can be measured experimentally by counting relic gravitons. Furthermore the physical mechanism of this entropy increase is explained via analogies with early-universe phase transitions. The role of Jack Ng's (2007, 2008a, 2008b) revised infinite quantum statistics in the physics of gravitational wave detection is acknowledged. Ng's infinite quantum statistics can be used to show that $\Delta S \approx \Delta N_{Gravitons}$ is a starting point to the increasing net universe cosmological entropy. Finally, in a nod to similarities with ZPE analysis, it is important to note that the resulting $\Delta S \approx \Delta N_{gravitons} \neq 10^{88}$, that in fact it is much lower, allowing for evaluating initial graviton production as an emergent field phenomena, which may be similar to how ZPE states can be used to extract energy from a vacuum if entropy is not maximized. The rapid increase in entropy so alluded to without near sudden increases to 10^{88} may be enough to allow successful modeling of relic graviton production for entropy in a manner similar to ZPE energy extraction from a vacuum state.

INTRODUCTION

What we would like to do is to add content to what Seth Lloyd presented about Entropy, i.e.

By necessity, entropy will be examined, using the equivalence between number of operations which Seth Lloyd used in his model, and total units of entropy as the author referenced from Sean Carroll, and other theorists. The key equation Seth Lloyd wrote is as follows, assuming a low entropy value in the beginning

$$\left|S_{Total}\right| \sim \left|k_B \cdot \ln 2\right| \cdot \ \#operations^{\ 3/4} \qquad (0)$$

Seth Lloyd is making a direct reference to a linkage between the number of operations a quantum computer model of how the Universe evolves is responsible for , in the onset of a big bang picture, and entropy..If equation (0) is accepted, which is debatable, then the issue is what is the unit of operation, i.e. the mechanism involved for an operation for assembling a graviton, and can that be reconciled with T(0,0) above. A good question is, if this is done, then how to get an appropriate operation, linkable with the number of emergent gravitons, so **at least** equation (0) will be congruent with

This article is to get definition as to Seth Lloyds supposition, in terms of candidates for the 'number of operations' of entropy and emergent structure, say relic gravitons

There are three componets as to analyzing both entropy, and machine collection of astrophysical data which may obtain relic conditions for astro physical data which may permit a useful research and development program for tying in the growth of entropy, in relic conditions with falsifiable data sets of big bang physics.

The **First**, **chapter** is to examine if or not GW from the big bang were either high, medium, or low frequency. This is relevant to what detectors may be utilized for GW frequency based signatures from the big bang. Part of this first section is determining if or not GW, for short wave length, HFGW play a dominant role in entropy generation as would be expected if relic GW are high frequency, We wish to state that if HFGW do not exist, for relic conditions, that low frequency GW are not important for entropy development, but DM production as within the region of space before the photon turn on of the CMBR sphere of approximately 400 thousand years after the big bang would be the most important contributing factor for entropy

The longer the wave length , i.e. the lower the energy contribution is, from material being injected into our universe from a prior universe, the more likely it is DM as a boost to entropy along the lines of the suggestion offered by Jack Ng (2007, 2008). If the wave length of material nucleated into the region of space before the turn on of CMB radition is high frequency as would be expected from very high frequency GW , then we have relic gravitons connected with HFGW as a primary driver of initial entropy growth.

The **Second chapter** , is to evaluate what is the minimum amount of INFORMATION from a prior universe to our present which would permit the same sort of physical laws in a prior universe, to our present universe. If the basic physical constants remain the same from a prior to our present universe, then the basic characteristic of physical law will remain invariant. Otherwise, different universe cycles will have different physics. For our own universe, experimental evidence places an upper limit on how much the "constants" could have changed. Broadly, the answer is: at most one percent over the lifetime of the universe, in our present cycle of creation. One nice piece of evidence comes from Supernova 1987a, which was special because it was not very far away. Theory predicts that such a supernova would create about 0.1 solar masses of nickel-56, which is radioactive. Nickel-56 decays with a half-life of 6.1 days into cobalt-56, which in turn decays with a half-life of 77.1 days. Both kinds of decay give off very distinctive gamma rays. Analysis of the gamma rays from SN1987a showed mostly cobalt-56, exactly as predicted. And, the amount of those gamma rays died away with exactly the half-life of cobalt-56. For more details, read: Neil Gehrels et al (1993), and Whitelock et al.(1991)

Two possibilities. First is that from a prior to a present universe, there is essentially the same range of physical constants. Secondly is that from a prior to our present universe, that the values of the physical constants varied significantly.

A third possibility is that if multiple universes existed, i.e. the typical 'baby' universes, with a brute 'Darwinian selection' criteria as to which universe may, or may not have survived, leading to say the present cosmos as one of the few lucky survivors of emergence from a prior cycle. If this third possibility is the case, then there would be no need for any data compression to preserve continuity of physical laws. In the article 'Quantum entanglement of baby universes' , Aganagic, Mina; Okuda, Takuya; Ooguri, Hirosi in (2007) elucidate the possibility that the parent (prior) universe generates baby universes by brane/anti-brane pair creation, and baby universes are correlated by conservation of non-normalizable D-brane charges under the process. I.e. this leaves unsaid if or not there is a selection process favoring the existence of a favored 'baby universe' which survived to become our universe, but it offers a mechanism as to how a family of universes could arise. The author, Beckwith, gave his version of such a hypothesis (2009) in one of his earlier 'entropy' articles , as a take off of Penrose's (2007) supposition of a variant of a cyclic universe hypothesis which does not explicitly use branes and anti branes. This seems to assume that the physical constants are the same. How would we know that? Answer, is that we do **not** know it. Part two by necessity breaks down the possible outcomes into three cases. The first case by necessity would mandate some form of data compression. Of which then a methodology is proposed as to how to conserve a minimum amount of information needed for a 1-1 mapping of physical constants from a prior universe to our present. The second and third case may be in sync with the hypothesis of causal discontinuity, as stated by A.W. Beckwith's (2008,2009) where he turned Fay Dowkers hypothesis of causal ordering on its head.

The **Third chapter** , depending upon if or not relic GW from the big bang were low, or high frequency in range, several of the detector candidates for GW detection will have their particular strengths and weaknesses, which will be enumerated , partly in line with what was brought up in the first section. I.e. the Li – Baker , and QUIET detectors will be referenced for HFGW, and perhaps a variant of either Raymond Chiao's detector scheme, or an updated version of LIGO , i.e. INDICO (Indian detector) for relic GW with significantly lower frequency range. The third 'chapter' if partial to QUIET would be having to answer a question raised by Michael J. Mortonson and Wayne Hu (2008) concerning if or not the following is true: "On large angular scales, the polarization of the CMB contains information about the evolution of the average ionization during the epoch of reionization. Interpretation of the polarization spectrum usually requires the assumption of a fixed functional form for the evolution, e.g., instantaneous reionization.”. If instantaneous re ionization is not the case, one may be forced to rely upon the Li-Baker approach for HFGW, i.e. DIRECT HFGW detection. If we do not have this problem, and noise issues in the amplification of HFGW signals from CMB ‘radiation’ are not too extreme, then the QUIET approach is feasible and may be the last word in terms of GW ‘signatures’ from the big bang. This approach of use of the CMBR data for extracting HFGW among other things would require a tensor/scalar ratio value of at least 1 % to verify inflation. If instantaneous re ionization does not occur, and there are serious noise issues , then non withstanding QUIETs excellent electronics work, one would either look at the Li-Baker approach for HFGW, or maybe other HFGW detectors.

If lower contributions to GW from relic big bang conditions occur, then perhaps INDICO (Indian detector) for relic GW would be the preferred venue of research. We can state though that the lower the frequency of gravitational waves from relic conditions, the more likely that synthesis/ emergence of DM shortly after the big bang may be our preferred way to generate entropy, as suggested by Jack Ng (2007,2008). If so, then lower frequencies of GW detection may be of little relevance to entropy generation, but would still be important for answering structure formation issues, i.e. the unexpected datum of earlier than expected galaxy formation may require judicious application of GW analysis.

Chapter 1. The nature of entropy ?

Does “entropy” have an explicit meaning in astrophysics?

This is where the paper should start because it addresses the graviton counting issue directly?

This paper will assert that there is a possibility of an equivalence between predicted Wheeler De Witt equation early universe conditions and the methodology of string theory, based upon a possible relationship between a counting algorithm for predicting entropy, based upon an article by Jack Ng (which he cites string theory as a way to derive his counting algorithm for entropy).

This is due to re stating as entropy $S \approx \langle n \rangle \big|_{gravitons}$ with $\langle n \rangle$ as a numerical graviton density and the expression given by Glinka (2007) for entropy (where Glinka uses the Wheeler De Witt equation), if we identify Ω as a partition function due to a graviton-quintessence gas. If confirmed, this may also lead to new ways to model gravity/ graviton generation as part of an emergent ‘field’ phenomenon. Now why would anyone wish to revisit this problem in the first place? The reason is because that there are doubts people understand entropy in the first place. As an example of present confusion, please consider the following discussion where leading cosmologists, i.e. Sean Carroll (2005) asserted that there is a distinct possibility that mega black holes in the center of spiral galaxies have more entropy, in a calculated sense, i.e. up to 10^{90} in non dimensional units. This has to be compared to Carroll’s (2005) stated value of up to 10^{88} in non dimensional units for observable non dimensional entropy units for the observable universe. Assume that there are over one billion spiral galaxies, with massive black holes in their center, each with entropy 10^{90}, and then there is due to spiral galaxy entropy contributions $10^{6} \times 10^{90} = 10^{96}$ entropy units to contend with, vs. 10^{88} entropy units to contend with for the observed universe. I.e. at least a ten to the eight order difference in entropy magnitude to contend with. The author is convinced after trial and error that the standard which should be used is that of talking of information, in the Shannon sense, for entropy, and to find ways to make a relationship between quantum computing operations, and Shannon information. Making the identification of entropy as being written as $S \sim \ln \; Partition - function$. This is Shannon information theory with regards to entropy, and the convention will be the core of this text. What is chosen as a partition function will vary with our chosen model of how to input energy into our present universe. This idea as to an input of energy, and picking different models of how to do so leading to partition functions models is what motivated research in entropy generation . From now on , there will be an effort made to identify different procedural representations of the partiton function, and the log of the partion function with both string theory representations, i.e. the particle count algorithm of Y.Jack Ng, and the Wheeler De Witt version of the log of the partition function as presented by Glinka (2007). Doing so may enable researchers to eventually determine if or not gravity/ gravitational waves are an emergent field phenomenon.

A further datum to consider is that Eqn (1) with its variance of density fluctuations may eventually be linkable to Kolmogrov theory as far as structure formation . If we look at R. M. S. Rosa (2006) , and energy cascades of the form of the 'energy dissipation law' , assuming u_0, l_0 are minimum velocity and length, with velocity less than the speed of light, and the length at least as large, up to 10^6 time larger than Planck length l_{Planck}

$$\varepsilon \approx \frac{u_0^3}{l_0} \tag{1}$$

Equ (1) above can be linked to an eddy break down process, which leads to energy dissipated by viscosity. If applied appropriately to structures transmitted through a 'worm hole' from a prior to a present universe, it can explain

1) How there could be a break up of 'encapsulating' structure which may initially suppress additional entropy beyond $S_{initial} \sim 10^5$ in the onset of inflation
2) Provide a 'release' mechanism for $\Delta S \approx \Delta N_{gravitons} \leq 10^{54} << 10^{88}$, with $\Delta S \approx \Delta N_{gravitons} \sim 10^{21}$ perhaps a starting point for increase in entropy in $\Delta t \approx t_{Planck} \sim 5 \times 10^{-44}\,\sec$, rising to $\Delta S \approx \Delta N_{gravitons} \leq 10^{54} << 10^{88}$ for times up to 1000 seconds after the big bang.

Different senarios for Entropy growth depending upon If or not we have Low to high Frequency GW from the big bang.

As mentioned above, there is a question of what frequency range of GW is dominant during the onset of the big bang. To begin with let us look at frequency range of GW from relic conditions. As given by for a peak amplitude as stated by **Tina Kahniashvili (2007). Now for the amplitude of a GW, as detected today**

$$h_c(f) = 1.62 \times 10^{-18} \left(\frac{T_*}{100\,\mathrm{GeV}}\right) \left(\frac{g_*}{100}\right)^{-5/6} \left(\frac{\gamma}{0.01}\right)^{3/2} \left(\frac{\zeta}{0.01}\right)^{1/2} \left[k_0^3 f H_{ijij}(2\pi f, 2\pi f)\right]^{1/2}. \tag{1a}$$

The equation , as given by Kahniashvili (2007) with a frequency f given below in Eqn. (2) which is for todays detected GW frequency a detector would observe, whereas ω_* is the frequency of a process synthesizing GW during a 2nd order phase transition in the early universe. Also, T_* is a mean temperature during that 2nd order phase transition. If as an example T_* is many times larger than 100 GeV, which is the case if GW nucleation occurred at the ORIGIN of the big bang, i.e. at temperatures $\sim 10^{32}\,Kelvin$, then it is likely that f in Equation 2 below is capable of approaching values of the order of what was predicted by Grishkuk (2007) , i.e. approaching 10 Giga Hertz. Eqn (1) **above**, would have either a small, or a huge T_*, which would pay a role as to how large the amplitude of a GW would be, detected today, as opposed to what it would be at the origin, say, of the big bang. . The larger f is, the more likely the amplitude is, of Eqn (1) would be very large. In both Eqn (1) above, and Eqn. (2) below, g_* is a degree of freedom for spatial conditions factor , which has , according to Kolb and Turner (1991) high values of the order of 100 right after the big bang, to values closer to 2 and/or 3 in the modern era. I.e. the degrees of freedom radically dropped in the evolution of space time.

$$f = 1.55 \times 10^{-3}\,\mathrm{Hz} \left(\frac{\omega_*}{k_0}\right) \left(\frac{g_*}{100}\right)^{1/6} \left(\frac{\gamma}{0.01}\right)^{-1} \left(\frac{T_*}{100\,\mathrm{GeV}}\right), \quad (2)$$

Here, in this choice of magnitude h of a GW today , and frequency f detected today , as presumed by using a factor given by Kahniashvili (2007) as

$$H_{ijkl}(\mathbf{x}', \mathbf{k}, \omega) = \frac{1}{(2\pi)^4} \int d^3\xi d\tau e^{i(\omega\tau - \mathbf{k}\xi)} R_{ijkl}(\mathbf{x}', \xi, \tau). \quad (3)$$

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