# Entropy growth in the early universe and confirmation of initial big bang conditions ( Wheeler De Witt eqn. results vs. String theory ?)

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Initial relic entropy growth is presented as a natural outgrowth of relic graviton production, as a generalization of Dr. J.Y Ng's infinite quantum statistics. The adaptation and modification of Ng's (2008) argument, is an outgrowth of string theory cosmology arguments, and is essentially a counting algorithm for relic graviton production. This article is a very abbreviated version of a presentation given in Chongquing, PRC, in April, 2009, at the Chongquing University Physic's department as a guest of Dr. Fangyu Li, and his gravitational research group.

## 1. Introduction

We wish to present two alternative routes to generation of entropy. The first, is a counting algorithm, as an adaptation of Y.J. Ng's infinite quantum (modified Boltzman's) statistics, whereas the second is referencing A. Glinka's research presentation on 'graviton gas' as a way of understanding a different perspective as to how to get a partition function for gravitons which is congruent to the Wheeler De Witt equation. Here are a few questions which are posed for the reader to think about.

1. Is each "particle count unit" as brought up by Ng, equivalent to a brane-antibrane unit in brane treatments of entropy?
2. Is the change of entropy $\Delta S \approx \Delta N_{gravitons}$ ?
3. Is this graviton production scheme comparable to Glinka's quantum gas , from the Wheeler De Witt equation?

## 2. Entropy generation via Ng's infinite quantum statistics

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 eqn 1 and eqn 2. Ng's result begins with a modification of the entropy/ partition function Ng used the following approximation of temperature and its variation with respect to a spatial parameter, starting with temperature $T \approx R_H^{-1}$ ( $R_H$ can be thought of as a representation of the region of space where we take statistics of the particles in question). Furthermore, assume that the volume of space to be analyzed is of the form $V \approx R_H^3$ and look at a preliminary numerical factor we shall call $N \sim \left(R_H / l_P\right)^2$, where the denominator is Planck's length (on the order of $10^{-35}$ centimeters). We also specify a "wavelength" parameter $\lambda \approx T^{-1}$. So the value of $\lambda \approx T^{-1}$ and of

$R_H$ are approximately the same order of magnitude. Now this is how Jack Ng changes conventional statistics: he outlines how to get $S \approx N$, which with additional arguments we refine to be $S \approx < n >$ (where <n> is graviton density). Begin with a partition function

$$Z_N \sim \left(\frac{1}{N!}\right)\cdot\left(\frac{V}{\lambda^3}\right)^N \tag{1}$$

This, according to Ng, leads to entropy of the limiting value of, if $S = (\log[Z_N])$

$$S \approx N \cdot \left(\log\left[V/N\lambda^3\right] + 5/2\right) \xrightarrow[Ng-\inf inite-Quantum-Statistics]{} N \cdot \left(\log\left[V/\lambda^3\right] + 5/2\right) \approx N \tag{2}$$

But $V \approx R_H^3 \approx \lambda^3$, so unless N in Eqn (2) above is about 1, S (entropy) would be < 0, which is a contradiction. Now this is where Jack Ng introduces removing the N! term in Eqn (1) above , i.e., inside the Log expression we remove the expression of N in Eqn. (2) above. The modification of Ng's entropy expression is in the region of space time for which the general temperature dependent entropy Kolb and Turner expression breaks down. In particular, the evaluation of entropy we do via the modified Ng argument above is in regions of space time where $g$ before re heat is an unknown, unmeasurable number of degrees of freedom The Kolb and Turner entropy expression has a temperature $T$ related entropy density which leads to that we are able to state total entropy as the entropy density time's space time volume $V_4$ with $g_{re-heat} \approx 1000$, according to De Vega, while dropping to $g_{electro-weakt} \approx 100$ in the electro weak era. This value of the space time degrees of freedom, according to de Vega has reached a low of $g_{today} \approx 2-3$ today. We assert that Eqn (2) above occurs in a region of space time before $g_{re-heat} \approx 1000$, so after re heating Eqn (2) no longer holds, and we instead can look at

$$S_{total} \equiv s_{Density} \cdot V_4 = \frac{2\pi^2}{45} \cdot g_{\bullet} \cdot T^3 \cdot V_4 \tag{3}$$

Where $T < 10^{32} K$. We can compare eqn (1) and (2) , as how they stack up with Glinka's (2007) quantum gas, if we identify $\Omega = \dfrac{1}{2|u|^2 - 1}$ as a partition function (with $u$ part of a Bogoliubov transformation) due to a graviton-quintessence gas, to get information theory based entropy

$$S \equiv \ln \Omega \tag{4}$$

Such a linkage would open up the possibility that the density of primordial gravitational waves could be examined, and linked to modeling gravity as an effective theory. The details of linking what is done with (2) and bridging it to (3) await additional theoretical development , and are probably conceptually understandable if the following is used to link the two regimes. I.e. we can use the number of space time operations used to create (2), via Seth Lloyds

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

## 3. Conclusion

We intend to examine how this is linkable to entropy variations in Eqn. (5) in future numerical simulations of CMBR irregularities. Furthermore, reconciling (1) and (2) may be a way to link Wheeler de Witt based cosmologies, as in part similar to what is done via early universe via brane theories. I.e. looking at research results of Samir Mathur (2007). This is part of what has been developed in the case of massless radiation, where for D space-time dimensions, and E, the general energy is , if $E \sim E_{total}$ is interpreted as a total net energy proportional to vacuum energy

$$S \sim E^{(D-1/D)} \tag{6}$$

## References


1. A.W. Beckwith, **http://sites.google.com/site/abeckwithdocuments/** Down load **Chongquing - tabulated results 1a.pdf**