ENTROPY GROWTH IN THE UNIVERSE, DARK MATTER MODELS, WITH A NOD TO THE LITHIUM PROBLEM

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In the 12th Marcel Grossmann Meeting, July 17, 2009, the author raised the issue of whether early graviton production could affect non-Gaussian contributions to DM density profiles. Non gaussianity of evolving cosmological states is akin to asking if there is a way to get quantum contributions due to squeezed initial vacuum states which act highly non classically. If particle counting algorithms in graviton production is important as for entropy, and if entropy perturbations affects the density profile of dark matter clumping profiles, then there is room to ask to what degree initial perturbations affecting structure formation are due to classical/ non linear processes, or more quantum theoretic states.

Introduction

1.1. *The Problem to Consider. Can Entropy Affect DM Density Profiles?*

The author benefited from having met Matarre, in July 9, 2009, in Como Italy, the gravitational potential has, perturbatively speaking an additional term f_{NL} added to variations in the gravitational potential term which Matarre gave as [1]

$$\Phi \equiv \Phi_L + f_{NL} \cdot \left[\Phi_L^2 - \left\langle \Phi_L^2 \right\rangle \right] + g_{NL} \cdot \Phi_L^3 \tag{1}$$

In terms of applications, Matarre told the author that the 2nd derivative, as given by $\nabla^2 \Phi$
contribute to a well known formula for variation of the density profile of Dark Matter [1].

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

Contributions from H, the Hubble parameter are Friedman equation issues, whereas the term f_{NL} may have inputs from either relic graviton production or from other sources, as Beckwith brought up in the Erice Nuclear physics school, 2009 [2] . The next section presents candidates for f_{NL} . Afterwards will be a brief discussion of the different models of density profiles for Dark Matter which may be influenced by choices of inputs for eqn (2).

1.2. *Candidate Inputs from Early Universe Cosmology Evolution into* f_{NL}

The basic model for f_{NL} makes the following assumptions. The first working assumption is that the influence of early universe conditions may be an initially dominant contribution to f_{NL}, and secondly that appropriate choices for structure formation, of galaxies and of , perhaps even BBN up to a point can be affected by appropriately chosen f_{NL}. Following Beckwith's contribution to Rencontres De Blois, 2009 [3] two candidates selected for f_{NL} came from entropy generated from relic Gravitons, as an adaptation of Ng's entropy production expression involving 'infinite quantum statistics' as given by removing the N (number of particles) from the denominator of the partition function expression , and choosing a small space time volume, V, plus a small wave length λ corresponding to high frequency gravitational waves. This is S (entropy) from early universe 'particle' creation. In the case Beckwith writes about it is with regards to gravitons

$$S \approx N \cdot \left(\log\left[V/N\lambda^3 \right] + 5/2 \right) \quad \textit{which becomes} \quad N \cdot \left(\log\left[V/\lambda^3 \right] + 5/2 \right) \approx N \tag{3}$$

This expression for entropy can be compared with Glinka's [4] derivation of quantum gas entropy $S \equiv \log\left[1/2[u]^2 - 1 \right]$, with u part of a Bogoliubov transformation which is for a physical system built up from the Wheeler De Witt equation (Quantum wave function of the universe), Both eqn (3) and $S \equiv \log\left[1/2[u]^2 - 1 \right]$ if they over lap would be affirming semi classical conditions for early universe emergent gravitational fields due to the similarities of the WdW equation and its solution with WKB semi classical solutions. Now, if there is an interaction of gravitons and neutrinos as predicted by Bashinsky [5] with early universe density fluctuation modified by $\left[1 - 5 \cdot (\rho_{neutrino}/\rho) + \vartheta\left([\rho_{neutrino}/\rho]^2 \right) \right]$, with $\rho_{neutrino}$ a small part of the ρ matter-energy density, that may be a clue as to neutrino-graviton interactions in the early universe, with a partial wave length over lap of $\vartheta\left[\lambda_{relic=Graviton} \right] \approx \vartheta\left[\lambda_{relic-neutrinos} \right]$ [5]. This may have consequences as to how eqn (2) affects dark matter density profiles.

2.0 Dark Matter Density fluctuations and their impact upon Dark Matter clumps

• There are two space time regimes which may be significant for DM being impacted by neutrinos and/or gravitons. First, for spatial regimes for red shifts $Z >> 1100$ which may be relevant to why today there is a nearby population II star (which is almost as old as the supposed population III stars) as represented by HE0107-5240. The readers should know that HE0107-5240 [6] has practically no Lithium 6, which appears to contravene BBN theory as given in conventional cosmology. HE0107-5240 would form by processes which would require a different $\tilde{f}_{NL}$ for early time entropy induced fluctuation put into eqn. (2) above than for the conditions affecting galaxy formation, $2 > Z > 1$ with an f_{NL} still involving neutrino-graviton interactions / entropy generation but also taking into account the possibility of G. Fuller and C. Kishimoto's [2,7] PRL reference as to neutrinos interacting with Dark Matter potential wells. If Fuller et al. [7] are right, then the clumping should affect Dark Matter density profiles as given by Berezinsky, Dokuchaev, and Eroshenko [8], which would change Dark Matter from their usually given form of

$$\rho_{\text{int}}(r) \equiv \frac{3-\beta}{\beta} \cdot \tilde{\rho} \cdot \left(\frac{r}{R}\right)^{-\beta} \tag{4}$$

3.0 Conclusions

Finding alterations of the above density profile may, if done correctly enable an investigation as to why the standard tree diagram of galaxy formation, for $2 > Z > .1$ [8] may no longer work. Note that this involves using f_{NL} of later times of at least a billion years ago , as opposed to f_{NL} as of $Z >> 1100$ which may explain the similarities and differences of Dark Matter interaction leading to very low lithium stars. What the author thinks is that processes contributing to f_{NL} at the onset of the big bang were decisively important to formation of low Lithium BBN, as reflected in HE0107-5240 ultra low lithium. The author's guess is that low lithium BBN and its relationship to f_{NL} would arise from the usual expectation of no dark energy, much dark matter, and chilled neutrinos, at the start of the big bang, whereas f_{NL} for $2 > Z > .1$ would be involved in the processes in which cosmic deceleration reverses, and there is the introduction of Dark Energy to re accelerate the expansion of the universe. The author is attempting to find phenomenological models to obtain falsifiable experimental criteria to investigate both suppositions.

References

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