COSMO19



Contribution ID: 65

Type: Talk

Baryon Physics and Tight Coupling Approximation in Boltzmann Code

Wednesday 4 September 2019 17:50 (20 minutes)

Most of the modern Boltzmann solvers are based on seminal work by Ma and Bertschinger (Astrophys.J. 455 (1995) 7-25). We found that in the work as well as in the code, the baryon equations of motions breaks general covariance. There are terms missing at the order of c_s^2 . Considering a covariant action for baryon perfect fluid with tiny temperature which has non vanishing c_s^2 , we show that these problems can be solved. The correction in the equations of motion are similar order as second order tight coupling approximation. We also study tight coupling approximation up to second order, with out choosing any gauge. We see that on making baryon equation of motion explicitly covariant does not make the code stiff or slow. There are some parameters whose best fit values are deviating by, at most, one percent. This deviation is a contribution coming from the covariant equations of motion. We believe this deviation has to be taken in to account in the context of precision cosmology.

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Session Classification: Parallel Sessions: CMB, Expansion Rate, Thermal History (C.A.R.L., H09)

Track Classification: Modified Gravity and Dark Energy