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Complete Hamiltonian analysis of cosmological perturbations at all orders

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The work is based on two following papers:

1. D. Nandi and S. Shankaranarayanan, Complete Hamiltonian analysis of cosmological perturbations at all orders, JCAP 1606 (2016), no. 06 038, [arXiv:1512.02539].
2. D. Nandi and S. Shankaranarayanan, Complete Hamiltonian analysis of cosmological perturbations at all orders II: Non-canonical scalar field, submitted in JCAP, [arXiv:1606.05747].

Summary

Cosmological perturbation theory is currently a preferred mathematical procedure to compare the equations of gravity with precise observations. However, due to the difficulties in interpreting gauge-invariance and invertibility in Hamiltonian formalism, there is no consistent and generalized Hamiltonian analysis for cosmological perturbation theory at any order for any kind of model of gravity. In this work, using a simple model, we provide a simple mathematical approach to deal with all the difficulties to obtain a consistent Hamiltonian formalism and extend the approach to canonical scalar field. We show that our approach can be applied to any order of perturbation for any first order derivative fields. We also apply our approach to Galilean scalar field model and show that, there is no extra degrees of freedom, as expected, at every order of perturbation and obtain all consistent equations of motion. We compare and contrast our approach to the Lagrangian approach (Chen et al [2006]) for extracting higher order correlations and show that our approach is quick and robust and can be applied to any model of gravity and matter fields without invoking slow-roll approximation. This approach can not only be used for higher order correlation but can also be used to obtain mixed-mode correlation functions at any level of perturbations. Finally, by introducing a new phase-space variable, we show that the approach can also be easily extended to generalized non-canonical scalar field and it leads to a new definition of speed of sound in phase-space.

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