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物　理　学　第　二　分　野

Theoretical and Observational Constraints on the Cosmology of theories of Gravity

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Abstract

In this thesis, we explore the theoretical and observational viability of various theories of gravity. In the light of present cosmological tension like H_0 tension, we would like to explore whether some modified theories of gravity can address them. At first, an investigation was made to check whether any ghost modes are present in Einstein Cubic Gravity theory which are strongly coupled in the exact isotropic and homogeneous cosmological space time. Considering odd-parity modes of linear inhomogeneous perturbations on a spatially homogeneous Bianchi type I manifold close to the isotropic de Sitter spacetime it is shown that in the regime of small anisotropy, the theory possesses new degrees of freedom compared to General Relativity, whose kinetic energy vanishes in the limit of exact isotropy. From the mass dispersion relation, it was found that such theory always possesses at least one ghost mode as well as a very short-time-scale (compared to the Hubble time) classical tachyonic (or ghost-tachyonic) instability. Then an exploration of the baryon physics and tight coupling approximation used in the Einstein–Boltzmann solvers is made. The equations of motion derived from the action obey the general covariance and Bianchi Identity. These equations were then implemented in the Boltzmann code, CLASS and investigated the change in the estimate of cosmological parameters by performing an MCMC analysis. With the covariantly correct baryon equations of motion, we find 1% deviation for the best fit values of some of the cosmological parameters that should be taken into account. Then phenomenology of a class of minimally modified gravity theories called $f(\mathcal{H})$ theories is studied. The dynamics of cosmology at the levels of both background and perturbations are studied, and a concrete example of the theory is presented. By confronting this example model to Planck data as well as some later-time probes, it is shown that such a realization of $f(\mathcal{H})$ theories fits the data significantly better than the standard ΛCDM model. Finally, an investigation on whether any Modified gravity can alleviate the present Hubble H_0 tension is also made from the point of view of late time resolution to the H_0 tension. In particular, we study two models: Generalized Proca theory and a type -II Minimally Modified Gravity (MMG) theory dubbed VCDM. We found that these models, especially VCDM, can reduce the H_0 tension. The VCDM theory provides an arena to test different modifications to the Hubble function.