General relativity well describes gravity according to current observations and experiments. However, we need dark components of the universe to explain the rotation curves of galaxies, the formation of large scale structures and the results of observations of type Ia supernovae and of the cosmic microwave background. The existence of such unknown components implies alternative theories of gravity where the gravitational force on cosmological scales deviates from GR. Ghost-free bigravity theory [1], which is also called dRGT bigravity, is a recently proposed gravity theory containing massive graviton, in addition to massless graviton. In bigravity, massive graviton and massless one are represented by linear combinations of two metrics, and gravity law is effectively modified in large scales. Even if bigravity is responsible for low energy phenomena, it is important to confirm that it does not conflict with observations related to high energy phenomena. This is the reason why we examined if bigravity is in harmony with the inflation scenario in the early universe.

Stability of de Sitter solutions in bigravity We investigated de Sitter solutions in a minimal bigravity model. We found the unique stable branch of de Sitter solutions out of several branches by examining the condition for the absence of the Higuchi ghost, observed in massive modes on de Sitter spacetime. This is one of the earliest work on inflation in bigravity, giving a concrete example of homogeneous solutions.

Cosmic no-hair conjecture in bigravity Cosmic no-hair conjecture, which claims that the classical anisotropy decays during inflation, should hold to explain the isotropy of the cosmic microwave background. We evaluated the decay timescale of anisotropic perturbations on the de Sitter solution that we obtained and found that the conjecture holds for stable de Sitter solutions in bigravity.

Primordial gravitational waves in bigravity To investigate the compatibility of bigravity with observations such as the cosmic microwave background, we analyzed inflationary solutions under the slow-roll approximation and calculated primordial gravitational waves, i.e., tensor perturbations generated during inflation. Primordial gravitational waves have not detected yet, but they are constrained by CMB observations and expected to be found through the polarization of the CMB or through space-based laser interferometers in the near future. In bigravity, we found that the tensor spectrum is almost flat and slightly red-tilted as in general relativity, which is guaranteed by the rapid decay of massive gravtion during inflation.

Curvature perturbations generated during inflation in bigravity Curvature perturbations are also generated during inflation and have been observed as temperature fluctuations of the CMB. We calculated the leading contributions in primordial curvature perturbations and evaluated an important observable quantity depending on inflation models, the tensor to scalar ratio, in bigravity. The ratio is constrained from above by the CMB observations, and simple inflation models, predicting a large tensor to scalar ratio, seem to be almost excluded. One may expect that the constraint on the ratio can be relaxed in some bigravity models. Contrary to this naive expectation, we found that the tensor to scalar ratio in bigravity is inevitably larger than that in GR, which means that the resulting constraint on simple inflation models is rather more stringent.

As a whole, we concluded that bigravity is consistent with ordinary inflation scenario.

[1] C. de Rham et al., PRL 106 (2011) 231101; S. F. Hassan and R. A. Rosen, JHEP 1202 (2012) 126.