論文の内容の要旨

論文題目: Generation of scalar, vector, tensor perturbations during cosmic inflation
（初期宇宙インフレーションにおけるスカラー・ベクトル・テンソルゆらぎの生成）

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Inflation is widely studied as the theory describing the very early universe and now it is considered as an indispensable component of the standard model of cosmology. During inflation, cosmological perturbations are generated from the quantum fluctuations and subsequently become the seed of the cosmic structures which are currently observed. The prediction of inflation, the scale invariant spectrum of the curvature perturbation, is tested various observation, especially by the cosmic microwave background radiation (CMB) observations with great accuracy and is confirmed to be consistent.

Nevertheless, the mechanism of inflation is still unclear. The scalar perturbation which has been observed by the CMB observations puts strong constraints on a number of inflation models. But it is not sufficient to determine the correct model. Thus in the next generation of cosmology, the perturbations other than the scalar one, namely vector perturbation and tensor perturbation become increasingly important.

Although primordial vector perturbation is not intensively investigated so far, it acquires a strong motivation from recent observations. It is known for a long time that galaxies and galaxy clusters have their own magnetic fields. However, the magnetic field even in void regions is detected in 2010 by blazar observations. Since astrophysical processes are not active there, it may indicate the primordial origin of the observed magnetic fields. Indeed, if primordial

magnetic field is generated in the early universe, magnetic fields in galaxies, clusters and voids can be explained in an integrated way. Thus the generation of magnetic field during inflation, or inflationary magnetogenesis, is a very interesting possibility.

It has been pointed out that the models of inflationary magnetogenesis proposed so far have problems. In this thesis, we discuss the kinetic coupling model (Ratra's model) and explore its obstacles in detail. Then we make model-independent arguments which universally constrain the possibility of inflationary magnetogenesis. In addition, we also consider the possibility that the magnetic field produced during inflation is further amplified during the subsequent inflaton oscillation phase. As a result, it turns out that the generation of magnetic field with a sufficient strength to explain the void observation is difficult mainly because of the consistency with the CMB observation.

The tensor perturbation with a primordial origin has been investigated as the primordial gravitational wave (GW) in the theoretical and observational context. However, previous works have focused on the tensor mode generated from the vacuum fluctuation and ignore the other possibilities. In this paper, we consider not only that the conventional GW but also GW produced by an alternative mechanism during inflation. That is the second order perturbation of a scalar field. If GWs from alternative sources dominate the observed primordial GW, the relation between the observation of the primordial GW and the properties of inflation can be drastically changed. Therefore it is important to investigate the alternative scenario of the GW generation. Contrary to the previous work, we show that the GW induced by the second order perturbation of a single spectator scalar field during inflation cannot be larger than the conventional GW from the vacuum fluctuation in a very general framework, namely the action with the k-essence and the Galileon term.