論文の内容の要旨

論文題目

Classical and Quantum Aspects of Cosmic Inflation Models

（インフレーション宇宙モデルの古典的および量子論的諸相）

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Cosmic inflation, the accelerated expansion phase in the early universe, has become the standard paradigm of the early universe, with predictions from the simplest models matching observations significantly. However, the exact model of inflation has not yet been determined, and extensive observational data and detailed theoretical investigation of models are needed to reach such goals. In this thesis, we approach cosmic inflation models from the theoretical side, mainly focusing on theoretical consistency within the models.

The thesis consists of two main parts, each consisting of two sections. In the first part, we utilize the generalized G-inflation framework, which is one of the most general single-field inflation frameworks, and investigate the non-trivial models therein. In the second part, we make use of the stochastic inflation formalism, a non-perturbative method that captures the coarse-grained stochastic fluctuations, and analyze the impact of fluctuations on inflationary scenarios.

Using the generalized G-inflation framework, we first consider the Higgs G-inflation model, which uses the standard model Higgs field as the inflaton. This model was found to exhibit singular and unstable behavior after inflation, during the oscillation phase of

the Higgs. We find an extension of the model that allows us to avoid such behavior, but at the same time find that the simplest predictions of Higgs G-inflation could not be recovered in that model. We generalize the model to include higher powers and reveal the conditions for which the Galileon-like term can dominate the dynamics during inflation.

Next, we analyze the general framework of potential driven generalized G-inflation, focusing on the consistency of the models regarding quantum corrections. We show that a Lyth bound like lower limit exists for the field range of non-canonical models exhibiting large tensor modes, but if the effect of new physics arises at the field value corresponding to the strong coupling scale during inflation, sub-strong coupling field excursion can be realized and such effects can be avoided (although this is not an evasion of the conventional Lyth bound). We also show that quantum corrections to the effective action from the model itself can be ignored if the irrelevant term under consideration dominates the dynamics in the first place.

Using the stochastic inflation formalism, we first consider the stochasticity of the standard model Higgs field during inflation, and show that the Higgs condensate due to the fluctuations can dominate the energy density of the universe after inflation. But we also show that the fluctuations created from the Higgs condensation are incompatible with observations, hence rule out inflation models such as certain scenarios of k-inflation.

Finally, we investigate the long-term dynamics of plateau potential inflation models, which are currently favored by observation. Adopting physically motivated boundary conditions at large field values, we obtain the eigenmodes of a Schrödinger-type equation, needed for the solution to the Fokker-Planck equation of the probability distribution function. Then, using an initial condition corresponding to the lowest order eigenmode, we calculate the expected e-folding number until the end of inflation, and show that due to the short time scale of inflation, such an initial condition is in general not reached within the model.