論文の内容の要旨

論文題目 I-ball formation and its evolution for an oscillating scalar field during reheating

(再加熱中の振動スカラー場が形成する I-ball とその発展)

指名 武田　直幸

After inflation, the energy of the inflaton is transferred into radiation, and then eventually thermal equilibrium state is established by the start of the hot big bang nucleosynthesis. This transmission is undergone by the perturbative decay of the inflaton. However, the oscillation of the inflaton changes this decay process by preheating. In addition to inflaton, other scalar fields exciting during the reheating would also experience the preheating, then by the explosive enhancement of the fluctuations, decay process would be affected.

These enhanced fluctuations trigger non-linear effect and lead to the various state of the field or produces observables such as the formation of the topological defects, Q-balls, Bose-Einstein condensation, or production of the gravitational waves. Among them, in this thesis, we have mainly investigated the formation of I-ball for one of the most plausible inflation model, R^2 inflation. Furthermore, we have investigated for more general case that field oscillates with logarithmic potential, motivated by the quantum or thermal correction during reheating epoch.

It is shown that the potential of the R^2 inflation model induces the instability of the fluctuations in the Minkowski spacetime, but in the expanding Universe, because of the weakness of the inflaton's self interaction, the enhancement is suppressed by the Hubble expansion, and then I-ball is not formed. Thus, for the R^2 inflation model, the decay process of the inflaton is precisely estimated by the perturbative decay.

On the other hand, we have showed that the logarithmically oscillating field forms I-ball even in the expanding Universe, executing lattice simulations. Moreover, we have found that this I-ball is formed when the quadratic term dominates the potential, and its configuration is well fitted by the estimated one assuming the conservation of the adiabatic invariant. This result suggests the adiabatic invariant would play the crucial role for the formation and evolution of the I-ball.