論文の内容の要旨

論文題目： **Proton Decay in High-scale Supersymmetry**

(高いスケールの超対称性と陽子崩壊)

氏名: 永田 夏海

Recent discovery of a Higgs boson with a mass of $\sim$ 126 GeV, as well as no evidence for new physics beyond the Standard Model so far, may imply that the supersymmetry (SUSY) breaking scale is somewhat higher than the electroweak scale. Indeed, although SUSY models with high-scale SUSY breaking challenge their role in providing a solution to the hierarchy problem, the models turn out to be quite fascinating from both theoretical and phenomenological points of view. Firstly, since the flavor changing neutral current processes and/or the electric dipole moments induced by SUSY particles are suppressed by their masses, the SUSY flavor and CP problems are relaxed when their masses are considerably heavy. Secondly, the heavy sfermions yield sufficient radiative corrections to lift the Higgs mass up to 126 GeV. As for the cosmology, the gravitino problem is avoided because of the high-scale SUSY breaking. In addition, the gauge coupling unification is achieved with great accuracy if the fermionic SUSY partners lie around TeV scale. Since chiral symmetries can protect the fermion masses, it is possible for them to be much lighter than the scalar particles. These fermionic SUSY particles contain candidates for dark matter in the Universe. A mass spectrum which satisfies these phenomenological requirements is naturally obtained on the assumption of a hidden sector where SUSY is broken dynamically. Thus, with the recent LHC results considered, the high-scale SUSY scenario is even promising.

In this thesis, we propose that the minimal SUSY Standard Model with high-scale SUSY

breaking has additional attractive points, which are brought to light when it is considered in the context of the grand unified theory (GUT). We first evaluate masses of superheavy gauge and Higgs multiplets showing up around the GUT scale by using the renormalization group method, and reveal that all of these particles, especially the color-triplet Higgs multiplets, can lie around a scale of $\sim 10^{16}$ GeV, contrary to previous results based on the low-scale SUSY breaking. This observation indicates two new aspects on the GUT scale particles; the color-triplet Higgs mass is larger by an order of magnitude and the GUT scale is slightly lower than those in the case of low-scale SUSY. Taking into account these features, we next study proton decay in the high-scale SUSY scenario. We have found that thanks to heavy color-triplet Higgs multiplets and high-scale SUSY breaking, the rate of the disastrous dimension-five proton decay induced by the color-triplet Higgs exchange is significantly reduced, and the current experimental limits on the $p \to K^+\bar{\nu}$ channel can be evaded. Further, a lower GUT scale leads to an enhancement of the rate of the $p \to \pi^0 e^+$ mode. Other proton decay modes may also be considerably accelerated if there exists large flavor violation in the sfermion mass matrices, which can be allowed in the case of high-scale SUSY breaking.

For a variety of decay modes, we have found that the resultant proton decay rates may lie in the region which can be reached in the future proton decay experiments. Therefore, although the high-scale SUSY scenario is hard to be probed in the collider experiments, the proton decay searches may give us a chance to verify the scenario as well as the existence of supersymmetry and the grand unification.