論文の内容の要旨

論文題目　Low-Scale Gauge Mediation Models at the LHC:
Their Test and Discrimination from Other Supersymmetric Models
(LHC における低スケールゲージ伝達型模型の検証および他の超対称性模型との識別)

氏名：中村栄太

The supersymmetric (SUSY) extension of the standard model (SM) is one of the most attractive candidates for the physics beyond the SM. As well as solving the hierarchy problem to a great amount, the SUSY SM often predicts an apparently correct GUT unification. In addition, many SUSY models provide a dark matter (DM) candidate. Once the presence of SUSY is inferred from experiments, the next problem is to search for the underlying mechanism of SUSY breaking. The scale of SUSY breaking is one of the most important clue for this search.

An attractive possibility of SUSY breaking mechanism is the gauge mediation model because in addition to the conceptual simplicity of using the well-established field theory as a building block of model construction, the gauge mediation model has an advantage in solving the flavor-changing neutral current problem. In particular, the low-scale gauge mediation model with a light gravitino of mass $m_{3/2} \lesssim \mathcal{O}(10)$ eV is very attractive since there is no cosmological problem for such a model. The light gravitino scenario is also interesting in the aspect of experimental testability since they typically predict lighter SUSY particles, which may be in the energy region able to be tested at the LHC.

In the thesis, we first review various types of low-scale gauge mediation models and their theoretical and phenomenological aspects. The theoretical constraints together with the assumption of a light gravitino set strong restrictions on the models. For

example, the model with a perturbatively stable SUSY breaking vacuum is already excluded by the Tevatron and LHC experiments. Other interesting possibilities are the minimal type model with a metastable vacuum and strongly interacting gauge mediation models. Strongly interacting models predict interesting possibility of lighter gauginos, but their prediction is rather ambiguous due to the strong interaction. In the thesis, we concentrate on the minimal model and study their collider phenomenology.

We review the experimental constraints and update the constraints coming from the recent results of the LHC experiments. We also show the discovery potential of the LHC in the near future. The result shows that the LHC is capable of testing a wide class of interesting models. In particular, if the number of messenger is less than 6, the minimal type gauge mediation model can be tested completely within a few 10 fb^{-1} at the 14 TeV run.

In the main part of the thesis, we study the test of low-scale gauge mediation models after discovery. We particularly study possible test at earlier stages. We consider a method using significances in multiple modes. This method is applicable from the early stage and is useful because it automatically incorporates the possible contamination from the SM background and can be used for a quantitative analysis.

As a concrete example, we study the discrimination of the minimal gauge mediation model and the minimal gravity mediation model. These models have different scales of SUSY breaking and predicts a quite different physics in high energy and cosmological history. Collider phenomenologically, however, their signatures are similar. However, because of the fact that usually almost all the produced SUSY particles decay into the next-to-lightest SUSY particle (NLSP) before decaying into the gravitino and that in gravity mediation models it is not always true, the leptons or photons from the NLSP decay may be a discriminant of the two models. However, this discrimination is of a quantitative nature and we are interested in the case with a smaller number of signal events, the estimation of the SM backgrouds and detector efficiencies are of primary importance. We perform a Monte Carlo simulation and pay attention to these effects. We propose a discrimination based on using significance variables in multiple modes. Using the lepton, tau-jet and photon modes as well as the jets plus no lepton mode, we show that the discrimination is possible at a very early stage after discovery.

We also applied our method for the discrimination of the co-annihilation region and the focus point region in the minimal gravity mediation model. By using the significances in the two jets and four jets modes, we show that the discrimination also possible at an early time. The discrimination is very important because it gives an insight on the origin of the DM.