論文の内容の要旨

論文題目　Supersymmetry after the Higgs discovery and its LHC phenomenology
（Higgs 粒子の発見を踏まえた超対称性理論とその LHC 現象論）

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We physicists are on a journey towards the ultimate theory which describes everything in our Universe. A great milestone achieved in 2012 is the discovery of the Higgs boson by the CMS and the ATLAS collaborations at the Large Hadron Collider (LHC); it completes the Standard Model of particle physics, which was developed through the mid to late twenties century.

The long twentieth century was over. Happily making a steppingstone of the Standard Model, we are now heading to more fundamental theories. Nature has many unsolved features: the Dark Matter, the Dark Energy, and the mechanism which produced current baryon asymmetry of our Universe, etc. Also we have to build a unified explanation of the three forces embedded in the Standard Model, and to develop a description of the gravitational force in the language of the quantum theories.

The supersymmetry is one of the most promising candidates for theories beyond the Standard Model, and its tail was expected to be caught at the early stage of the LHC. However, our expectation was not fulfilled, and we have no footprints observed yet. What does this mean?

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The current status of the supersymmetric theories is described in this dissertation. First, the simplest model of supersymmetric Standard Model is introduced, which is called the MSSM. Under this framework, the discrepancy in the muon anomalous magnetic moment between the prediction from the Standard Model and the experimental result suggests the supersymmetric particles are of order 100 GeV, which is also supported by discussions on the little hierarchy problem. However, the LHC experiments have found no scalar-quarks or gluinos in such mass range, and moreover, the Higgs boson mass of 126 GeV requires, within the MSSM framework, the scalar-top mass of order 1–10 TeV. This current status forces us to abandon the simplest supersymmetry-breaking frameworks of the CMSSM and the GMSB scenarios.

Two promising possibilities remain there: the first is that the scalar-quarks and the gluino are much heavier than of order 100 GeV while the other SUSY particles remain near the order, and the second is to extend the MSSM with extra fields. The second scenario is investigated in this dissertation; the V-MSSM is proposed as an extension of the MSSM with a $(\mathbf{10}+\overline{\mathbf{10}})$ pair of the SU(5) decuplets. In the framework the Higgs mass is increased by effect from the extra matters, and thus the 126 GeV is achieved with the scalar-top having a lighter mass. This fact resurrects the CMSSM and the GMSB scenarios. This dissertation examines the GMSB scenario under the V-MSSM; it is called V-GMSB scenario.

It is shown that the V-GMSB has a potential to realize the 126 GeV mass of the Higgs boson with holding the explanation of the muon magnetic moment discrepancy, if the masses of the extra quarks are approximately less than 1.2 TeV. Constraints on the V-GMSB from the LHC experiments are discussed then; it is concluded that the gluino mass must be approximately heavier than 1.1 TeV, and that the extra quarks be heavier than 300–650 GeV depending on the decay branches of them.

LHC prospects are briefly discussed. As the extra quarks are expected to be approximately less than 1.2 TeV, searches for the particles are of great interest at the 14 TeV LHC; constraints from the supersymmetry search, especially on the gluino mass, are expected to be much improved there. Therefore, it is expected that the fate of the V-GMSB is adjudicated at the court of the 14 TeV LHC.