Research Statement

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1 Research Interests

My research interests focus on phenomenology predicted by the supersymmetric (SUSY) models. While no signature has yet been reported by collider experiments, a model beyond the standard model (SM) for particle physics is needed to explain various problems in the SM.

Supersymmetric grand unified theories (SUSY GUTs) are the promising models beyond the SM (BSMs). Indeed, the SUSY GUTs provide an unified description of forces, a candidate of DM, and so on.

In general, underlying theories often predict unusual phenomena such as flavor and/or CP non-conserving processes. Pursuing both areas of collider phenomenology and high-intensity frontier deepens our understanding of particle physics. Since several indirect observables are planned to search, it is necessary to prepare theoretical predictions and to reduce theoretical uncertainties. In order to see the theoretical predictions for them more realistically, we should construct an underlying theory based on the experimental constraints and the observed values for the electroweak parameters. Moreover, it is also essential to ameliorate theoretical predictions by including appropriate corrections.

Phenomenology in Split SUSY Models

Models with heavy sfermions are the promising scenarios after the Higgs discovery, which are called split-SUSY models. I have shown that the gauge coupling unification can be achieved in these models more precisely than in the low-scale SUSY scenarios. This fact implies that the mass of the additional multiplets which give rise to rapid proton decay is larger than in the low-scale SUSY scenarios [1].

The high-intensity experiments have potential for verifying the heavy sfermion models. The minimal SUSY $SU(5)$ GUT model with multi-TeV sfermions is excluded due to the rapid decay mode. However, I have shown that the minimal model with heavy sfermions is consistent with the Super-Kamiokande experiment and the rapid decay mode can be discovered by future experiments [2].

I have also interests in CP-violating processes. In general, split-SUSY models can include additional matters besides the MSSM particles. I have shown that there is an additional contribution to nucleon EDMs in the generic scenarios [3], that is, the CP-violating gluon three-point operator generated via the physical phase of the gluino mass parameter. Since this gluonic contribution can be comparable to an ordinary Barr-Zee contribution, it is necessary to include the additional contribution for estimating the low-energy observables precisely. It is expected that we can distinguish among split-type SUSY models using both of proton, neutron, and electron EDMs by future experiments for nucleon EDMs.

Quantum Corrections to Higher-dimensional Operators

Rare processes are often described by higher-dimensional operators which are generated by integrating out massive degrees of freedom. There is a large hierarchy between the ultraviolet scale and the scale where matrix elements are estimated. In order to predict observables precisely, it is important to include the effects of the renormalization group equations (RGEs) and finite threshold corrections.

While the effect of two-loop RGEs from gauge interactions for the proton decay operators has been estimated by several researches, that of one-loop threshold corrections had not been estimated in spite of the same order correction. I have estimated the size of finite (one-loop) threshold corrections to the proton decay operators [4, 5]. The theoretical uncertainty is reduced by my work and the next order corrections are expected to be smaller than ambiguities of hadron matrix elements estimated by lattice simulation.

2 Future Direction

The rare processes are complementary to the collider data if new particles are found; but if not, they are significant in order to check the BSMs. I plan to construct the TeV-scale physics model based on the collider experiment data. The LHC experiments constrain the colored particles severely, especially the gluinos in the MSSM. Recently, I have constructed the supersymmetric model with extra vector-like multiplets which realizes a heavy gluino and 1 TeV stops [6]. Based on the TeV-scale physics, I have a plan to estimate other observables which can be tested via the flavor and/or CP violated processes.

While my main research topics are the observables for high-intensity experiments and precise calculations for them, I have also interests in different areas. For example, cosmology, collider phenomenology, and model buildings of UV completions. I believe that complementary researches of the above-mentioned areas lead to our deep understanding of our world.

References

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