Research statement

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My research interests lie in the phenomenology of a broad range of models beyond the standard model (SM) of particle physics. In spite of the great success of the SM, there remain many problems that cannot be solved within the SM. These questions include, for example, the existence of the dark matter (DM), naturalness of the electroweak (EW) scale, structure of the gauge symmetries, and origin of the quark and lepton families. To answer one or several of them, numbers of models are proposed such as the minimally supersymmetric standard model (MSSM), grand unified theory (GUT), flavor symmetry, and so on. They often lead to some interesting phenomenology that can be used to distinguish them from the SM. I seek ways to test them using both a top-down approach where a model or its parameter space is constrained from theoretical consideration, and a bottom-up approach where the experimental search probes a new particle contained in a model.

Achievements so far

Since we now live in the EW vacuum, the requirement of the (meta-)stablity of the vacuum can be used to test and constrain models in a top-down approach. This approach is powerful because it can probe new particles that are too heavy to be accessed using any ongoing or planned experiment. Also, this approach is applicable to many models which contain some additional scalar fields and/or couplings to the SM Higgs boson. During the last few years, I have been developing the next-to-leading order calculation of the decay rate of the EW vacuum ([1,8,9] of my publication list). My treatment filled a gap of existing calculations and enabled us to precisely evaluate the decay rate with error estimations.

It is also important to use the collider experiments as an example of the bottom-up approach. In particular, recent hadron colliders provide a huge amount of data, under which a hint of the new physics may be buried. To fully use the data, it is necesarry to develop

a proper physics quantity or a wise way to extract the signal of a new particle. So far, I focused on the search for massive particles with EW charges (EWIMPs) [3–5] that are DM candidates appearing in many well-known models such as MSSM. I developed a way to use the signal shape to reduce the systematic uncertainties and obtained the best limit so far for Higgsino, an EWIMP DM candidate in MSSM, which are generally difficult to search for.

It is an another interesting way of research to search for or to build a new physics model. All problems in the SM are hints of the most fundamental physics theory, which is our ultimate goal. By providing a simple solution to them, we can enrich our knowleadge about what could be there beyond the SM. In several works, I focused on models with discrete flavor symmetry [2,6,7] and GUT models [10,11] that provide an unified description for SM fermion families and gauge symmetries, respectively. I constructed models and looked for the parameter space in which model predictions are consistent with our cosmological history and experimental results.

Future plans

Now it is an exciting time with many ongoing and future planned experiments that provide a huge number of hints of the new physics. The results of these experiments will guide future theoretical works. At the same time, a great deal of effort is devoted to developing new approaches to the problems of the SM and new techniques to extract the information from experimental results. As a young researcher at this time, I am eager to engage in fields of great progress and to keep seeking a trace of the new physics.

Recently, we have made significant progress in developing techniques that enable us to analyze the collider data in a systematic way. These include, for example, the effective field theory and machine learning. One possible way is to consider how to use them to enlarge the reach of the collider experiments. Another possibility is