Statement of Research Interests

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My research field is Theoretical High Energy Physics, in particular, my major interest is in physics beyond the Standard Model. Although Standard Model is successful in describing all known properties and interactions of the existing particles, it is only a low-energy effective description of a more fundamental theory as it leaves many questions unanswered. One of the most prominent question is the origin of electroweak symmetry breaking. The simplest picture for electroweak symmetry breaking through a scalar Higgs doublet suffers from the naturalness problem if we try to extrapolate the theory to higher energies, due to the quadratically divergent radiative corrections to the Higgs mass squared. The mysteries of the flavor sector and CP violation also call for explanations. In addition, from the progress of our understanding of the universe, new forms of matter and energy are required to account for many cosmological observations, such as the flattening of the galactic rotation curves, structure formation, and accelerated expansion of the universe, etc.. They all require new physics beyond the Standard Model. I am interested in exploring the possible candidates for new physics and studying their phenomenological implications. These include supersymmetry, extra dimensions, new strong dynamics, and so on. The followings are descriptions of the major directions of my research.

Electroweak symmetry breaking: The origin of the electroweak symmetry breaking is currently the most pressing question in high energy physics. Possible explanations involve supersymmetry, extra dimensions, or new strong dynamics. In supersymmetric theories, we need to understand how supersymmetry is broken and how the superpartners of the Standard Model particles acquire their masses, as well as the origin of the mass parameter "μ term" of the Higgs sector. Supersymmetry at the weak scale also allows us to extrapolate physics to very high energies. The successful gauge coupling unification points toward a Grand Unified Theory, which implies many more important questions and phenomenological consequences, such as the mass splitting of the multiplets of the grand unified group, proton decays, superpartner spectrum, and so on.

Existence of large extra dimensions is another exciting possibility. It offers alternative explanations of the hierarchy problem and the electroweak symmetry breaking. The fundamental Planck scale would be much lower than we thought can if there exist large extra dimensions, which could make the quantum gravity effects accessible in future experiments. In addition, the Higgs field and the origin of electroweak symmetry breaking may arise due to the propagation of ordinary matter and gauge fields in extra dimensions. The locality in extra dimensions gives new ways to explain small numbers and hierarchies of scales in particle physics. The progress in understanding the correspondence between four dimensional and higher dimensional theories provides us better pictures for both cases and generates new ideas for new physics. For example, the AdS/CFT correspondence has been very useful in building new models to address many questions in high energy physics. Another related idea is the "little Higgs" theory which provides a new way to stabilize the weak scale without supersymmetry while still naturally having a light Higgs.

Cosmology: We have seen a lot of progress in cosmology in recent years. Through numerous precision experimental observations, we are getting a clear picture of the evolution of the universe. However, a deep understanding of many questions in cosmology may rely on the progress in our understanding of particle physics. Inflation, dark matter, and dark energy all probably require new ingredients in particle physics. Another interesting possible explanation for some of the questions is to consider that gravity is modified at large distance. I am interested in exploring various possibilities and particle physics models to answer these cosmological questions.

Experimental tests of new physics: With many new experiments underway or to be started in the near future, we will have great chances to discover new physics beyond the Standard Model. New physics generically predicts many new states which will be produced in the future collider experiments, e.g., the superpartners in supersymmetric theories and the Kaluza-Klein states in theories with extra dimensions. To identify the new particles and to distinguish various possibilities, we need detailed studies of their signatures and as much experimental information as possible. It is essential to have many precise measurements of the interactions and the spectrum of the new states. In addition to the direct discovery of new particles at high energy colliders, new physics can also appear or be constrained in other types of low energy and astrophysical experiments. These include precision electroweak observables, flavor-changing processes, CP violation, muon magnetic dipole moment, dark matter, cosmic rays, and so on. By combining all the possible experimental results we will then be able to obtain a more complete picture of physics at the very fundamental level.

Other related topics: In addition to the above mentioned subjects, I also have been working in many related topics such as flavor physics, CP violations, neutrinos. I am also interested in some formal aspects of the field theory, such as exact results and dualities and their applications in particle physics.