Shufang Su

Research Interest

My primary research area is high energy theoretical particle physics. My main research interest is new physics beyond the Standard Model (SM). My recent research activities include phenomenology of low energy supersymmetric models, collider searches, Higgs studies, top-quark physics, electroweak precision measurements and particle cosmology.

While the success of SM of the elementary particles has been confirmed precisely by the LEP, SLD, and Tevatron, the problem of the instability of the Higgs mass against radiative corrections (known as the "hierarchy problem") points to new physics above the electroweak scale. Supersymmetry (SUSY), the symmetry between boson and fermion, is the most promising candidate among various proposals. In addition to the solution to the hierarchy problem via the cancellation of the contribution between boson and fermion, SUSY provides gauge coupling unification, radiatively induced electroweak symmetry breaking, and a rich superparticle spectra around the electroweak scale, which is within the reach of the on-going Tevatron RUN II and future high energy collider experiments.

The direct search for superparticles through their productions and consequent decays is desirable. Once SUSY is discovered, detailed study of the properties of superparticles would give us useful information on the origin of SUSY breaking. Furthermore, many indirect SUSY signatures are also possible because heavy superparticles can impact the low energy measurements through radiative corrections. I have done work in both directions. I have been involved in the SUSY studies at e^+e^- linear colliders, and also participated in several working groups in Snowmass 2001: *summer Study on the Future of Particle Physics*, in particular, in the work of "the snowmass points and slopes", which defines benchmark scenarios for SUSY searches at current and future colliders.

One example of the direct SUSY searches is my recent work on the top-squark (superpartner of top-quark) study at a future e^+e^- linear collider (with T. Moroi and R. Kitano). We studied the pair production of the light top-squark with its consequent decay of $\tilde{t}_1 \to t\chi_1^0$ (with χ_1^0 being the lightest neutralino), followed by $t \to bW$. The stop mass, left-right mixing and the lightest neutralino mass can be obtained from the production cross section with polarized electron beam and stop decay kinematics. In addition, with these results, information on the neutralino mixing can be extracted from the measurement of the angular distribution of b-jet in the top decay, which provides some knowledge on the Higgs mixing parameter μ.

More recently, the results of cesium atomic parity-violation and deep inelastic ν- ($\bar{\nu}$-) nucleus scattering, which can be interpreted as determinations of the scale-dependence of $\sin^2\theta_W$, imply -2σ and $+3\sigma$ deviations, respectively, from the predicted SM value. Two new measurements involving polarized electron scattering: parity-violation (PV) Möller (ee) scattering at SLAC and elastic, PV ep scattering at the Jefferson Lab, could be used to determine $\sin^2\theta_W$ at the scale: $|Q^2| \approx 0.03$ $(\mathrm{GeV}/c)^2$. Worked with A. Kurylov and M.J. Ramsey-Musolf, I computed the one-loop SUSY contributions to ee and ep parity violation processes. Works on the SUSY contribution (including R-parity violation) to ν- ($\bar{\nu}$-)N scattering at NuTeV is in progress.

The search for the light neutral Higgs boson is a crucial test of SUSY that can be performed with the present and the next generation of high-energy colliders. The prediction of a relatively light Higgs boson is common to all supersymmetric models. Finding the Higgs boson is thus one of the main goals of today's high-energy physics.

Working together with S. Ambrosanio, A. Dedes, S. Heinemeyer and G. Weiglein, I investigated the Higgs boson sector of the Minimal Supersymmetric Standard Model (MSSM) in the framework of the three most prominent soft SUSY-breaking scenarios, mSUGRA, mGMSB and mAMSB. Given the LEP II exclusion bounds on the Higgs searches and a possible 2 σ Higgs signal, an extensive comparison of the three soft SUSY-breaking scenarios in terms of exclusion regions in the $M_A - \tan\beta$ plane, their compatibility with the signal observed at LEP and the corresponding SUSY particle spectra has been explored in detail. We are currently investigating the physics of the lightest CP-even MSSM Higgs boson at the Tevatron, the LHC, a linear e^+e^- collider, a $\gamma\gamma$ collider and a $\mu^+\mu^-$ collider. We are studying the observability and parameter regions with suppressed production cross sections (compared to a SM Higgs boson with the same mass) for all colliders. For the lepton and photon colliders, the impact of precision measurements of the Higgs branching ratios is explored.

While the discovery of the lightest CP-even MSSM Higgs is almost certain at the LHC, detection of the heavy Higgs bosons H^0, A^0 and $H^\pm$ of MSSM poses a special challenge at future colliders. Even at the LHC, a wedge-shaped region of the $M_A - \tan\beta$ parameter space at moderate $\tan\beta$ remains open, in which the heavy MSSM Higgs bosons will not be discovered. The associated production of a heavy Higgs with a light SM particle offers the possibility of producing the heavy Higgs at the e^+e^- collider with mass more than half the center-of-mass energy, when the dominant pair production is kinematically forbidden. H. Logan and I calculated the associated production of the charged Higgs boson and $W^\pm$ gauge boson in high energy e^+e^- collisions in the MSSM framework. With J. Gunion and T. Farris, we are studying the single heavy CP-odd A^0 production process $e^+e^- \to \nu\bar{\nu}A^0$.

I also worked on the SUSY corrections to the top quark pair production near threshold at a e^+e^- linear collider. I did some work on the phenomenological viability and implications of low energy N $= 2$ supersymmetry scenario. I studied the contribution of the extra chiral families to the precision measurements, and the interrelation between the extra fermion families and the Higgs sector.

I intend to continue research related to the interplay between the low energy effective SUSY models and experimental SUSY searches. Given great discovery potential of Higgs at the Tevatron RUN II and the LHC, and precision study of Higgs properties at a linear collider, I will pursue more detail study on the Higgs production, determination of its couplings, and the impact of Higgs search on the rest of MSSM superparticle spectra. I am also interested in studying various aspects of particle phenomenology and pursuing new ideas in particle physics. I recently get interested in cosmology and have some ideas in mind for future possible projects. One idea is based on a recent proposal to the cosmological constant problem by modifying the Einstein equation at large distance scale (N. Arkani-Hamed *et. al.*, hep-th/0209227). A possible project is to work out the cosmological solution to this modified Einstein equation in a perturbative approximation, and find its impact on the cosmic microwave background.

These are some of the areas which I am interested in studying. I believe this line of research is relevant to the objectives of your high energy theoretical physics program, and I would be very interested in working with members of your group to study problems along these lines.