Neutrino masses in supersymmetry: R-parity and leptogenesis

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Abstract

In the supersymmetric standard model of particle interactions, R-parity nonconservation is often invoked to obtain nonzero neutrino masses. We point out here that such interactions of the supersymmetric particles would erase any pre-existing lepton or baryon asymmetry of the universe before the electroweak phase transition through the $B + L$ violating sphaleron processes. We also point out that all models of radiative generation of neutrino masses suffer from the same problem. We then show how neutrino masses may be obtained in supersymmetry (assuming R-parity conservation) together with successful leptogenesis and predict the possible existence of new observable particles.

Two issues in particle physics are critically important today. One is the possible existence of neutrino masses, as evidenced by the ongoing excitement generated by the recent report of atmospheric neutrino oscillations [1], as well as previous other indications of solar [2] and accelerator [3] neutrino oscillations. The other is the possible existence of supersymmetry, as evidenced by the enormous, continuing efforts of both experimentalists and theorists in devising ways of searching for the predicted new particles in existing and future high-energy colliders [4]. In the minimal standard model (SM) of quarks and leptons without supersymmetry, neutrinos are massless. To make them massive, new physics have to be assumed [5].

In the minimal supersymmetric standard model (MSSM) which assumes R-parity conservation, neutrinos are also massless. To make them massive, there exist four generic mechanisms: the seesaw mechanism [6], the triplet Higgs mechanism [7], the radiative mass generation [8], and through R-parity violation [9]. All these mechanisms have one very important consequence in common, namely, there are now unavoidable lepton-number violating interactions at some intermediate scale above that of electroweak symmetry breaking. Combining this lepton-number violation with the $B + L$ violating sphaleron processes [10], any pre-existing $B$ or $L$ or $B - L$ asymmetry of the universe could be erased [11,12].

Here we point out that in the R-parity violating models for neutrino mass, the unavoidable lepton-number violation at the supersymmetry breaking scale will erase any primordial $B$ or $L$ or $B - L$ asymme-