Nonthermal particle acceleration and energy partitioning of thermal and nonthermal particles in collisionless plasma universe

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In hot and rarefied plasma in our universe, the mean free path is much larger than the characteristic system size of the astrophysical objects, and the collision between charged particles are rare. In such a collisionless system, the collective behavior of the plasma is governed by the interaction between electromagnetic fields and charged particles. In this system, local thermal equilibrium is not achieved in the time scale of our interests, and the velocity distribution function of plasma contains nonthermal population, whose energies are much beyond thermal energy. In fact, nonthermal particles are ubiquitously observed from various astrophysical phenomena such as solar flares, supernova shocks, pulsar wind nebulae, and black holes and so on. Those nonthermal particles are often approximated by a kappa distribution function with a power-law distribution function in high energy regime. It is important to understand the mechanisms of nonthermal particle acceleration for dynamical evolution of the high-energy astrophysical phenomena and for advancing our knowledge of plasma physics. In this talk, I focus on magnetic reconnection in both non-relativistic and relativistic plasmas, which is one of the key acceleration processes in plasma universe, and I discuss how the energy partitioning between thermal and nonthermal plasmas is realized by using electromagnetic particle-in-cell numerical simulations.