Particle acceleration in plasma universe: magnetic reconnection, shock waves, and accretion disks

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Nonthermal particles are ubiquitous in space and astrophysical plasmas, and explosive phenomena such as supernova remnant shocks, solar flares, and Earth’s substorms have demonstrated evidence for the production of high-energy particles. Yet the particle acceleration mechanism remains to be unresolved in collisionless plasmas. While a great variety of acceleration processes are occurring in those astrophysical settings, magnetic reconnection is known to be one of major mechanisms of generating non-thermal high energy particles. By using particle-in-cell simulations, we firstly review that magnetic reconnection particularly plays an important role on not only plasma thermazilation/heating but nonthermal particle acceleration, and then argue that the interaction of many magnetic islands under magnetic reconnection can generate very high-energy particles. Secondly, we discuss that those multiple interactions of reconnection can naturally happen in a wide variety of magnetically active regions such as high Mach number shocks with fast gas flows and accretion disks gravitationally bounded around massive black holes. Finally, we argue that magnetic reconnection imbedded in those macroscopic plasma phenomena can efficiently generate very high energy particles observed in plasma universe.