Nonthermal particle acceleration in magnetic reconnection and turbulence in collisionless relativistic plasmas

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One of the key recurrent themes in high-energy plasma astrophysics is relativistic nonthermal particle acceleration (NTPA) necessary to explain the bright X-ray and gamma-ray flaring emission with ubiquitous power-law spectra in astrophysical objects such as pulsar wind nebulae, hot accretion flows and coronae of accreting black holes, and black-hole powered relativistic jets in active galactic nuclei and gamma-ray bursts. Two leading physical processes often invoked as possible NTPA mechanisms are collisionless magnetic reconnection and turbulence. In order to understand these processes, as well as their resulting observable radiation signatures, I have recently initiated a broad theoretical and computational research program in kinetic radiative plasma astrophysics. This program employs large-scale first-principles particle-in-cell kinetic simulations (including those that self-consistently incorporate radiation-reaction effects) coupled with analytical theory. In this talk I will review the resulting progress that we have achieved in recent years towards understanding and quantitative characterization of NTPA in reconnection and turbulence over a broad range of physical regimes. I will present 2D and 3D simulation results that demonstrate that both reconnection and turbulence in relativistic collisionless astrophysical plasmas can robustly produce non-thermal energy spectra with power-law indices that show an intriguingly similar characteristic dependence on the plasma magnetization. I will also describe the effects of strong radiative cooling on reconnection and turbulence.