Particle energization in radiative relativistic plasma turbulence

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Turbulence is a fundamental process for energizing particles in collisionless astrophysical plasmas, including systems such as pulsar wind nebulae, black-hole accretion flows, and jets emanating from active galactic nuclei. In these high-energy astrophysical systems, the plasmas often attain relativistic energies and are efficiently cooled by radiation; understanding the kinetic properties of turbulence in this exotic regime is essential for predicting radiative signatures (luminosity, spectra, and variability). Particle-in-cell (PIC) simulations of relativistic plasma turbulence offer a powerful tool for exploring the kinetic properties of a collisionless radiative plasma subject to external cooling. I will overview recent work on this topic based on PIC simulations of relativistic turbulence in electron-positron (pair) plasmas [1] and in electron-ion plasmas [2] subject to strong external inverse Compton radiative cooling. For the pair composition, the plasma is thermalized by the cooling, as predicted by simple analytical models of diffusive particle acceleration. For electron-ion composition, the ions continuously heat up (and accelerate nonthermally) while electrons gradually cool down (and thermalize); consequently, the ion-to-electron temperature ratio grows in time, signifying the absence of efficient collisionless mechanisms of electron-ion thermal coupling. I will also highlight the role of nonthermal electrons that are beamed intermittently in direction and in time, which may source rapid high-energy flares commonly observed in high-energy astrophysical systems. Finally, I will conclude by discussing future prospects on the topic of radiative turbulence.

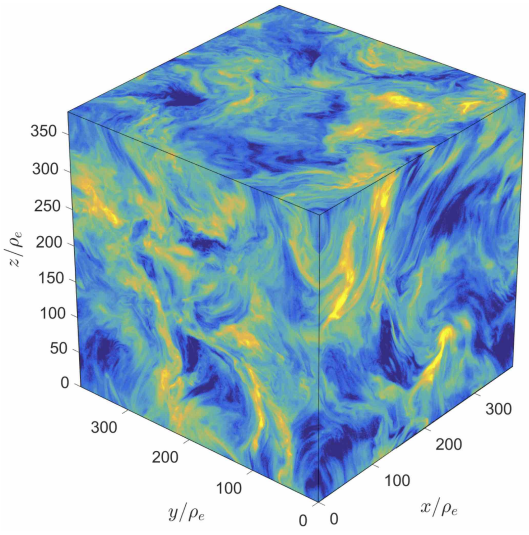

Figure 1: *PIC simulation of driven turbulence in radiative relativistic pair plasma [1].*

References

[1] V. Zhdankin, D.A. Uzdensky, G.R. Werner, and M.C. Begelman, MNRAS **493**, 603 (2020)

[2] V. Zhdankin, D.A. Uzdensky, and M.W. Kunz, Astrophys. J. **908**, 71 (2021)