

Bridging the gap between fluid and kinetic magnetic reconnection simulations using an effective resistivity closure

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Abstract

Magnetic reconnection is one of the most important physical processes capable of powering many high-energy transient phenomena (such as flares from black hole magnetospheres, blazar jets, and fast radio bursts), as the dissipation of magnetic fields can efficiently accelerate charged particles and thus lead to the production of the observed non-thermal emission. Numerical models adopting a fully-kinetic approach (as in PIC simulations) can self-consistently capture the properties of magnetic dissipation during a reconnection event, but their high computational cost makes the study of the large-scale dynamics of compact objects magnetospheres extremely challenging. On the other hand, fluid models (e.g. relativistic MHD) are instead widely used to describe the accretion/ejection of matter and magnetosphere dynamics on temporal and spatial scales set by a black hole, but they generally can't reproduce a self-consistent dissipation mechanism, being limited by either numerical dissipation or an explicit resistivity parameter not constrained by the microphysics.

I will present a recent study that compares, for the first time, the dynamics of a typical PIC model of relativistic reconnection with the results of resistive RMHD regime adopting a non-constant effective resistivity, which can capture the local enhancement of magnetic dissipation within the reconnecting current sheet. Such “effective resistivity” can not only qualitatively reproduce the typical reconnection rates of kinetic models (which usually are one order of magnitude lower in the RMHD framework), but can do so even at modest grid resolutions and for different levels of magnetization. I will then show the results from hybrid RMHD-PIC models that quantify the acceleration of charged particles in the reconnecting pair-plasma, showing once again a remarkable agreement between PIC simulations and RMHD models with our effective resistivity prescription. Our findings provide, therefore, a general framework to introduce a more realistic description of magnetic dissipation and particle acceleration within large-scale simulations of magnetized astrophysical accretion flows and jets.