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Particle acceleration via magnetic reconnection in large-scale MHD jet simulations

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Abstract. We present a new algorithm for the identification and physical characterization of current sheets and reconnection sites as well as the update of post-reconnection particles spectra in 2D and 3D large scale relativistic magnetohydrodynamic simulations. Lagrangian particles, which follow the fluid, are used to sample plasma parameters before entering the reconnection sites that form during the evolution of the different configurations considered. With the sampled parameters and a subgrid model based on results of Particle-in-Cell simulations we introduced in the PLUTO code an algorithm able to describe the post-reconnection spectra associated to the non-thermal component.

Keywords. magnetic reconnection, radiation mechanism: non-thermal, MHD

Magnetic reconnection (MR) is a plasma process that dissipates the energy stored in magnetic field, through a rearrangement of magnetic field topology, resulting in particles heating and acceleration. It is thought to play an important role in astrophysical sources like jets from active galactic nuclei (AGNs). MR has been studied with Particle-in-Cell (PIC) simulations, obtaining a description of the final spectrum based on plasma quantities that particles experience entering a MR region. Cold magnetization σ and the ratio between plasma and magnetic pressure β result to be the fundamental parameters to determine the resulting post-reconnection particle distribution and the acceleration efficiency.

In Nurisso *et al.* (2023) we developed a novel method to identify current sheets and to sample σ and β in magnetohydrodynamic (MHD) simulations in the Lagrangian Particle (macroparticle) module in the PLUTO code. Outside acceleration sites macroparticles spectra evolve accordingly to the relativistic cosmic–ray transport equation while MHD equations are solved concurrently, using the fluid velocity to evolve their position. While the macroparticles move towards and enter a MR region the plasma quantities necessary to infer the post-reconnection particles spectrum are sampled.

The macroparticles spectra update post-MR is implemented in Nurisso *et al.* (2023). The amount of magnetic energy available for the electron non-thermal population is

estimated and the spectra are updated according to the sampled σ and β values. Spectra are then convolved with the pre-existing ones so that multiple acceleration events can be considered consistently. The description of MR in the Lagrangian Particles module constitutes, for the first time in large scale MHD simulations, a framework to study, with spatial and time resolution, acceleration due to MR in astrophysical sources.

References

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