Magnetic reconnection as initial mechanism of particle acceleration in AGN jets

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Jets form active galactic nuclei show extremely variable high-energy emission. Relativistic shocks are though to play an important role in accelerating particles to the energies needed for this but diffuse shock acceleration (DSA) can only be this efficient if the initial particles start out at relatively high energies. The jets are believed to be born magnetically dominated and then transition to be kinetically dominated. Several works based on three-dimensional magneto-hydrodynamic (MHD) simulations of relativistic jets, such as Medina-Torrejón et al. (2021); Medina-Torrejón et al. (2023), have shown that the resulting turbulence in the transition region drives magnetic reconnection and this can efficiently accelerate particles (de Gouveia dal Pino and Lazarian, 2005). We propose that, in blazar jets, the initial acceleration is due to magnetic reconnection and DSA further increases the particles energies resulting in the characteristic double-humped spectral energy distributions we observe.

In this work, we intend to perform MHD simulations where particles are accelerated by turbulent magnetic reconnection in kink unstable jets (Medina-Torrejón et al., 2021; Medina-Torrejón et al., 2023). We use the resulting energy distribution of the particles (see e.g. Fig. 1) as starting point to simulate their propagation in the jet. This entails first and second order Fermi acceleration and emission losses and can be described with a Fokker-Planck type equation, which can be numerically solved with stochastic differential equations (Kruells and Achterberg, 1994; Guenther, 2022). The resulting spectral energy distribution (SED) will be compared to existing data, such as the blazar PKS 1830-211 (see Fig. 2).

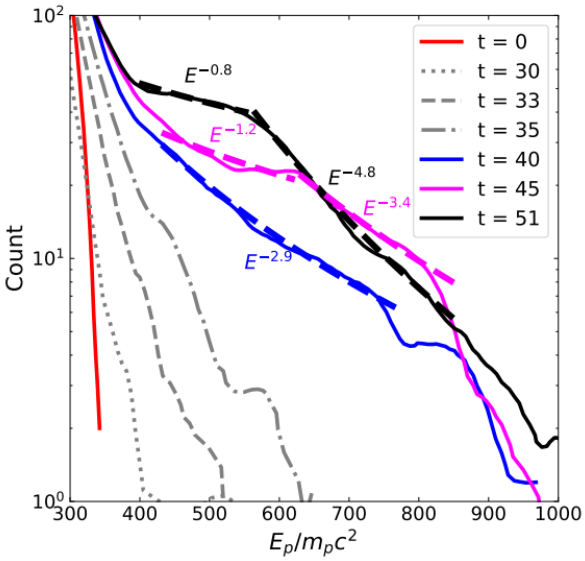

Figure 1 – Particle energy spectrum evolution as a function of the normalized kinetic energy for the particles evolved in the MHD-PIC simulation of a relativistic jet.

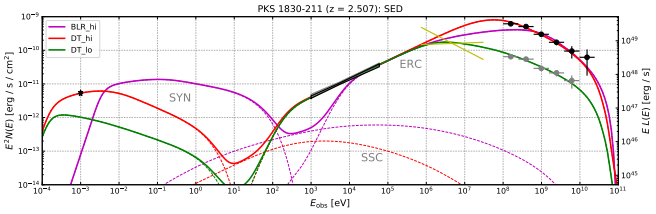

Figure 2 – Preliminary SED of PKS 1830-211 as examplary data that the simulations will be compared to.

References

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