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Accounting for mixing in synchrotron spectral modelling of flickering AGN jets using Lagrangian particles

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We use PLUTO (Mignone et al., 2007) relativistic hydrodynamics (RHD) simulations to connect information about electron energy spectra to the ages and fuelling processes of active galactic nuclei (AGN). We adapt the Lagrangian particle module (Vaidya et al, 2018 and Mukherjee et al, 2021) to model emission from RHD simulations without explicitly evolving the magnetic fields. We further adapt this module to account for the mixing of shocked material with unshocked material, which we find is particularly important for systems with high density contrast between these two populations.

This talk will focus on the adaptations made to account for mixing between shocked and unshocked populations and to allow this modelling in RHD simulations and will cover some early results from the work so far.

We plan to use our simulations to assess the applicability of spectral ageing models to radio observations of jets from AGN, particularly in cases where the jet has a power which varies over time. Estimating the ages of AGN is a key component in being able to estimate the duty cycle and jet power of these systems. By estimating the strength of the magnetic field based on the internal energy density of the fluid, rather than by evolving the magnetic field in a relativistic magnetohydrodynamic (RMHD) simulation, we mirror observational approaches based on equipartition arguments and separate the analysis of the effects of varying jet power from those of detailed shock acceleration physics.

Our approach will allow us to quantify the effects of mixing and of electrons passing through multiple shocks on the energy spectra of the electron populations. Early results suggest that in highly variable jets, the source might look younger after high power periods than after lower power periods due to increased injection of energy into newly shocked material and that we might expect more distinct patches of recently shocked material further back in the lobes shortly after a period of high jet power.

References:

Mignone, A. et al. 2007, PLUTO: A Numerical Code for Computational Astrophysics. The Astrophysical Journal Supplement Series, 170

Mukherjee, D. et al. 2021, Simulating the dynamics and synchrotron emission from relativistic jets –II. Evolution of non-thermal electrons. MNRAS, 505

Vaidya, B. et al. 2018, A Particle Module for the PLUTO Code. II. Hybrid Framework for Modelling Nonthermal Emission from Relativistic Magnetized Flows. The Astrophysical Journal, 865

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