Gamma-ray flares from magnetic reconnection in relativistically magnetized plasmas: minijets vs. plasmoids

K. Nalewajko[1], J. Ortuño-Macías[1]

[1] *Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences, Warsaw, Poland*

The main cosmic sources of high-energy (HE; GeV-scale) gamma-ray radiation are (1) blazars, the most luminous class of active galactic nuclei (AGN), the broad-band emission of which is produced in powerful narrowly collimated jets attaining relativistic bulk speeds and anchored at supermassive black holes; (2) pulsars (rotating neutron stars with strong magnetic fields) and associated wind nebulae (PWN). These sources are also characterized by strong time variability, with rapid gamma-ray flares posing a particular theoretical challenge. A common feature of these gamma-ray emitters is relativistically magnetized collisionless plasma. Efficient gamma-ray emission requires an efficient mechanism of energy dissipation and non-thermal particle acceleration, and relativistic magnetic reconnection is a primary candidate. To explain the production of rapid gamma-ray flares, two aspects of magnetic reconnection received particular attention: outflows from the magnetic diffusion regions attaining relativistic bulk velocities – so-called minijets, and plasmoids (flux ropes) resulting from the tearing instability. The relative importance of minijets and plasmoids is investigated [1] by means of particle-in-cell (PIC) numerical simulations of antiparallel magnetic fields in relativistically magnetized plasma. The algorithm includes radiative cooling due to synchrotron process, and radiative signatures in the form of observer-dependent light curves are calculated. It is demonstrated that minijets and plasmoids co-exist in the same reconnection layer. While minijets can accelerate particles to higher energies, plasmoids dominate the radiative output due to higher particle density. Hierarchical tail-on plasmoid mergers (smaller and faster plasmoids capturing larger plasmoids) can explain the production of rapid gamma-ray flares.

[1] J. Ortuño-Macías & K. Nalewajko „Radiative kinetic simulations of steady-state relativistic plasmoid magnetic reconnection", 2020, MNRAS, 497, 1365, arXiv:1911.06830