

Simulation Study of Diffusive Synchrotron Radiation from Hot Spots in Relativistic Jets such as M87

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Abstract

We propose to apply numerical simulations and modeling to obtain emission spectrum from relativistic shocks and to compare the emission spectrum with observed optical-X-ray spectra from the M87 jet and 3C273. In particular, the project involves the study of relativistic collisionless shocks associated with knots and other optical structures (synchrotron spectrum models and break frequencies) observed in the kpc scale jet from knot HST-1 to knot A. Recent PIC simulations have revealed that in collisionless shocks, plasma waves and their associated instabilities (e.g., the Weibel, Buneman and other two-stream instabilities) are responsible for particle (electron, positron, and ion) acceleration and magnetic field generation. A 3-D relativistic electromagnetic particle (REMP) code will be used to investigate the shock processes in unmagnetized and magnetized electron-ion and electron-positron plasmas in order to obtain self-consistent spectra based on the trajectories of electrons in inhomogeneous magnetic fields. The diffusive synchrotron radiation (DSR) (jitter radiation) theory (Fleishman 2006; Medvedev 2006) shows that the synchrotron radiation spectrum produced by relativistic electrons in the jet is modified by the presence of small-scale random magnetic fields assumed to be generated by the Weibel instability. A high-frequency power-law component to the spectrum is yielded by taking account of the perturbations to the electron trajectories as a result of small-scale magnetic fields, which deviate from the standard synchrotron spectrum, especially at the high frequency. In our investigations, the density of the plasmas, the ambient magnetic field strength and direction, and jet Lorentz factor will be varied in order to evaluate the effect of changes in macroscopic properties (deceleration in jet velocity) that might be expected along the M87 jet. Emission spectra calculated based on electron trajectories in collisionless relativistic shocks (hot spots) generated by the Weibel instability in our simulations and its comparison with observations will enable us to address the radio-optical-X-ray spectra and its variability in M87 and other relativistic sources.

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