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Particle acceleration and high-energy emission in AGN jets: M87 and Cen A

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Jets of active galactic nuclei (AGN) are observed from sub-parsec (pc) to megaparsec (Mpc) scales. They are powerful particle accelerators, producing emissions ranging from radio to gamma rays. In this talk, I will present our analytical and numerical work on particle acceleration in jets. Multi-wavelength (MWL) observations, such as those for Cen A and M87, suggest continuous particle acceleration along the jet. We found that this can be naturally accounted for within the framework of stochastic-type acceleration (Fermi II and shear acceleration) in a spine-sheath type jet. By solving the Fokker-Planck equation, we obtained analytical particle spectra for stochastic-type acceleration, which resemble cutoff-power-law distributions. We found that the MWL emission from the sub-pc scale jet of M87 and the kiloparsec (kpc)-scale jet of Cen A can be well explained by stochastic-shear acceleration. Relativistic magnetohydrodynamic (MHD) simulations and test particle simulations were performed to validate this acceleration process using the MHD-PIC module from the PLUTO code. In the simulations, spine-sheath structures are self-generated mainly through the Kelvin–Helmholtz instability, where simulated cosmic rays are accelerated close to the Hillas limit. Application to Cen A suggests that its kpc-scale jets can account for the dipole anisotropy in ultra-high-energy cosmic rays (UHECRs). These results suggest that stochastic-shear acceleration is both unavoidable and efficient in AGN jets.

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