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Acceleration and Origins of Very- and Ultra-High-Energy Cosmic Rays

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The origin of cosmic rays (CRs) remains an open question, with their spectrum featuring two key breaks: the knee (˜3 PeV) and the ankle (˜3 EeV). Ultra-high-energy cosmic rays (UHECRs) above the ankle are widely believed to originate from extragalactic sources, while the transition of galactic to extragalactic CRs occurs between the knee and the ankle. Recent observations suggest that Centaurus A contributes significantly to UHECR anisotropies, supporting the role of radio galaxies as UHECR sources. In this talk, I will present a framework based on turbulent acceleration in relativistic velocity-shearing jets. This provides a natural explanation of both multi-wavelength (MWL) observations of radio galaxies and UHECR production. Our relativistic magnetohydrodynamic and particle-in-cell (RMHD-PIC) simulations show that CRs can be accelerated near the Maximum theoretical (Hillas) limit. Using jet parameters derived from MWL modeling, we find that Centaurus A-like sources can accelerate CRs to rigidities of several EV, while Cygnus A-like sources can reach several tens of EVs. Additionally, we show that similar acceleration mechanisms in galactic ultra-luminous X-ray sources could contribute to the CR flux between the knee and the ankle.

Collaboration(s)

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