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Energy Spectrum and Mass Composition of Ultra-High-Energy Cosmic Rays from Radio Galaxies

We investigate the potential contribution of radio galaxies (RGs) to ultra-high-energy cosmic rays (UHECRs) above 10^{18} eV. In earlier research, we used relativistic hydrodynamic simulations of jet-driven flows and a Monte Carlo method for cosmic-ray transport to show that shocks, turbulence, and relativistic shear can accelerate Galactic cosmic rays to energies exceeding 10^{20} eV. We found that the time-asymptotic energy spectrum of UHECRs escaping from relativistic jets has a double power-law form with an extended exponential cutoff. This is mostly caused by relativistic shear acceleration.

In this study, we apply this source spectrum to four well-known RGs—Virgo A, Centaurus A, Fornax A, and Cygnus A—and use the publicly available CRPropa code to simulate UHECR propagation over cosmological distances. We estimate the energy spectrum and mass composition of UHECRs reaching Earth and find that Virgo A, with its higher jet Lorentz factor, produces a higher flux and a lighter composition compared to Centaurus A and Fornax A, which have lower Lorentz factors. Cygnus A, despite being a powerful FR-II galaxy, contributes minimally due to its large distance. These results suggest potential differences in UHECR flux and composition between the northern and southern hemispheres at the highest energies.

Collaboration(s)

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