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Ultra-high-energy cosmic ray acceleration by magnetic reconnection in relativistic jets and the origin of very high energy emission

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Relativistic jets are believed to be born magnetically dominated.
Very and ultra-high energy cosmic rays can be efficiently accelerated by magnetic reconnection in these sources. We here demonstrate this by means of three-dimensional relativistic magnetohydrodynamical (3D-RMHD) simulations, injecting thousands of initial low-energy particles in the transition region of the relativistic jet from magnetically to kinetically dominated, where its magnetization parameter sigma ~1. In this region, there is efficient magnetic energy dissipation by fast magnetic reconnection which is naturally driven by kink instabilities (KI) in the initial helical magnetic fields of the jet. We find that the particles are accelerated up to energies $E \sim 10^{18}$ eV for background magnetic fields $B \sim 0.1$ G, and $E \sim 10^{20}$ eV for $B \sim 10$ G. We have also derived directly from the simulations the acceleration rate due to magnetic reconnection which has a dependence on the particles energy, $r_{acc} \propto E^{-0.1}$. The energy spectrum of the accelerated particles develops a power-law tail with spectral index $p \sim -1.2$. Our results may explain observed variable emission patterns, specially at very high energies as well as the associated neutrino emission recently detected in blazars.

Keywords

AGN blazers, particle acceleration, relativistic MHD simulations, UHECRs

Collaboration

CTA

other Collaboration

Subcategory

Theoretical Results

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