Particle Acceleration by Magnetic Reconnection in Relativistic Jets to Extreme Energies

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Relativistic Jets from astrophysical sources like active galaxies are among the most extreme particle accelerators and very high energy (VHE) emitters in the universe. These jets are born magnetically dominated and as such can accelerate particles efficiently by magnetic reconnection in their inner regions close to the source. This process has helped to explain, for instance, the origin of VHE flares in these sources. In this invited talk, I will discuss three-dimensional (3D) magnetic reconnection and particle acceleration in turbulent magnetized flows. I will also present recent results that combine 3D global magnetohydrodynamic relativistic simulations with injection of test particles, showing how the particles are stochastically accelerated in a Fermi process by magnetic reconnection up to ultra-high energies (UHEs) in the relativistic jets. In the simulated models, turbulent fast magnetic reconnection is driven by current-driven-kink instability (CDKI) in the helical magnetic fields of the jet. Average reconnection rates of the order of 0.05 v_A are obtained, where v_A is the Alfvén speed. The simulations reveal a clear association of the accelerated particles with the regions of fast reconnection and largest current density. The accelerated particles develop a power-law spectrum with spectral index $p \sim -1.2$ which is compatible with observations, but slightly flatter due to the lack of particle back reaction into the background plasma. Finally, I will show that these accelerated particles could explain the gamma-ray flares and associated neutrino emission observed in astrophysical sources.