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3D particle-in-cell simulations of particle acceleration in instabilities created by relativistic jets in a cold, ambient plasma

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Astrophysical jets, associated with the activity of central black holes in active galactic nuclei or occurring in Gamma-ray bursts, are a source of ultra-relativistic particles. However, we still miss details on how particles are accelerated to such high energies in astrophysical environments. We will present how the interaction of a jet with a toroidal magnetic field injected within a cold, ambient plasma develops Weibel instabilities, mushroom instabilities and kinetic Kelvin-Helmholtz instabilities and how these in turn modify the magnetic field and thus create electric field sufficiently large to accelerate particles to higher energies. We here consider magnetized electron-positron and electron-ion pairs carrying an initial toroidal magnetic field. For the first time, we perform 3D particle-in-cell simulations allowing us to not only monitor the temporal evolution of fields and instabilities, but also the positions and energies of individual jet and ambient plasma particles. We will present the evolution of the electromagnetic field and its spatial distribution as well as the densities and energies of jet and ambient particles. Finally, we will compare results with simulations results of unmagnetized jets and discuss them with respect to polarimetric observations.

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