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Three-dimensional particle-in-cell simulations of a plasma jet/cloud streaming across a transverse magnetic field

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The dynamics of collisionless plasma jets/clouds in magnetic field configurations typical for the terrestrial magnetotail and frontside magnetosheath is a topic of interest for understanding the physics of the magnetosphere and its interaction with the solar wind. The presence of high-speed jets in the frontside magnetosheath has been recently proved experimentally by Cluster and THEMIS spacecrafts. There is increasing evidence that the bursty bulk flows in the magnetotail have jet-like features. In the present paper we use fully electromagnetic 3D explicit particle-in-cell (PIC) simulations to investigate the interaction of a localized three-dimensional plasma element/jet/cloud with a transverse magnetic field. We consider a plasma jet/cloud that moves in vacuum and perpendicular to an ambient magnetic field. Ampère and Faraday's laws are used to compute the self-consistent electric and magnetic fields on a three-dimensional spatial grid having a step-size of the order of the Debye length and using a time-step that resolves the plasma frequency. The initial magnetic field inside the simulation domain is uniform and the plasma bulk velocity at the beginning of the simulation is normal to the magnetic field direction. The total time scale of the simulation is of the order of few ion Larmor periods. Space and time variations of the plasma parameters and of the electromagnetic field are analyzed and discussed. We emphasize non-MHD effects like the energy-dispersion signatures at the edges of the plasma element, similar to results previously reported by Voitcu and Echim (2012) using test-kinetic simulations.

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