Cherenkov Emission of Whistlers from Electron Holes during Magnetic Reconnection*

Martin V. Goldman,1 David L. Newman,1 Giovanni Lapenta2

1 University of Colorado, Boulder, CO, 80309, USA
2 Leuven Universiteit, Leuven, Belgium

Kinetic simulations of magnetotail reconnection have revealed electromagnetic whistlers originating near the exhaust boundary and propagating into the inflow region. The whistler production mechanism is not a linear instability, but rather is Cherenkov emission of almost parallel whistlers from localized moving clumps of charge (finite-size quasiparticles) associated with nonlinear coherent electron phase space holes. Whistlers are strongly excited by holes without ever growing exponentially. In the simulation the whistlers are emitted in the source region from holes that accelerate down the magnetic separatrix towards the x-line. The phase velocity of the whistlers, \( v_\phi \), in the source region is everywhere well-matched to the hole velocity, \( v_H \), as required by the Cherenkov condition. The simulation shows emission is most efficient near the theoretical maximum \( v_\phi = \) half the electron Alfvén speed, consistent with the new theoretical prediction that faster holes radiate more efficiently. While transferring energy to whistlers the holes lose coherence and dissipate over a few local ion inertial lengths. The whistlers, however, propagate to the x-line and out over many 10's of ion inertial lengths into the inflow region of reconnection. As the whistlers pass near the x-point they modulate the rate at which magnetic field lines reconnect.

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