Electrostatic turbulence driven by current sheets: relation to magnetic reconnection

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Electrostatic instabilities and electron phase space holes driven by a current sheet have been linked to magnetic reconnection by Drake, et al.[1] In this paper we study the electrostatic stability of current sheets and the nonlinear evolution of electrostatic turbulence together with the self-consistent modification of the current sheets by the turbulence they produce. We use a combination of (Vlasov) simulation and theory.

The evolution and lifetime of electron phase space holes turn out to be quite sensitive to the current sheet properties —especially its thickness, strength and composition. The longevity of holes also depends on the electron to ion temperature ratio and the magnitude of the guide magnetic field (parallel to the current sheet).

Robust holes are found, for example, when all of the following conditions are met:

- the guide field is larger than the reconnection field,
- the electrons are strongly magnetized and drifting (relative to ions) in the direction parallel to **B** at twice the electron thermal velocity,
- the ions are weakly magnetized, and
- the sheet thickness is small (e.g., on the order of 10 Debye lengths).

Another condition favorable to the longevity of holes occurs when ions are hotter than electrons.

If the current sheet is thick and the electrons and ions are the same temperature, holes can form by trapping of electrons in the potential energy troughs of oblique electron plasma waves driven by weakly magnetized ions, but they fill in quickly — leaving a tail on the electron distribution function and a reduced current due to momentum transfer from electrons to ions.

Electrostatic instabilities, electron holes and tails on the electron distribution function are studied in relation to magnetic reconnection under a variety of different parameter conditions (using realistic ion masses). Time scales are compared to determine under what conditions electrostatic effects can accompany and possibly influence magnetic reconnection (tearing mode evolution).

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[1]Drake, J. F., M. Swisdak, C. Cattell, M. A. Shay, B. N. Rogers, and A. Zeiler, *Formation of Electron Holes and Particle Energization During Magnetic Reconnection,* Science, 299, (2003)