Role of the Lower-Hybrid Drift Instability in a Reconnecting Current Sheet

William Daughton
Plasma Physics Group
Los Alamos National Laboratory
Los Alamos NM, 87544

In the study of collisionless magnetic reconnection, the subject of anomalous resistivity has a long and controversial history. Many researchers have considered the lower-hybrid drift instability as a possible candidate for producing anomalous resistivity. Unfortunately for neutral sheet geometry, non-local theory predicts the fastest growing modes are electrostatic in character and well localized on the edge of the sheet, while enhanced fluctuations are required in the central region to influence magnetic reconnection. Thus many researchers have concluded that the lower-hybrid does not influence the development of reconnection. However, intriguing new results from the MRX device at Princeton report electromagnetic fluctuations in the lower-hybrid frequency range in the central region of a reconnecting current sheet [1]. Furthermore, these results indicate a correlation between the fluctuations and enhanced rates of magnetic reconnection.

In this work, the properties of the lower-hybrid drift instability are re-examined. The linear Vlasov stability is calculated using a formally exact technique in which the orbit integrals are treated numerically and the eigenvalue problem for the resulting system of integro-differential equations is solved using a finite element representation of the eigenfunction [2]. For the fastest growing lower-hybrid modes with wavelength on the electron gyroscale $\rho_e k_y \sim 1$, the resulting mode structure is localized on the edge of the current sheet. However, for modes with wavelengths intermediate between the electron and ion gyroscale $k_y(\rho_i \rho_e)^{1/2} \sim 1$, the lower-hybrid instability has a significant electromagnetic component to the mode structure which is localized in the central region of the sheet. The addition of a weak guide field complicates the mode structure and gives rise to fluctuations in all three components of the magnetic field. These new predictions from linear Vlasov theory are confirmed using fully kinetic particle-in-cell simulations which indicate the modes saturate at large amplitude in the central region of the sheet. These results suggest the possibility that the electromagnetic fluctuations may potentially influence the development of magnetic reconnection.

[1] H. Ji, S. Terry, M. Yamada, R. Kulsrud, A. Kuritsyn, and Y. Ren, Electromagnetic Fluctuations during Fast Reconnection in a Laboratory Plasma, submitted to PRL (2003).
[2] W. Daughton, Electromagnetic properties of the lower-hybrid drift instability in a thin current sheet, submitted to Phys. Plasmas (2003)