Electron drift instabilities in ExB plasmas: kinetic theory and PIC simulations

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In this work, we present particle-in-cell (PIC) simulations and kinetic theory that demonstrate the importance of electron drift instabilities (EDIs) in typical **E**x**B** discharges, such as Hall-effect thrusters (HETs). Kinetic theory [1-2] predicts that these EDIs produce an enhanced electron-ion friction force that acts as an additional electron momentum loss mechanism. This momentum loss can be orders of magnitude higher than that due to electron-neutral or electron-ion Coulomb collisions, and can explain the "anomalous" electron cross-field transport observed in HETs. The instability-enhanced friction also leads to ion rotation and heating.

Predictions from kinetic theory are compared with results from different 1D (azimuthal) and 2D (radial-azimuthal and axial-azimuthal) PIC simulations where good agreement is found. In particular, the observed instability spectrum in the simulations matches the dispersion relation for EDIs, and "anomalous" electron and ion transport is found to result entirely from an instability-enhanced friction force. The amplitude of electron density fluctuations in the 2D (axial-azimuthal) PIC simulations is found to decrease sharply just downstream of the exit in HETs, and reaches levels almost identical to those measured experimentally [3]. Clear evidence of ion-wave trapping is observed in all simulations, and plays an important role in saturation of the instability.

References:

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