3D Reconnection: onset and topology

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Abstract

We study the stability and non linear behaviour of perturbations in a current sheet. Our tools are a kinetic linear code, explicit massively parallel PIC simulations and implicit PIC simulations. Three classes of instabilities are considered.

First, the tearing instability is observed to grow and cause reconnection as predicted by the linear theory. However, in accord with an early theoretical study, the tearing mode in 2D is observed to saturate at very low amplitude, too low to explain the onset of macroscopic magnetic reconnection observed in 3D simulations and in real plasmas. Furthermore, in presence of a magnetic field component orthogonal to the current sheet, the tearing instability is stabilized.

Second, modes propagating in oblique directions appear to be irrelevant in the cases considered.

Third, the true cause of the onset of reconnection is linked to the modes propagating in the current direction and particularly to the lower hybrid drift instability (LHDI). The LHDI is shown to cause 3 modifications of the initial Harris configuration: creation of a velocity shear, introduction of temperature anisotropy and thinning of the initial current profile. These effects offset the saturation and stabilization mechanisms of the tearing instability and allow reconnection to progress beyond the saturation level of the pure tearing mode.

The modifications induced by the LHDI cause a profound change of the topology and configuration of the reconnection region. An example of the reconnected configuration is shown in the figure below, where, besides the presence of a classic reconnection x-line, one can observe the presence of kinking in the y direction and a flux rope structure replaces the usual 2D plasmoid.