Role of LHD instabilities in reconnection: application to the tail

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Abstract

Carrying out a large scale three-dimensional full kinetic simulation, we have shown that the effects of lower-hybrid waves at the edges of the current sheet provide a quick triggering of magnetic reconnection (QMRT) even in ion-scale current sheets. A thin embedded electron current layer is formed as a result of the non-linear evolution of the lower hybrid drift instability (LHDI), which is sustained by accelerated meandering electrons around the neutral sheet, and the emergence of thin electron current layer is subject to QMRT.

The electron acceleration is caused by the inductive electric field associated with the change of the magnetic structure due to the LHDI non-linear evolution. (1) At first, the cross-field current in the boundary region is strongly reduced during the non-linear phase of LHDI. (2) Associated with the current reduction, the magnetic field penetrates toward the neutral sheet. (3) The electric field associated with the change of the magnetic field profile accelerates meandering electrons around the neutral sheet. (4) As a result, the electron current density around the neutral sheet is enhanced, and the thin electron current layer is formed. Since the growth rate of the collisionless tearing instability essentially depends on the amount of the electric current carried by the non-adiabatic particles, the increase of the accelerated meandering electrons strongly controls the evolution of the tearing mode.

To evaluate whether the quick triggering mechanism mediated by LHDI is truly realistic, we performed a parametric study of magnetic reconnection with LHDI. Consequently, we confirmed that the proposed scenario of the quick reconnection triggering is available with the real ion-electron mass ratio m_i/m_e=1836. However, there may be an upper-limit to the current sheet thickness for this type of quick triggering mediated by LHDI alone because the LHD wave activity becomes weaker in the thicker current sheet. Another parametric simulation study on QMRT changing the current sheet thickness, *D*, shows that the growth rate is approximately scaled as 1/*D*. When the thickness of current sheet is more than the ion inertia length, this QMRT scaling law breaks down. In such cases, the bifurcated current sheet, instead of the embedded thin current layer, is generated as a result of the LHDI non-linear evolution in thicker current sheets. We found that the speed of reconnection triggering in the bifurcated current sheet is still much quicker than that predicted by two dimensional theories. We will discuss the application of QMRTs to the bifurcated tail current sheet observed by Cluster-II.