Study on the reconnection jet fronts based on fully kinetic simulations

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We have performed a series of 3-D fully kinetic particle-in-cell simulations of anti-parallel magnetic reconnection to investigate the three-dimensional development of reconnection jet fronts treating three instabilities: the lower hybrid drift instability (LHDI), the ballooning/interchange instability (BICI), and the ion kink instability. Sufficiently large system size and high ion-to-electron mass ratio of the simulations allow us to see the coupling among the three instabilities in the fully kinetic regime for the first time. In this study, we particularly focused on the two cases changing the initial density ratio R between the center of the current sheet and the background region. In Case-A, R is set to be 20, which is large enough to excite the LHDI at the reconnection jet fronts. In this case, as the jet fronts develop, the LHDI and BICI become dominant over the ion kink instability. The rapid growth of the LHDI enhances the BICI growth and the resulting formation of finger-like structures. The small-scale front structures produced by these instabilities are similar to recent high-resolution observations of the dipolarization fronts in the near-Earth magnetotail using the Magnetospheric Multiscale (MMS) mission. On the other hand, in Case-B in which R=3.3, we see neither rapid growth of the LHDI nor turbulent development of the jet fronts. These results indicate the importance of the LHDI in the turbulent development of the reconnection jet fronts and the resulting energy conversion at the jet fronts.