磁気リコネクションのセパラトリクス領域における波動活動

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Wave activities in the separatrix regions of magnetic reconnection

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It is important to understand the nature of waves arising in association with magnetic reconnection in collisionless regime. The wave activities could give rise to the anomalous magnetic dissipation and/or particle scattering leading to the nonthermal plasma component. In fact, satellite observations in the Earth magnetotail have indicated that the wave activities are significantly enhanced in a variety of frequencies near the reconnection region. In particular, recent Cluster observation has shown that three types of waves are activated in the separatrix regions of magnetic reconnection where intense electron beams are coincided. One of the waves is the Langmuir wave with the electron plasma frequency, the second is the electrostatic solitary wave (ESW), and the last is the whistler wave with electron cyclotron frequency. However, because of the limited space-time resolution, it is difficult to identify the generation mechanisms and the role of these waves only from the satellite data. Therefore, numerical simulations with full kinetic approach can be a strong tool to reveal the nature of the waves.

In this study, we have performed a large-scale 2D particle-in-cell simulation with adaptive mesh refinement under an open boundary condition. We used more realistic values of the ion-to-electron mass ratio and background plasma density compared to those in the previous simulations. This set of the parameters gives much faster electron outflow velocity than the local electron thermal velocity, so that the electron beam instabilities are subject to be triggered. As a result, the present simulation has shown that the separatrix regions are a full of microscopic waves with the electron scales, contrary to the previous simulations. It is found that both the electrostatic and electromagnetic waves are excited and propagate almost along the field line. The ESWs are also reproduced due to a nonlinear effect of the electrostatic mode.

In this paper, we show recent results of a large-scale particle-in-cell simulation of collisionless reconnection and discuss the generation mechanisms of the waves which are excited in the separatrix region.