



Electrostatic Solitary Waves and Electron-beam instabilities in the Separatrix Region of Magnetic Reconnection

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Electrostatic solitary waves (ESWs) are one kind of highly nonlinear structures in collisionless plasma, which are often interpreted as electron phase-space holes (electron holes or EHs) with electron trapping. Kinetic simulations have demonstrated that ESWs are produced in the nonlinear stage of various plasma instabilities related to electron beams, including the electron two-stream instability, the electron bump-on-tail instability, the Buneman instability.

Electron beams in magnetic reconnection may generate ESWs. Actually, satellite observations and numerical simulations have demonstrated the existence of ESWs in the vicinity of the X line, the separatrix region, and the jet front of magnetic reconnection. Furthermore, recent studies indicated that multiple kinds of ESWs with different propagating velocities may coexist near the reconnection separatrices. It is interesting to analyze the detailed characteristics of the ESWs, including generation mechanisms, propagating directions and speeds.

By performing 2-D PIC simulations of symmetric reconnection with the focus on the excitation of ESWs in the separatrix region, we find that multiple kinds of ESWs can be simultaneously formed around the separatrices. Near the current sheet in the outflow region, there are two kinds of ESWs propagating away from the X-line, the slower one corresponds to the Buneman instability and the faster one results from the electron two-stream instability. In the separatrix region, there is one kind of ESWs propagating toward the X line, which is generated by the electron two-stream instability.

We also run a case with a guide field, and there exist two kinds of ESWs: the ESWs propagating away from the X line can be generated near the separatrices with electron outflow, while the ESWs propagating toward the X line can be generated near the separatrices with electron inflow. The two kinds of ESWs are associated with the electron two-stream instability and the Buneman instability, respectively.