PARTICLE SIMULATION OF PLASMA RESPONSE TO AN APPLIED ELECTRIC FIELD PARALLEL TO MAGNETIC FIELD LINES

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We study response of thermal plasmas to an induced electric field via particle simulations. We assume a small segment of the magnetic field line in the magnetotail where a large scale of induced electric field appears due to meandering motion of the current sheet. Taking the small uniform area as a simulation model, we performed one-dimensional electrostatic particle simulation with a constant external electric field applied to a Maxwellian thermal plasma with isotropic electrons and ions. The electric field is assumed to be due to magnetic induction which has a much longer time scale compared to the time scale of the kinetic processes studied in the present particle simulations. Due to the acceleration of electrons and ions in the opposite directions, there arise counter streaming electrons and ions that cause the Buneman instability. Depending on the ratio of the ion temperature to the electron temperature, the responses to the electric field are different. For a case with hot ions with the temperature much grater than that of electrons, the Buneman instability leads to formation of large isolated electrostatic potentials which trap a low energy part of electrons to move with ions. For colder ions, the Buneman instability is taken over by excitation of ion acoustic waves, which defuse the low energy part of the accelerated electrons to stabilize the instability. However, a substantial part of the electrons are grouped together at the high energy part, forming a distinct bump in the electron distribution. In the present simulations we have found that an induced electric field can form an electron beam along the magnetic field line. Since the electron beam leaves the region of the induced electric field moving into an unperturbed plasma, the accelerated electrons can cause a bump-on-tail instability. This leads to formation of electrostatic solitary waves as frequently observed by the Geotail spacecraft in the plasma sheet boundary layer (PSBL). The persistent observation of the electrostatic solitary waves indicates their association with the induced electric field that results from the meandering motion of the current sheet in the magnetotail.