Observations and Effects of Dipolarization Fronts Observed in Earth's Magnetotail

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Dipolarization fronts in Earth's magnetotail are characterized by sharp jumps in magnetic field, a drop in density, and often follow earthward fast plasma flow. They are commonly detected near the equatorial plane of Earth's tail plasma sheet. Sometimes, but not always, dipolarization fronts are associated with global substorms and auroral brightenings. Both Cluster, THEMIS, and other spacecraft have detected dipolarization fronts in a variety of locations in the magnetotail. Using multi-spacecraft analyses together with simulations, we have investigated the propagation and evolution of some dipolarization events. We have also investigated the acceleration of electrons and ions that results from such magnetic-field changes. In some situations, the velocities of fast earthward flows are comparable to the Alfvén speed, indicating that the flow bursts might have been generated by bursty reconnection that occurred tailward of the spacecraft. Based on multi-spacecraft timing analysis, dipolarization fronts are found to propagate mainly earthward at 160–335 km/s and have thicknesses of ~900–1500 km, which corresponds to the ion inertial length or gyroradius scale. Following the passage of dipolarization fronts, significant fluctuations are observed in the x and y components of the magnetic field. These peaks in the magnetic field come ~1–2 minutes after passage of the dipolarization front. These Bx and By fluctuations propagate primarily dawnward and earthward. Field-aligned electron beams are observed coincident with those magnetic field fluctuations. Non-Maxwellian electron and ion distributions are observed that are associated with the dipolarization that may be unstable to a range of electrostatic and/or whistler instabilities. Enhanced electrostatic broadband noise at frequencies below and near the lower-hybrid frequency is also observed at or very close to these fronts. This broadband noise is thought to play a role in further energizing the particles. Such studies provide insights into the particle acceleration mechanisms associated with substorm dipolarization, and, in turn, the effects of those acceleration mechanisms on the structure and evolution of dipolarization fronts.

Keywords: Magnetosphere; magnetotail; dipolarization; acceleration.