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Ion and electron kinetic physics associated with magnetotail dipolarization fronts

Jonathan Eastwood (1), Martin Goldman (2), David Newman (2), Xiao-Jia Zhang (3), Heli Hietala (3), Vratislav Krupar (1), Rishi Mistry (1), Giovanni Lapenta (4), and Vassilis Angelopoulos (3)

(1) Imperial College London, Department of Physics, London, United Kingdom, (2) University of Colorado, Department of Physics, Boulder CO, USA, (3) UCLA, Institute of Geophysics and Planetary Physics, Los Angeles CA, USA, (4) Katholieke Universiteit, Center for Plasma Astrophysics, Leuven, Belgium

Magnetic reconnection plays an important role in controlling the dynamics of the Earth's magnetotail. In particular, a dipolarization front (DF) may form at the leading edge of the reconnection exhaust as a consequence of its interaction with the pre-existing plasma sheet. Earthward moving DFs typically exhibit a rapid increase in the northward component of the magnetic field which divides the pre-existing plasma sheet from the hotter, high speed and lower density reconnection exhaust. Extensive observations have been made of DFs at Earth with multi-point missions such as Cluster, THEMIS/ARTEMIS and now Magnetospheric Multi-Scale (MMS). In this invited contribution we will first review previous work showing that DFs are often relatively thin and locations where significant particle acceleration and heating can occur in a variety of ways.

The dynamics and kinematics of ions and electrons at DFs are very different, as a result of their different particle masses. The reflection of ions by DFs leads to acceleration and heating, and we show that via kinetic effects, some part of the pre-existing plasma sheet ion population is entrained and accelerated into the exhaust. This interaction in fact occurs over a macroscopic region, rather than simply being limited to the thin DF interface. This leads to a more general consequence which is that reconnection exhausts are not necessarily simply fed by plasma inflow across the separatrices, but also by plasma from the region into which the jet is propagating; the implications of this finding are discussed. In contrast, electron acceleration and thermalisation is more related to the presence of instabilities in particular associated with temperature anisotropy and the growth of whistler waves. We discuss the observational evidence and also explore the possibility of the role that Cherenkov emission of whistlers by electron holes could play in this process.

Finally we will briefly highlight recent new work in this area, and expected future advances. This will focus on the development of 3D simulations of DF physics and data from MMS.