Magnetic mirror structures associated with magnetopause flux ropes investigated with Magnetospheric Multiscale mission (MMS)

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Magnetic reconnection is a fundamental plasma physics process which governs energy and mass transfer from the solar wind into the Earth’s magnetosphere. Electron acceleration during reconnection has been widely investigated with multiple mechanisms proposed. Many of these mechanisms involve flux ropes: twisted magnetic field structures formed during reconnection. Drake et al. 2006 suggest that contracting magnetic islands (or flux ropes in 3D) could trap and energise electrons by a Fermi acceleration process.

Whilst previous missions have observed and characterised flux ropes, the temporal resolution of the data was typically not great enough to study structures in detail, particularly on electron scales. Here we investigate magnetopause flux ropes using data from NASA’s four spacecraft Magnetospheric Multiscale mission (MMS). MMS measures the thermal electron and ion 3D distribution at 30 msec and 150 msec time resolution, respectively, and at spacecraft separations down to a few kilometers.

We focus on electron pitch angle distributions and examine how they can be used to investigate magnetopause flux ropes. In particular, the distributions are used to identify electron trapping in magnetic mirror structures on the magnetospheric edge of the flux ropes. These features are found to have extended 3D structure along the body of the flux rope. We evaluate possible formation mechanisms, such as the mirror instability, and potential electron acceleration mechanisms, such as betatron and Fermi acceleration. Magnetic mirror structures could represent an important particle acceleration feature for flux ropes and magnetic reconnection.