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Observations of thin current sheet during magnetic reconnection in the Earth's magnetotail

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Magnetic reconnection in the near-Earth magnetotail has been considered as the major driver of the energy conversion process leading to large-scale reconfiguration of the magnetotail, such as storm and substorm. The reconnection jet (known as bursty bulk flow) and its interaction with the Earth's dipole field lead to further acceleration of particles and formation of field-aligned currents so that the energy is transported toward inner magnetosphere as well as dissipated in the ionosphere. High-time resolution measurements from the four MMS spacecraft have enabled us to study dynamics of the sub-ion as well as electron-scale processes in thin current sheets formed in the reconnection region as well as the thin fronts or boundaries of the reconnection jets. In this presentation, we highlight two types of observations of the thin current sheets during magnetic reconnection in the magnetotail based on multi-point data analysis of fields and particles.

Observation of electron diffusion region
MMS observations of a thin current sheet crossing event during a near-Earth magnetotail reconnection enabled us to resolve detailed structure of the electron diffusion region (EDR). Figure 1 shows an EDR crossing of quasi-2D magnetic reconnection from Nakamura et al. [2019] presenting the current sheet and motion of X-line deduced from the four spacecraft measurements. Identifying the spacecraft location relative to X-line enabled us to determine the spatial change in field and particle within the EDR. Non-gyrotropic features of electrons and their contribution to the reconnection electric field was determined.

Observation of boundaries of outflow region
Separatrix region, which is the boundary between the reconnected and un-reconnected fields, is also a key region of energy conversion related to reconnection. In contrast to the very rare encounter of EDR region by spacecraft in magnetotail, there has been a number of MMS observation in the outer edge of the ouflow region, which extends along the magnetotail. MMS multi-point observations of field-aligned motion of the electrons at the separatrix boundary were used for remote sensing of the reconnection site [Varsani et al., 2018] and also obtained characteristic feature of the localized out flow [Nakamura et al., 2018].

The evolution of the current sheet and the reconnection electric field is discussed based on these observations at the vicinity of the electron diffusion region and at the boundaries of outflow region.

References:
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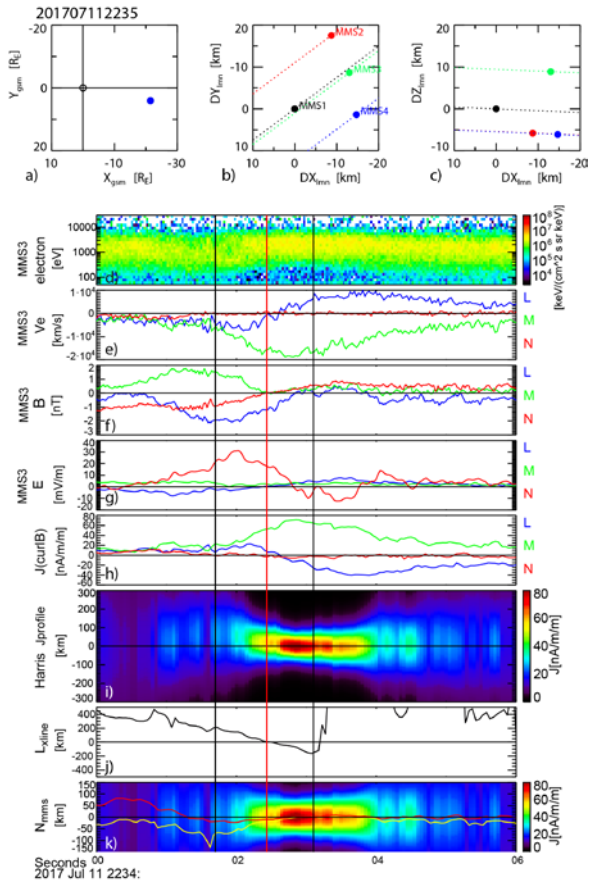

Figure 1. Magnetospheric Multiscale (MMS) spacecraft location and overview of the thin current sheet observation near the X-line. (a) Location of MMS with spacecraft constellation in (b) L M plane and (c) L N plane. (d) Electron energy spectra, (e) electron flow, (f) magnetic field, (g) electric field (h) current density (i) current sheet model, (j) location of the X-line and (k) spacecraft location within the current sheet model (from Nakamura et al., 2019)