Magnetic island formation in reconnecting electron-scale current sheet: MMS observations in the magnetotail

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Magnetic reconnection controls the transport of solar wind mass and energy into Earth's magnetosphere and is the key to explosive energy release in the magnetotail during magnetospheric substorms. A simplest form of magnetic reconnection in space occurs in the magnetotail where the magnetic fields are nearly antiparallel, no significant jumps in plasma parameters exist across the current sheet, and no significant turbulence is seen in the inflow (lobe) regions. The Magnetospheric Multiscale (MMS) spacecraft, however, have revealed complex features such as a displacement of the stagnation point relative to the X point in the outflow jet direction even for magnetotail reconnection. Here, using in situ observations from MMS in the magnetotail, we present evidence of secondary magnetic island formation in a reconnecting electron-scale current sheet in the magnetotail detected by MMS. The electron diffusion region (EDR) of the event, first reported by Zhou et al. (ApJ, 2019), was recovered by two reconstruction techniques. One is based on electron magnetohydrodynamics equations (Sonnerup et al., JGR, 2016), and the other on polynomial expansion of the magnetic field using instantaneous measurements by the four spacecraft of the magnetic field and particle current density (Denton et al., JGR, 2020). The results from both reconstructions show that a small-scale magnetic island was growing in a reconnecting current sheet with a thickness of about one electron inertial length, consistent with fully kinetic simulations of antiparallel reconnection (Daughton et al., PoP, 2006). It suggests that secondary island formation is an intrinsic process in the EDR of antiparallel reconnection, and reconnection may drive turbulence energy cascade at sub-ion scales by creating sub-ion-scale islands in electron-scale current sheets.

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