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Observations of Large Scale Magnetic Reconnection under Guide Field within Thick Current Sheet at the Magnetopause Boundary Layer

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Magnetic reconnection is a fundamental plasma process, during which magnetic energy is converted into plasma kinetic and thermal energy. It is always accompanied with changes of magnetic field topological structures. Magnetic reconnection are frequently observed in the astrophysical and space plasma, such as in solar flares, solar wind, Earth's magnetopause and magnetotail etc.[1,2,3]

The crucial region during magnetic reconnection can be divided into ion diffusion region (where the ions can be demagnetized) and electron diffusion region (where the electrons can be demagnetized) due to the different mass between the ions and the electrons. Around or in the diffusion region, the significant phenomenon is Hall effect that can form Hall currents, Hall bipolar electric field and Hall quadrupolar out-of-plane magnetic field because of the relative motion between the ions and the electrons.[4] Electron diffusion region, which is embedded in the ion diffusion region, can extend along the outflow direction and develop two-scale structure, i.e., outer electron diffusion region and inner electron diffusion region. The inner electron diffusion region containing the X-line is the core region during the magnetic reconnection, which features intense electron currents, nonzero $\boldsymbol{E}' = \boldsymbol{E}+\boldsymbol{V}_e\times\boldsymbol{B}$ and electron dissipation $\boldsymbol{J}^*\boldsymbol{E}' > 0$ etc[5]; while the outer diffusion region can extend tens of d_i (where d_i is ion inertial length) along the outflow direction, where the electrons are remain decoupled from the magnetic field and form a super-Alfvénic outflow jet, strong electron currents and $\boldsymbol{J}^*\boldsymbol{E}' < 0$. The inner electron diffusion region has recently been *in-situ* identified at the terrestrial magnetopause by the unprecedented high-resolution measurements from the MMS mission, while the outer electron diffusion region or super-Alfvénic electron jet was also observed in the terrestrial magnetosheath, in the terrestrial magnetotail, and at the magnetopause.[6,7,8]

With the contribution of Magnetospheric Multiscale mission, we report a large scale of electron diffusion region (EDR, with the width of 1 d_i) extended at least 50 d_i (ion inertial length) in the outflow region within thick current sheet (the width of ~4 d_i) at Earth's Magnetopause Boundary Layer in Fig. 1. Magnetic reconnection took place with a certain guide field but without obvious ion burst outflow. During the crossing of magnetic reconnection region, it is accompanied with a strong positive energy dissipation ($\boldsymbol{J}^*\boldsymbol{E}'>0$) and obvious electron accelerations at the energy range of 30-600 eV. These electrons are accelerated along to parallel and anti-parallel magnetic field direction. In addition, we found that the parallel electric field dominated the acceleration progress than other factors. Our observations help us to more deeply understand the reconnection process in the space plasma.

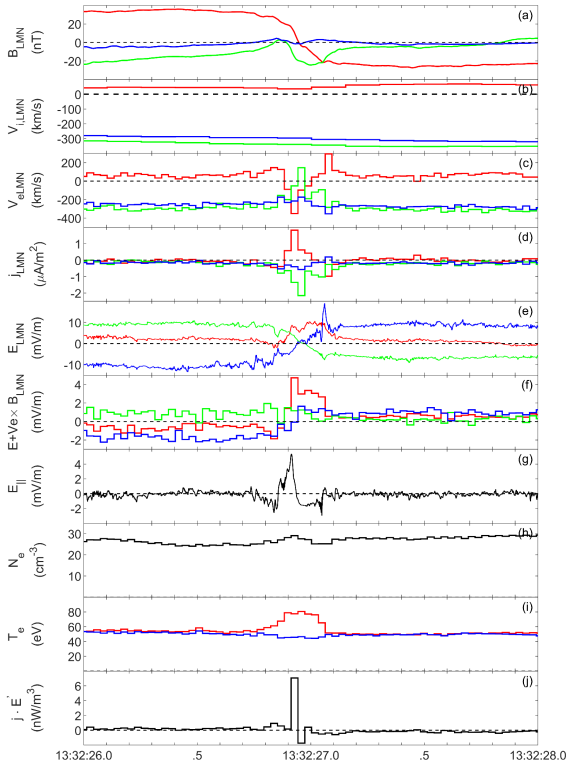

Fig. 1. MMS observations of electron diffusion region at the magnetopause boundary layer.

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