Electron Pressure-Strain Interaction Structures as a Marker for Reconnection Growth Phase: MMS Observations

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Abstract

Magnetic reconnection is a fundamental plasma process that converts electromagnetic energy into bulk kinetic and thermal energy of the plasma through topological rearrangement of the magnetic field. Understanding the onset and early phases of magnetic reconnection remain one of the central open problems in space plasma physics. A key observational challenge in studying reconnection using in situ spacecraft measurements lies in diagnosing the temporal phase of the process, namely distinguishing between the growth phase and later phases, e.g. the steady state. Recently, Barbhuiya et al. (2025) (1) proposed that the opening of the separatrices within the electron diffusion region (EDR) may serve as a signature of the reconnection growth phase. Using 2D PIC simulations, Ref.(1) demonstrates that the opening of the separatrices is associated with electron flow patterns which result in characteristic spatial structures in the electron pressure-strain interaction. Recent studies have shown that the pressure-strain interaction can be estimated in near-Earth space by using Magnetospheric Multiscale (MMS) (2,3). In this study, we test the prediction of Ref.(1) by analyzing EDR encounters observed by MMS mission in Earth's magnetotail. (1) Barbhuiya, M. H., Cassak, P. A., Chasapis, A., Shay, M. A., Cozzani, G., A. Retinò, J. Gephys. Res, 130, e2024JA033446 (2025).
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