Reconstruction of the electron diffusion region of magnetotail reconnection seen by the Magnetospheric Multiscale spacecraft

*Hiroshi Hasegawa[1], Richard E. Denton[2], Rumi Nakamura[3], Kevin J. Genestreti[4], Takuma Nakamura[3], Kyoung Joo Hwang[5], Tai D. Phan[6], Roy B. Torbert[4], Jim L. Burch[5], Barbara L. Giles[7], Dan J. Gershman[7], Chris T. Russell[8], Bob J. Strangeway[8], Per Arne Lindqvist[9], Yuri V. Khotyaintsev[10], Robert E. Ergun[11], Naritoshi Kitamura[12], Yoshifumi Saito[1]

1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Dartmouth College, 3. Space Research Institute, Austrian Academy of Science, 4. University of New Hampshire, 5. Southwest Research Institute, 6. University of California Berkeley, 7. NASA Goddard Space Flight Center, 8. University of California Los Angeles, 9. Royal Institute of Technology, 10. Swedish Institute of Space Physics, 11. University of Colorado, 12. University of Tokyo

Magnetic reconnection is a fundamental plasma process that controls transfer of solar wind energy and mass to planetary magnetospheres and causes explosive energy release associated with solar flares and sudden auroral brightening. NASA's Magnetospheric Multiscale (MMS) mission, which consists of four identical spacecraft launched in March 2015, aims at elucidating how magnetic reconnection works with unprecedented high temporal and spatial resolution measurements of charged particles and electromagnetic fields in space. MMS has been observing Earth's magnetotail since May 2017, and encountered the central region of magnetic reconnection, called the electron diffusion region (EDR), on 11 July 2017 (Torbert et al., Science, 2018). We present results from the reconstruction of the electron diffusion region (EDR) observed in this event. The conditions were suited for the reconstruction technique, developed by Sonnerup et al. (JGR, 2016), that produces magnetic field and electron streamline maps based on a two-dimensional (2-D), time independent, inertia-less form of electron magnetohydrodynamic equation, assuming an approximately symmetric current sheet and negligible guide magnetic field. Our reconstruction results (Hasegawa et al., JGR, 2019) indicate that although the X point was not captured inside its tetrahedron, MMS approached the X point as close as one electron inertial length ~27 km. The opening angle of the recovered separatrix field line, combined with theory, suggests that the dimensionless reconnection rate was 0.17, which is consistent with the measured reconnection electric field 2–4 mV/m. The stagnation point of the reconstructed electron flow is shifted earthward of the X point by ~90 km, one possible interpretation of which is discussed. The energy conversion rate **j*E'** in the electron frame tends to be higher near the stagnation point, consistent with earlier observations and simulations, and is not correlated with the amplitude of broadband electrostatic waves observed in the upper-hybrid frequency range. The latter suggests that the waves did not contribute to energy dissipation in this particular EDR.

References:

Hasegawa, H., Denton, R. E., Nakamura, R., Genestreti, K. J., Nakamura, T. K. M., Hwang, K.-J., et al., Reconstruction of the electron diffusion region of magnetotail reconnection seen by the MMS spacecraft on 11 July 2017. Journal of Geophysical Research: Space Physics, 124. https://doi.org/10.1029/2018JA026051, 2019.
Sonnerup, B. U. O., H. Hasegawa, R. E. Denton, and T. K. M. Nakamura, Reconstruction of the electron diffusion region, J. Geophys. Res. Space Physics, 121, 4279-4290, doi:10.1002/2016JA022430, 2016.
Torbert, R. B., J. L. Burch, T. D. Phan, ... Y. Saito, Electron-scale dynamics of the diffusion region during symmetric magnetic reconnection in space, Science, doi:10.1126/science.aat2998, 2018.

Keywords: magnetic reconnection, magnetotail, electron diffusion region