Advances in Reconnection, Acceleration and Turbulence with MMS

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The NASA Magnetospheric Multiscale (MMS) mission was launched in March 2015 to investigate electron-scale phenomena (magnetic reconnection, particle acceleration and turbulence) in the boundary regions of the Earth's magnetosphere. Four spacecraft in tetrahedral configuration with scale sizes of 7 - 160 km perform high time resolution plasma measurements (30 ms for electrons, 150 ms for ions), accurate 3D electric and magnetic field measurements, and energetic particles and ion composition measurements to investigate conversion of magnetic energy to charged particle energy in the electron diffusion region (EDR) of reconnection. These capabilities also allow investigation of ion diffusion regions, flux transfer events, hot flow anomalies, bow shocks, Kelvin-Helmholtz instabilities, and many other phenomena in the geospace boundary regions. A rather complete picture of asymmetric reconnection at the dayside magnetopause and the magnetosheath has been obtained. Predictions about the source of the reconnection electric field, the location of the electron stagnation region Earthward of the X-line, and the existence of electron crescent distributions in the electron diffusion region (EDR) have been confirmed and described in greater detail. New discoveries include similar crescent distributions in electron outflow jets, generation of high-frequency waves by the crescent distributions, and energy conversion occurring near the X-line only for significant guide fields while otherwise confined to the stagnation region. Observations of reconnection in the magnetotail reveal multiple electron crescent distributions as suggested by simulations, generation of high-frequency waves by the multiple crescents, electron acceleration to several hundred keV by turbulent electric fields, and reconnection rates of 0.1 - 0.2 as predicted by simulations. The tetrahedron formation will be maintained until 2022 after which different configurations (string of pearls, leader with following three-spacecraft cluster, etc.) may be used for targeted investigations. The current orbit with perigee of ~1.3 R_E, apogee of 29 R_E, and inclination of 28 deg., will be maintained.

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