Magnetic Reconnection at the Earth's Magnetopause

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The observations at the Earth's magnetopause by the MMS have produced an extraordinarily detailed view of the dynamics of reconnection.[1] While some theoretical ideas on the structure of the electron diffusion region have been confirmed in the observations (e.g., the crescents in the electron velocity distributions and the shift in the peak of the reconnection-driven current toward the magnetosphere[1]), there have been a number of surprises that contradict the expectations of pre-MMS theory and models. The electron diffusion region is much more turbulent than expected, even in reconnection events with weak magnetic shear and a strong ambient guide field.[2] Measured magnetic energy dissipation rates can take on extreme values, more than two orders of magnitude greater than in pre-MMS predictions.[3] 2D and 3D PIC simulations of specific MMS reconnection events have been instrumental in unraveling some of these MMS discoveries. The localized regions of intense dissipation are associated with standing whistler-like structures and involve dissipation of the self-generated Hall magnetic field.[4] 3D simulations of the Oct 16, 2015, (weak guide field)[5] and the December 8, 2015, (strong guide field) events both exhibit strong lower hybrid drift turbulence that is peaked along the magnetopause separatrix and is driven by the ion pressure gradient across the magnetopause. In the simulations the turbulence is strong enough to prevent the reconnection-driven current layer from collapsing to electron scales. While the simulations also suggest that the turbulence is strong enough to impact Ohm's law by producing an anomalous resistivity or viscosity, the observations don't support this conclusion. Thus, the impact of the strong turbulence measured at the magnetopause on reconnection remains an open question that is still being explored.

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