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Parallel Electric Fields Associated with Sub-Solar Reconnection: MMS Observations

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We present MMS observations of parallel electric fields associated with sub-solar magnetic reconnection and provide an early interpretation of their implications on the reconnection processes. The MMS satellites have observed many instances of large-amplitude parallel electric fields (10's to greater than 100 mV/m) that appear to lie on or near the magnetic reconnection separatrix, in particular, near a strong current layer on the magnetospheric-side separatrix. These parallel electric field events are directly associated with magnetic reconnection and, on most occasions, are recorded by more than one of the MMS spacecraft.
We see several types of parallel electric fields. We interpret purely parallel electrostatic waves and the evolved non-linear states of these waves as mixing of cold plasma with warm magnetosheath plasma on a freshly reconnected field line. Large-amplitude spikes associated with tangled magnetic fields represent possible secondary reconnection events.
Whistler waves and evolved non-linear whistler waves are associated with associated with mixing of plasmas. These observations suggest that (1) magnetic reconnection is often "patchy" and results in tangled magnetic field lines and that (2) cold plasma (<10 eV) is often present in sub-solar reconnection.