The X-line structure in the near-Earth magnetotail during substorms

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Magnetic reconnection is thought to be one of the key processes in the Earth's magnetotail during substorms. In this process, the stored magnetic energy is converted into the kinetic energy. The relative motion of ions and electrons around the diffusion region generates the Hall current system, which produces a quadrupole magnetic field across the tail. This ion-electron decoupling motion is supposed to make the electric field toward the equatorial plane, which makes particles move dawnward by the ExB drift.

In this study, we have investigated the X-line structure in the near-Earth magnetotail during substorms using magnetic field and plasma data obtained from Cluster multi-satellite observations. During a substorm on 21 August 2002, when Cluster satellites were located on the dawn side of the magnetotail, tailward ion flow at a velocity of about -1200 km/s with negative B_z and subsequent earthward flow at V_x>500 km/s were observed. This flow reversal was accompanied by the current sheet thinning with a thickness of about 500 km and cross-tail current density above 15 nA/m^2. Near the reconnection region, the quadrupole magnetic field was observed, which indicates the existence of the Hall current structure around the X-line. When a satellite crossed the outermost region of the plasma sheet around the reconnection site, 2-component ions were observed: one was the high energy ions with a temperature of about 30 keV outward from the X-line, and the other was the lower energy ones with a temperature of about 5 keV streaming into the X-line. The latter inflow ions often showed the duskward motion almost perpendicular to the magnetic field. This observation seriously disagrees with the expected ExB dawnward drift which is caused by the ion-electron decoupling.