

Superposed epoch study of the substorm triggering in the Earth's magnetotail

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Time development of near-Earth magnetotail during substorms has been investigated by superposed-epoch analysis with Geotail data. The start time of each substorm was determined by Polar/UVI and Image/FAR data. Key parameters derived from plasma and magnetic field data of Geotail were sorted in the X(GSM) - Z(estimated) coordinates, according to the method described in a paper by Machida et al. [JGR, 25291, 2000], in which we assume that an event with higher plasma-beta should be located closer to the plasma-sheet center.

The result shows that the earthward flows exist in the plasma-sheet boundary layer from $-20R_E$ to $-30R_E$ in X prior to the substorm onset as well known already. Interestingly, the duskward electric field enhancement starts in the lobe side at $X \sim -10R_E$ and propagate to the downtail plasma sheet. In the plasma sheet boundary layer around $X = -15R_E$, the total pressure enhances from about 6 min before the substorm onset. These are the key elements to understand the triggering mechanism of substorm.

After $t = 0$, i.e., the auroral break-up, the dipolarization and the tailward flows with southward magnetic fields related to plasmoids start. There is some evidence of earthward flows, but it is not as pronounced as the tailward flows. The total pressure decrease starts 2 min before the onset at $X \sim -17R_E$ and this variation propagates to the surrounding regions. This seems to be the initial phase of the explosive variations associated with the substorm. Interestingly, the duskward electric field does not enhance in this region, contradicting with a conventional theory of the magnetic reconnection, in which the duskward electric field enhances first at the magnetic neutral line and propagates to the surrounding regions after the reconnection starts.