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Auroral expansions associated with magnetospheric flows and electric fields: THEMIS coordinated observations

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Substorms are abrupt energy release processes in the magnetosphere-ionosphere system, associated with reconfiguration of the magnetosphere and auroral breakup. At substorm onsets, plasma flows in the magnetotail and ionospheric convection are enhanced with auroral dynamic enhancement such as poleward expansion and westward traveling surge. Due to global and rapid auroral expansions, we do not still understand the temporal and spatial evolutions of aurora and their connections to the magnetospheric disturbances.
In order to address this problem, we have analyzed simultaneous observations of THEMIS spacecrafts and all-sky imagers (ASIs). The THEMIS probes first enable the multi-point observations of particles and fields in the near-Earth equatorial region including plasma sheet. And ASIs first provide global vision of aurora with high temporal (3 s, same resolution of spacecraft's) and enough spatial resolution.
This paper shows one example at ~0700 UT on 2 March 2008, when aurora expanded westward near the footprints of TH-D (Xsm=-11.3 Re, Ysm=2.9 Re) and TH-E (Xsm=-11.1 Re, Ysm=3.8 Re). Both spacecraft observed magnetic dipolarizations, fast plasma flows, and intense electric fields 30 seconds after the expansion. The spacecraft also saw the depletion of plasma pressure, implying the plasma bubbles.
So far we have identified eight events in which azimuthal auroral expansions and the bubble signatures were observed simultaneously. We found that the azimuthal speeds of auroral expansions were positively correlated with the azimuthal component of fast plasma flows in the near-Earth plasma sheet. A typical speed of auroral expansions is 7 km/s (about 230 km/s mapped to the equatorial magnetosphere). In the magnetosphere, a typical speed of magnetospheric flows was 340 km/s. The latter speeds were dominated by ExB drifts, as evident from the observed intense electric fields. We conclude that these electric fields which corresponded to the depletion of plasma pressure are important factors for the speed of the auroral expansions.
In order to study the magnetosphere-ionosphere coupling during these transient events, we plan to use the THEMIS mode data of the SuperDARN radars with the temporal resolution of 7 s. With ionospheric convections observed by the radars, we expect to identify the convection change during the substorm expansion phase with auroral expansions and magnetospheric fast flows.

Keywords: aurora, substorm, magnetosphere, ionospheric convection