Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PEM30-P01 Room:Convention Hall Time:May 24 10:45-12:15

Investigations of triggering mechanism of substorm through the analysis of Themis probe data

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In our previous paper, we have presented the result of our superposed epoch analysis applied to the Themis data in which the velocity moments were derived from the ESA, the low energy particle instrument with the upper limit energy of 25 keV. There are some concerns that the flow velocity of plasma obtained only with ESA can be underestimated since the ion fluxes above 25 keV energy range in the near Earth plasma sheet cannot be ignored. Thus we reexamined the Themis data taking into account the contribution of high-energy particles measured by high-energy particle instrument SST. As we expect, the flow velocity of plasma was found to be greater than that evaluated previously in the plasma sheet region of X $>$ -13 Re. In our previous study, we pointed out that the earthward flows become quiet about 3 min prior to the auroral breakup, followed by abrupt enhancement of the earthward flows in the region of -10 $>$ X(Re) $>$ -18 at the time of auroral breakup (i.e., at t=0). Further, we proposed a new model for substorm onset called Catapult Current Sheet Relaxation Model. In a revised superposed epoch analysis result, we found that the relaxation starts first at X ~ -12 Re which corresponds to the inner edge of that current sheet and then propagates both earthward and tailward. The tailward propagation of the occurrence of earthward flows corresponds to the relaxation of the catapult current sheet. It is confirmed that about 1 min after the enhancement of the earthward flow at X ~ -12 Re, the catastrophic change of the current sheet reaches the tailward edge of the current sheet at X ~ -18 Re at which the magnetic neutral line is formed and the magnetic reconnection starts. Therefore we conclude that the flows appear about 1 min before the substorm onset and continue for about 2 min are produced by the relaxation of the catapult current sheet. In contrast, those follow the initial flows must be produced by the magnetic reconnection.

Keywords: substorm, Themis probes, current relaxation, magnetic reconnection