Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

PEM021-11 Room: Function Room A Time: May 24 11:45-12:00

The substorm in the magnetosphere-ionosphere compound system

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Tanaka et al. [2010] successfully demonstrated dynamic behavior of a substorm in the magnetosphere-ionosphere compound system by using a global self-consistent MHD simulation. In the compound system, A substorm is regarded as a phenomenon in the state transition associated with southward turn of the IMF. After the southward turn, the null-separator structure of the open -closed field lines of the magnetosphere for the northward IMF condition is gradually deformed in association with reconnection with the IMF. During the deformation, a new magnetic reconnection suddenly occurs in the plasmasheet. At the onset of the reconnection, the separator line in the nightside (the last closed field line) still exists. Therefore, there appears an open field line in the region inside of the separator line. After this chain-structure of the filed lines disappears, there appears the magnetosphere-ionosphere convection system suitable to the new southward IMF condition. During this transition, the sudden reconnection in the plasmasheet plays a role of discontinuous change of the convection system. Thus the state transition is discontinuous. This discontinuous process ensues enhanced pressure in the Ring current region due to a fast Earthward flow driven by the magnetic tension accumulated in the growth phase of the substorm. This enhanced pressure finally drives Region2-type current with rapid growth.

The scenario described above is a typical dynamics of the substorm revealed from a numerical result with typical solar wind parameters. Bearing in mind that there are many kinds of observation of the substorms depending various parameters of the solar wind, we need to continue our research on the substorm from the viewpoint how a substorm behaves under various solar wind condition.

One of such topics is the SC-triggered substorm which is regarded to be a substorm occurred simultaneously at the SC onset [Kokubun et al., 1977]. Probably, it is quite difficult to draw only from the observations a definite conclusion about relation between the substorm and the SC. However, the self-consistent MHD model settles the issue. So we carried out the simulations in which an impulse of dynamic pressure is imposed in the solar wind with southward IMF. From the simulation, it is revealed that the onset time of the substorm expansion does not change so much. This indicates that the SC does not have strong influence on the substorm occurrence.

Another example is the problem that the IMF northward turn triggers a substorm or not [Lyons, 1 995]. There has been a debate about this problem [Hsu and McPherron, 2002]. As for the simulation, the sudden decrease in the AL index (sudden enhancement of the auroral electrojet) is observed when the northward turn occurs during a late stage of the growth phase. On the other hand, if the northward turn occurs in an early phase of the growth phase, the substorm (decrease in the AL index) tends to be suppressed. These results indicate that a substorm occurs when the interval of southward IMF is sufficiently long.

References

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Keywords: substorm, magnetosphere-ionosphere compound system, numerical simulation