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A shock wave in the magnetosheath observed in the substorm growth phase

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We detected a shock wave in the lower-latitude side to the cusp region in the magnetosheath during the substorm growth phase in the global MHD simulation. This shock is transient because it appears after the southward turn of the IMF and disappears after the onset of substorm. From analysis of the numerical data, we identify the shock as the fast shock. Therefore, this shock is caused by collision between the fast plasma flow in the magnetosheath and the high-pressure region of the cusp extended into the magnetosheath.

The points to be settled are acceleration mechanism of the magnetosheath plasmas and disappearance mechanism of this shock. As for the acceleration, the laval nozzle model [Yamauchi and Lundin, 1997] is one of the candidates, but the simulation result does not seem to support it. Otherwise, the magnetosheath plasmas are accelerated through release of the magnetic tension caused by magnetic field merging between the solar wind field and the magnetospheric field. As for the disappearance, it seems to coincide with the substorm onset. We find that the plasma pressure in the upsteam side of the magnetosheath shock increases at the substorm onset. By analyzing the numerical results carefully, it is obtained that gradual increase in pressure triggered by sudden increase in pressure in the inner magnetosphere in the nightside propagates toward the dayside cusp region. This indicates that the magnetosheath plasma pressure will increase. Then, increase in the sound speed makes the supersonic flow the subsonic flow. Therefore, the shock wave disappears. It is noted that magnetic field erosion from the dayside magnetosphere to the lobe in the magnetotail is also seemed to be ceased at the same time. However, the erosion is active in the early phase of the growth phase and gradually less active in the latter phase of the growth phase. This result probably indicates that activity of the erosion does not control the formation of the shock.

Yamauchi, M. and R. Lundin (1997), The Wave-Assisted Cups Model: Comparison to Low-Latitude Observations, Phys. Chem. Earth, 22, 729-734.

Keywords: shock wave, magnetosheath, cusp, MHD simulation, substorm