Mechanics and energetics of substorm expansion onset

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Substorm expansion onset is a long-standing unsolved issue in magnetospheric. Processes taking place in the equatorial plane have been paid much attention for many years, but the connection between the equatorial plane and the ionosphere remains unclear. We focus on abrupt intensification of upward field-aligned current (FAC) that is central to this issue. That is because the upward FAC is responsible for accelerating electrons downward and emitting bright aurora and development of auroral electrojet. Here, on the basis of results of the global MHD simulation (REPPU), we show that the abrupt intensification of the upward FAC is reasonably explained by magnetohydrodynamics (MHD) processes. First of all, we focused on the magnetic field line from the onset position to the equatorial plane. The upward FAC is intensified along the magnetic field line except near the equatorial plane. The generation of the upward FAC (as a function of vorticity) takes place primarily at off-equator, not equatorial plane. The value of J.E is negative in the middle of the magnetic field line where the upward FAC is generated. This implies that the plasma moves against the Lorentz force to twist the magnetic field line and generate the FAC. These results may suggest that the abrupt intensification of the upward FAC results primarily from processes taking place at off-equator, not the equatorial plane. We will discuss the causality between the formation of the near-Earth neutral line (NENL) and the onset in terms of mechanics and energetics.

Keywords: Substorm, MHD simulation

