サブストーム開始に伴う磁気圏近尾部とオーロラアークの発展: 新しいサブストーム発生機構のモデル

Near-Earth magnetotail and auroral arc development associated with substorm onset: A new interpretation of substorm triggering

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Using data from Time History of Events and Macroscale Interactions during Substorms (THEMIS) spacecraft and ground-based observatories at high temporal and spatial resolutions, we studied the time sequence of near-Earth magnetotail and auroral arc development associated with a substorm onset. We discuss four steps of auroral development, auroral fading, initial brightening of an auroral onset arc, enhancement of the arc's wave-like structure, and poleward expansion, and link them to magnetotail changes. A case study shows that near-Earth magnetic reconnection began at X ~ -17 Re at least ~1 min before auroral fading and ~3 min before initial auroral brightening. Large-scale ionospheric convection was also enhanced just before auroral fading and before initial auroral brightening. Then low-frequency waves were amplified in the plasma sheet at X ~ -10 Re, with the pressure increase likely due to arrival of an earthward flow from the near-Earth reconnection site ~4 min after initial auroral brightening and ~50 s before enhancement of the wave-like auroral structure. Dipolarization began ~7 min after initial auroral brightening and ~30 s before auroral poleward expansion. On the basis of these observations, we suggest that near-Earth magnetic reconnection plays two roles in substorm triggering. First, it generates a fast earthward flow and Alfven waves. When the Alfven waves, which propagate much faster than the fast flow, reach the ionosphere, large-scale ionospheric convection is enhanced, leading to auroral fading, initial brightening, and gradual growth of the wave-like auroral structure. Second, when the reconnection-initiated fast flow reaches the near-Earth magnetotail, it promotes rapid growth of an instability, such as a ballooning instability, and the wave-like auroral structure is further enhanced. When the instability has grown sufficiently, dipolarization and auroral poleward expansion are initiated.

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