サブストーム時における THEMIS 全天カメラ・複数衛星の同時観測

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Coordinated observations of the THEMIS all-sky imagers and multiple spacecraft during substorms

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Fast azimuthal auroral expansion as well as poleward expansion is a characteristic feature of the expansion phase of substorms. In this study, we adopted coordinated observations of the THEMIS all-sky imagers and multiple spacecraft for investigation of azimuthal auroral expansion associated with magnetic dipolarization. For the first time we detected the azimuthal expansion of auroral arcs passed nearby the magnetic footprints of the multiple spacecraft staying in the near-Earth plasma sheet, using high spatiotemporal auroral observations.

During azimuthal auroral expansion at the footprint locations, the multiple THEMIS spacecraft frequently observed fast azimuthal flows and intense electric fields as well as magnetic dipolarization. The time difference of the observed dipolarization by the multiple spacecraft indicated that a large-scale structure propagated azimuthally with the speed close to the measured in-situ plasma flows. The plasma flow speed was dominated by the ExB drift associated with the dipolarization and intense electric field. Two event studies commonly suggest that the leading edge of the azimuthal auroral expansion corresponds to the fast azimuthal plasma flow, which is associated with the front of the magnetic dipolarization and intense electric field.

The statistical analysis with 16 events, which showed that the speed of the azimuthal auroral expansion in the ionosphere and plasma flow in the magnetosphere had east-west asymmetry, i.e., faster in westward direction. The averaged speeds of the azimuthal auroral expansion were 8.8 km/s (westward) and 5.3 km/s (eastward). When mapped onto the equatorial plane, these speeds (267 and 162 km/s) were comparable to the averaged azimuthal speeds observed by the spacecraft (190-235 km/s westward and 112-139 km/s eastward). The faster westward propagation in the ionosphere and magnetosphere implies that onset tends to occur in the distorted duskside convection cell in the ionosphere, which has westward background plasma flows in the premidnight sector.

We detected the intense electric fields in the near-Earth plasma sheet associated with the auroral expansion. The existence of auroral motion approximately with the ExB flow speed suggests that the measured electric fields are potential electric fields related to the ionosphere along the magnetic field lines. The abrupt formation of the fast ExB flows and their propagation away from the onset location lead us to suggest that the intense large-scale electric fields, which are possibly generated through substorm onset instability, propagate azimuthally in the ExB drift speed and lead to azimuthal expansion of an auroral arc.

サブストーム研究を目的として、我々は THEMIS の全天カメラ群と複数衛星の同時観測イベントを解析している。THEMIS 衛星はプラズマシートを含めた磁気赤道域における電磁場・粒子観測を 3 秒の時間分解能で達成している。また、全天カメラ群は 20 地点のオーロラ画像をつなぎ合わせることで、オーロラの大規模なダイナミクスを高い時空間分解能で捉えることを初めて可能とした。今回はサブストーム時におけるオーロラの東西方向の拡大について同時観測例を紹介する予定であるが（英語版参照）、解析の進捗状況によってはオーロラの Poleward Boundary Intensification (PBI) と呼ばれる現象についての同時観測例を紹介する場合もある。