Coupling of Dipolarization Front Flow Bursts to Substorm Magnetospheric and Ionospheric Expansion Phase Phenomena

L. Lyons, Y. Nishimura, T. Kikuchi, A. Runov, E. Donovan, V. Angelopoulos

THEMIS has revealed magnetotail dipolarization fronts with large $+\Delta B_z$ propagating Earthward as coherent structures [Runov et al., 2009, 2011]

- Have characteristic signatures predicted by bubble models of flow channels [Chen and Wolf, 1993; Pontious and Wolf, 1990]
  - Increase in earthward $V$ and $P_{mag}$ decrease in plasma $n$ and $P$.

Question: How are fronts related to well-known geomagnetic disturbances?

- Streamer-flow channel association well known, but front associated changes much stronger than typical
2009-02-27

THE
07:30-08:15UT

Large $PV^{5/3}$
decrease
(low entropy plasma flows
in, replaces higher)

Particle energization
$P_{\text{tot}}$ decrease
Sharp dipolarization
Strong earthward flow
Sharp N decrease
Onset 0746:48 (pseudo 0743:54)

Streamers 1, 3, 4 near THEMIS B, C, Streamer 2 near E, D
Onset: Nothing much – only some modest $V_y$

Streamers: Strong dipolarization (fronts), flows

**Suggests:** Largest mid and inner plasma sheet substorm effects can be longitudinally localized and due to flow channels/streamers
Onset arc

SNAP

RANK

70°

C FCHURABB GILL

FSMI

SNKQ

60°

AE D

Streamer 1

Streamer 2

(Streamer 1 (split))

Streamer 3

Streamer 4

2009-02-27/07:47:54

2009-02-27/07:54:36

2009-02-27/07:59:30

UT, 2009-02-27
Suggests: In addition to mid and inner plasma sheet substorm, largest auroral $\Delta B$ and mid-lat. positive bay due to flow channels/streamers
Onsets 0304:18; 0308:30; 0313:12 (1st and 3rd near THEMIS E, A, D)

Streamer 1,2,4,5 near THEMIS D, E (2 reaches near G10, 0317); Streamer 3 near NRSQ
Onset 1 and 3 near D, E: Weak dipolarization and modest $V_x$, $V_y$

Streamers near D, E: Strong dipolarization (fronts), flows

*Suggests:* Largest mid and inner plasma sheet substorm effects can be longitudinally localized and due to flow channels/streamers
- Largest auroral $\Delta B$ and largest mid-lat. positive bay due to flow channels/streamers
- GOES-10 dipolarization also
Summary

1. Examined activity during periods having strong dipolarizations classified as dipolarization fronts [Runov et al., 2009, 2011]
   - 6 events identified having good conjugate coverage by THEMIS ASIs

2. Found Dipolarization fronts to be associated with equatorward moving streamers originating after substorm onset
   - As is well known, streamers form repetitively during expansion phase
   - Suggests that longitudinally narrow flow bursts accompanied by dipolarization can form several times during an expansion phase.

3. Contrary to expectations
   - Largest expansion phase flows and dipolarization associated with streamers, rather than onset instability
   - Mid-latitude positive bays and largest auroral oval ΔB’s delayed by a few minutes from the auroral substorm onset, and instead coincided with streamer initiation

4. If above results are found to be general, it would suggest that
   - Multiple flow bursts fundamental element of magnetosphere-ionosphere convection during substorm expansion phase, and are major contributor to substorm dipolarizations, auroral zone magnetic bays, mid-latitude positive bays