Suprathermal electron acceleration during reconnection onset in the magnetotail

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Energetic electrons, jet braking, magnetic flux pile-up (Bz)

Jet braking related to regions of magnetic flux pile-up (Bz increase, dipolarization)

These are regions of most energetic electrons

Birn et al., JGR, 2005

Jet braking
Substorm onset open question

Reconnection \( \sim 25R_E \)

Current Disruption \( \sim 8-10R_E \)

Current Wedge

Onset Aurora

Current Disruption Paradigm: \( A \rightarrow B \rightarrow C \)

Near-Earth Neutral Line Paradigm: \( C \rightarrow A \rightarrow B \)
Figure 6

A) 17:12 stretched tail

B) 17:15 starts plasma sheet reconnection

C) 17:18 starts lobe reconnection

D) 17:21 pileup region hits C2/C4

E) 17:25:30 more dipolar magnetosphere

Cluster 2,3,4

Preexisting plasma sheet
Reconnected lobe
Reconnected plasma sheet
Lobe
✓ Cluster located in the tail between the reconnection region in far tail and dipolar field lines closer to the Earth.

✓ Large separation, 10000km.

✓ C3 furthest from the current sheet.

✓ C4 closest to the Earth.

Figure 1
✓ Dipolarization – magnetic flux pile-up associated with the reconnection jets.

✓ Mainly earthward ion flows, reversal around E.

✓ Hot ions, T increases at the end of the interval.

✓ Suprathermal electrons, highest flux around E.

✓ Thermal electrons, temperature increase between C and F.
✔ **Small substorm onset**
AE increase (E/F) ~9 min after tail reconnection onset (B) and a few min after full jet braking (E).

✔ **Pi2 onset (C) ~2-3 min** after reconnection onset, maximum Pi2 amplitude just after full jet braking.
- Bz, all satellites observe magnetic flux pile-up. C4 strongest (E), C2 earliest (B).
- Bx, proxy for distance to the current sheet. C3 furthest.
- Flux transport across C1, C2. C4 observes return fluxes. Flux change at E.
- Thermal electrons show temperature increase on all spacecraft.
- Plasma density, as proxy for being in the current sheet.
✓ Poynting flux.

✓ Integrated Poynting flux C2

✓ Integrated Poynting flux all spacecraft. First increase at C2 around B.
A) 17:12 stretched tail

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Figure 6

Red: Reconnected lobe
Yellow: Preexisting plasma sheet
Blue: Cluster 2,3,4
Green: Lobe
Acceleration of suprathermal electrons is associated to magnetic flux pile-up regions but is not directly correlated with the peaks in the magnetic flux pile-up.

Whistler emissions can be indicators of local regions of electron heating. *Khotyaintsev et al., 2011*

For more discussion on acceleration mechanisms see also *Fu et al., 2011*.

Figure 7
SUMMARY

✔ 10,000 km Cluster separation observations of tail reconnection/substorm onset.

✔ Reconnection proceeds in a few steps:
  1) reconnection of preexisting plasma sheet,
  2) reconnection of lobe plasma,
  3) formation of magnetic flux pile-up (dipolarization region).

✔ Pi2 generated after 1) step.

✔ AE index increase a few min after 3) step.

✔ Suprathermal electrons fluxes increase at each of the steps with highest fluxes at 3) step.

✔ Highest suprathermal electrons fluxes are not directly correlated to peaks in magnetic flux pile-up.