Cluster-II Observations of Continuous Reconnection at the Dusk Magnetopause

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Data:
* CIS: Onboard moments (4 s resolution)
* FGM: spin-averaged (4 s)
Orbits and Questions Addressed

I. MP crossings on Jan16, Jan 26 and Feb 26, 2001

II. Questions addressed: Under steady IMF:

* Continuous or intermittent reconnection?
* Single or multiple reconnection X-line(s)?
Dusk Flank MP on 2001-01-26: Overview

- **Multiple MP jets** over 2 hours of jets at MP
- M’sphere
- M’sheath
- Similar for S/C 3
- Similar for S/C 4
- Height, GSE

\[
\frac{N_i}{(\text{cm}^{-3})} \\
|v| \quad \text{(km/s)}
\]

\[
\begin{align*}
\text{S/C 1} & \quad \text{jets} \\
\text{S/C 2} & \quad \text{HIA} \\
\text{S/C 3} & \quad \text{HIA} \\
\text{S/C 4} & \quad \text{CODIF}
\end{align*}
\]
2001-01-26: Accelerated flows

Plasma jets detected at all complete MP crossings and FTEs
Test of Reconnection: Walén Test [Sonnerup 1987]

1. Good deHoffmann-Teller frame: \( \mathbf{E}_{\text{H-T}} = (\mathbf{V} - \mathbf{V}_{\text{H-T}}) \times \mathbf{B} \approx 0 \)

2. \( \mathbf{V} - \mathbf{V}_{\text{H-T}} = \pm \mathbf{V}_A \)

* Excellent agreement with theory!
* Positive Walén slope --> crossing north of X-line
More Evidence for Reconnection at MP

* Excellent agreement with theory for other MP as well
Evidence for Reconnection in FTEs

* Flows in FTE satisfy the Walén relation remarkably well
Evidence for Single, Stable X-Line

Jettings in the same direction for 2 hours!

Steady IMF
- $B_z < 0$
- $B_y < 0$

Component Merging [Sonnerup, 1974; Gonzales and Mozer, 1974]

IMF $B_y < 0$

Reconnection site below and sunward of Cluster-II for 2 hours

For steady IMF:
- reconnection large-scale ($\neq$ random)
- reconnection sites controlled by IMF
* Jets seen at every MP crossing by all spacecraft.
* S/C 4 stayed longer in MP, detected jets longer.

-> Continuous reconnection. Jets persist even when S/C exits MP
Partial MP crossings: Evidence for Bulges

$N_i (\text{cm}^{-3})$

$|v| (\text{km/s})$

S/C 1

M’sphere

M’sheath

S/C 1

jets

S/C 3

S/C 4

HIA

CODIF

Sckopke et al. [1981]

Shi et al. [1988]
More Examples: Other Passes

Jan 16-17, 2001

Ni (cm$^{-3}$)

S/C 1

|v| (km/s)

Feb 26, 2001

Ni (cm$^{-3}$)

S/C 1

|v| (km/s)
Summary

* High quality CIS and FGM data for MP investigations

* Excellent Walen relation at most MP crossings $->$ Reconnection

* The reconnection site appears stationary for steady IMF

  $->$ Reconnection site (including FTE) controlled by IMF

* Continuous (perhaps not steady) reconnection embedded in bulges propagating along the MP $->$ FTEs?