Electric fields at the magnetopause

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Outline

We encourage the use of electric field data!

*Plasma = charged particles, B, E*

✔ Chapman – Ferraro current
✔ Magnetic reconnection
✔ Flux transfer events (FTEs)
✔ Plasma waves
✔ Anomalous collisions
Micro scales  ←  Macro scales

- Langmuir e- holes
- LHDI double layers
- Whistlers
- Kinetic Alfvén
- Alfvén
- KH FTEs

Debye length  e- scale  H+ scale

E≠-vxB  E≈-vxB

Cluster separation

[km]

0.1  1  10  100  1000  10,000  1RE
Chapman-Ferraro current

\[ \Delta \Phi \sim kV \]
Plasma waves

Steep density gradients seen in satellite potential

Cluster

Magnetopause current layer

\[ \Delta \Phi \sim kV \]

\[ \delta E \]

\[ n \]

[De Keyser et al, 2005]
Magnetic reconnection

Generalized Ohms law and Cluster

\[ E = -v \times B + \frac{1}{ne} (j \times B) - \frac{1}{ne} \nabla p_e + \frac{m}{ne^2} d_j + \eta j \]

\[ E_{\parallel} = -\frac{1}{ne} \nabla p_e + \frac{m}{ne^2} d_j + \eta j \]

At spin resolution
- \( B \) 3D[FGM], \( E \) [EFW,EDI], \( n \) [CIS, PEACE, WHISPER], \( p_e \) [PEACE], \( v \) [CIS], \( j \) [PEACE+CIS, curlometer]

At high time resolution (5 S/s and higher)
- \( B \) 3D[FGM,STAFF], \( E \) [EFW,EDI], sometimes \( n \) [WBD]
- \( n \) satellite potential [EFW]
- \( j \) [curlometer, planar current sheet assumption]
- \( T_e \)
- \( v \)
Flux Transfer events (FTEs)

Poster today!

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FTE, E field structure

- L $\leq$ ion gyroradius
- Strong E. E/B $\sim V_A$
- Strong j$_{||}$ $\sim 0.3 \mu$A/m$^2$
- Density gradient
- Large potential jump
- dt < 1s

Cluster 2 BM (blue) and EFW i-burst (green)

$2.5 \text{ kV}$
Wave-particle interaction often through electrostatic waves

- E.g., lower hybrid, ion/electron acoustic, solitary waves
- Using internal burst one can estimate the phase speed of waves for which $\omega/k < 400\text{km/s}$
- Example – drift lower hybrid waves
- $k\rho_e \sim 1$
- low coherence

[Vaivads et al, 2004]
Anomalous collisions

Momentum equation derived from the Vlasov equation separating AC and DC scales

\[ nm(\partial_t u + u \nabla u) - nq(E + u \times B) + \nabla \cdot p = q\left( \frac{\delta n \delta E}{\eta_j} + \frac{\delta j \times \delta B}{\eta_j} \right) \]

Anomalous collision frequency

\[ \nu_y^{\text{eff}} = \frac{q}{nm\nu_y} \left( \frac{\delta n \delta E_y}{|y|} + \frac{\delta j \times \delta B}{|y|} \right) \]

The first (and second?) term can be measured experimentally in space!

Lower hybrid drift waves lead to the thinning of the current sheet and onset of the reconnection.

[Scholer et al., 2004]
Anomalous resistivity, Cluster observations

Current sheet

Density gradient

LHD waves

Anomalous resistivity $\nu \sim f_{\text{LH}}$

[Sillin et al., 2005]
Summary

We encourage the use of electric field data!

Plasma = charged particles, B, E

✔ Chapman – Ferraro current
  Strong E fields, potential jump, density gradient within 1s

✔ Magnetic reconnection
  Generalized Ohms Law

✔ Flux transfer events (FTEs)
  Strong E fields, potential jump 2.5kV, density gradient within 1s

✔ Plasma waves
  Wave-particle interaction often through electrostatic waves.
  e.g. Lower hybrid waves. Can measure phase velocities < 400 km/s.

✔ Anomalous collisions