Two-scale nature of electron solitary waves at the dayside magnetopause

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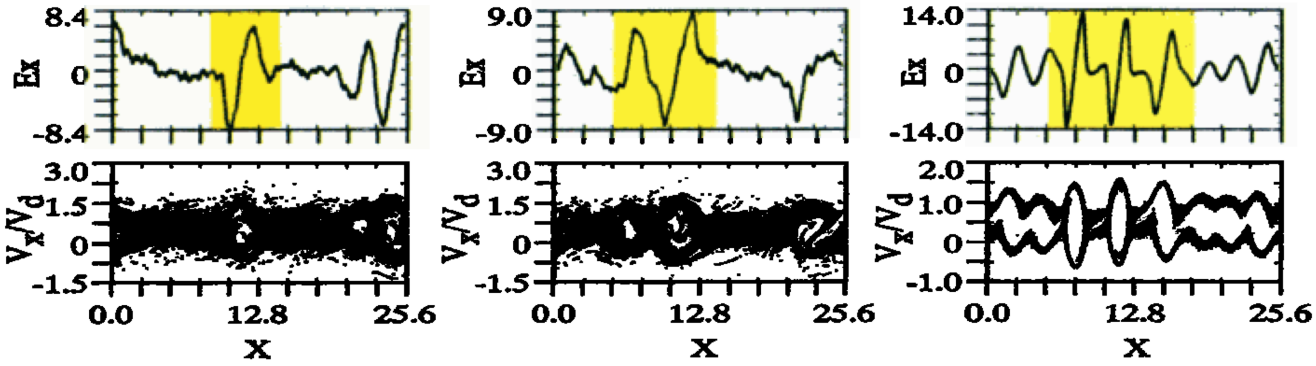
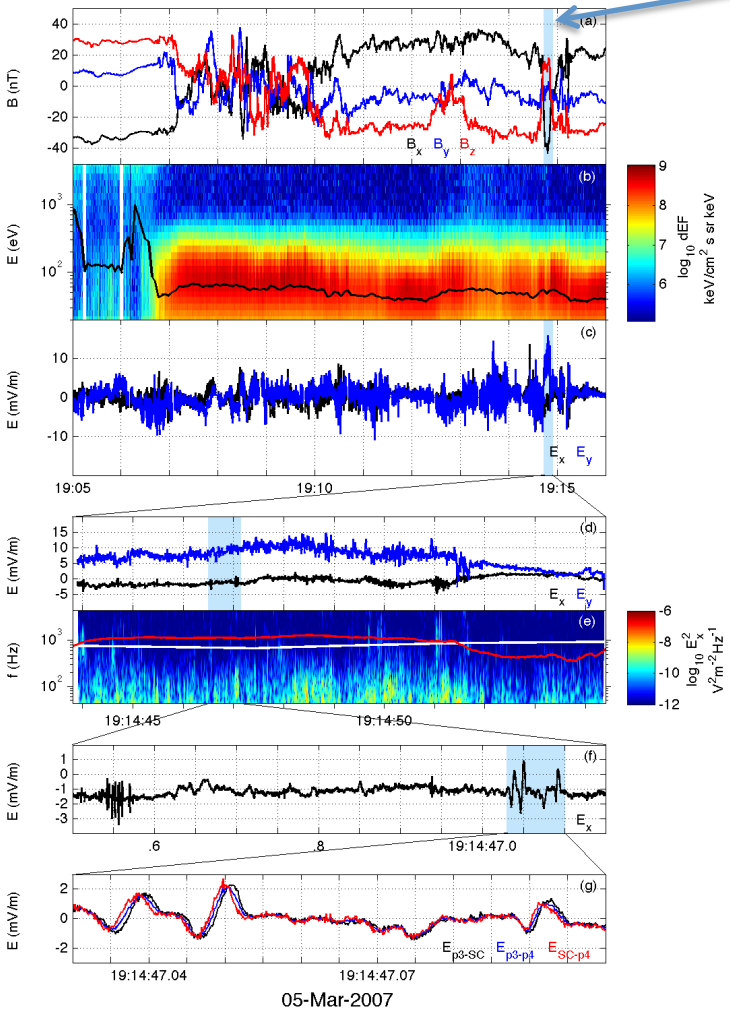
Electron solitary waves

- Debye scale dipolar electric fields parallel to B.
- Can be produced by Buneman, bump-on-tail, or bistreaming instabilities.
- They are often associated with reconnection separatrices, current sheets, and electron beams.



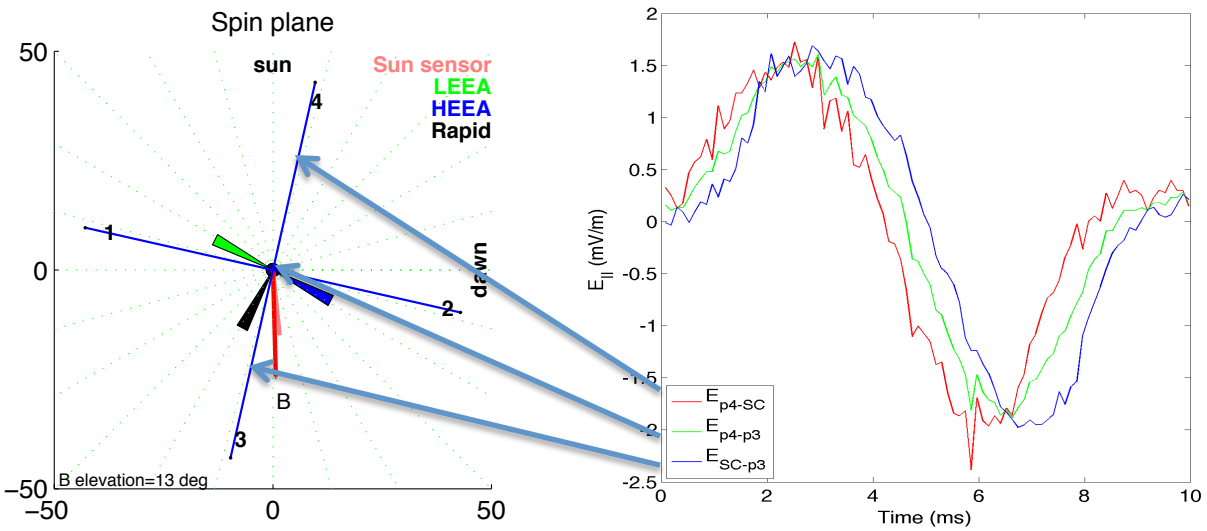
[Matsumoto et al., 1994].

5 March 2007 – Cluster 2

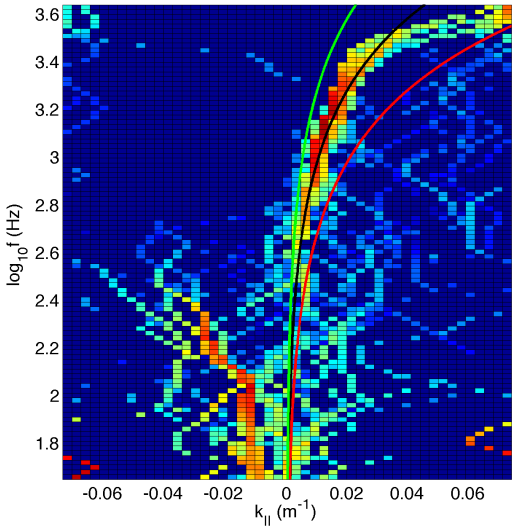


- Asymmetric reconnection observed.
- Two distinct ESW time scales present.
- ESWs are observed near current sheet, suggesting Buneman instability.
- Bistreaming instability may produce the fast ESWs.
- Time delays between different probe combinations are clearly seen.

Size and speeds of electron holes

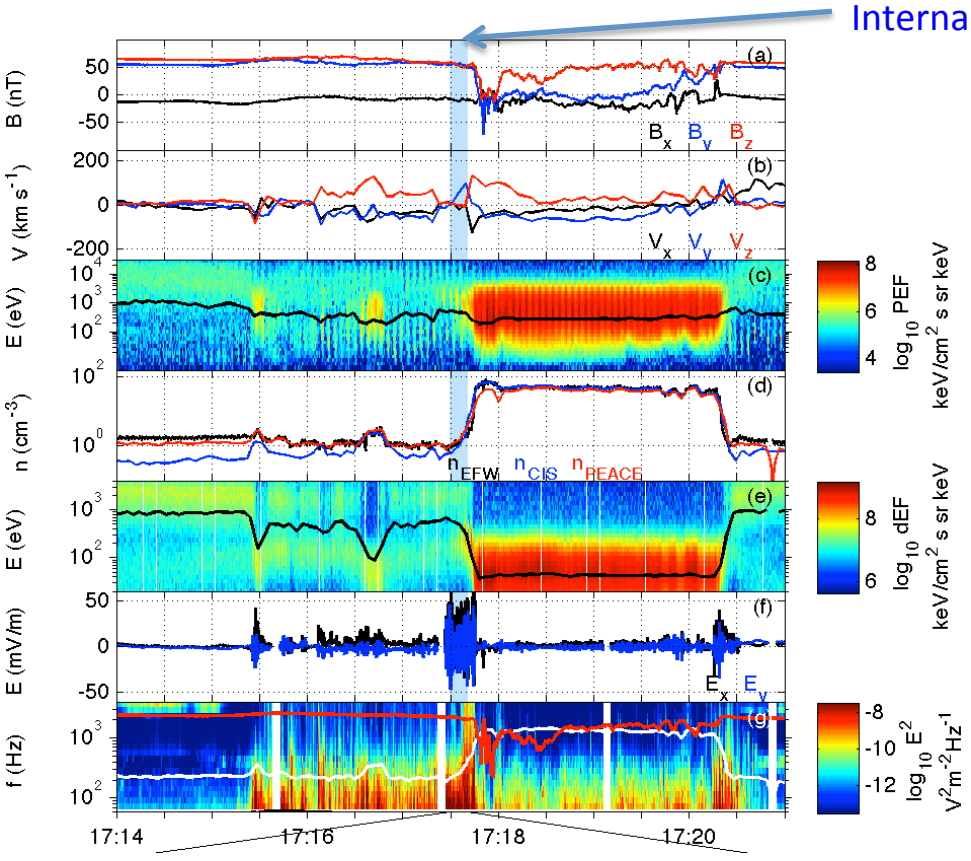


V = 1200, 600, 300 km/s



- ESW speeds and lengths estimated from time delays between probes.
- ESWs move parallel to B. Electric field diverges.
- V ~ 50 km/s for slow holes; V ~ 600 km/s for fast holes.
- Length scale is l ~ $6\lambda_D$ for both fast and slow electron holes.
- Maximum ESW potentials are V_0 <~ 1 V.

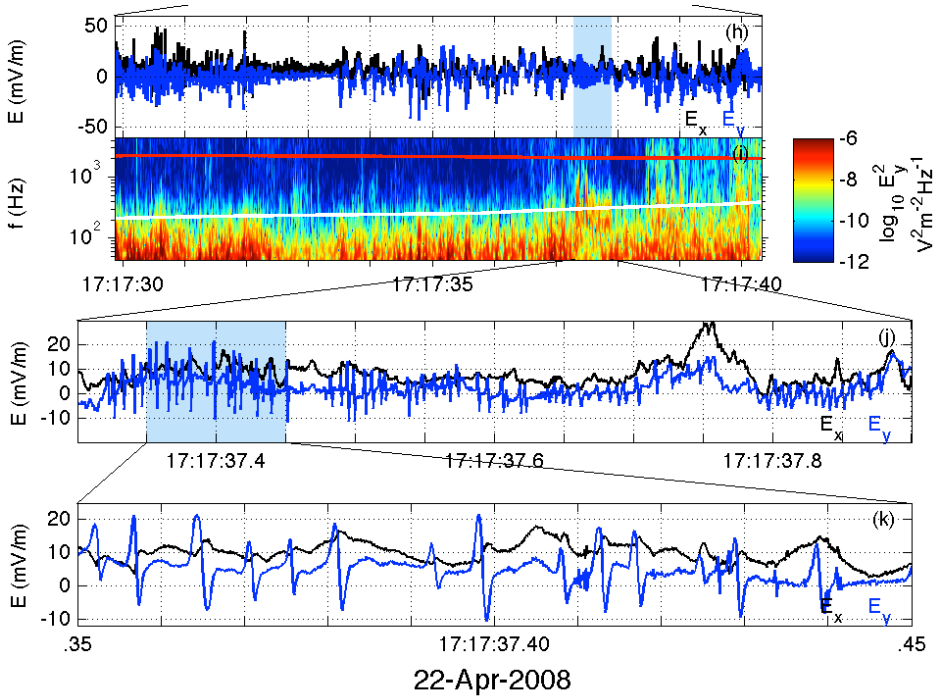
22 April 2008 – Cluster 3,4

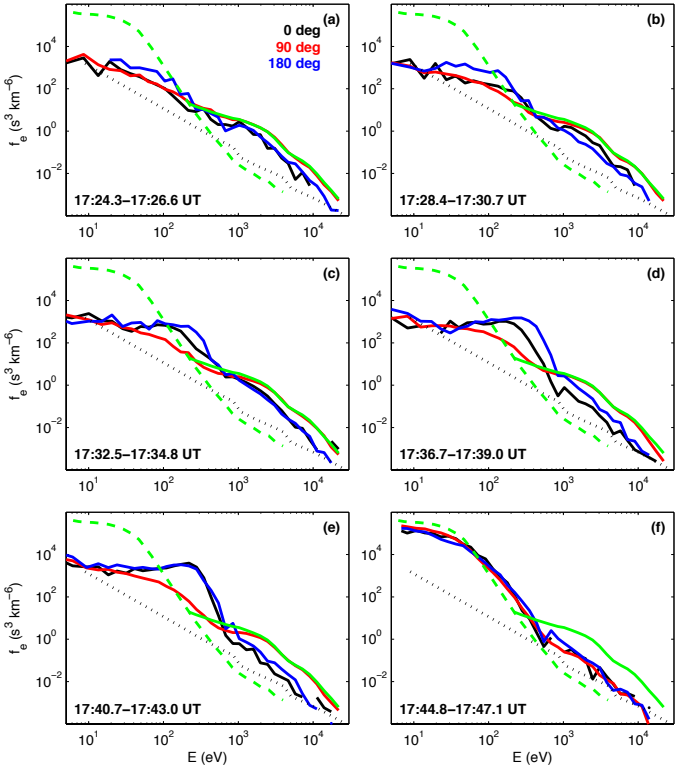


Blue shading indicates EFW's internal burst mode interval.

- Partial magnetopause crossing.
- Northward ion flow.
- Mixing of MS and SH electron observed.
- Most intense electric fields are observed at the magnetopause.

ESWs and electron distributions





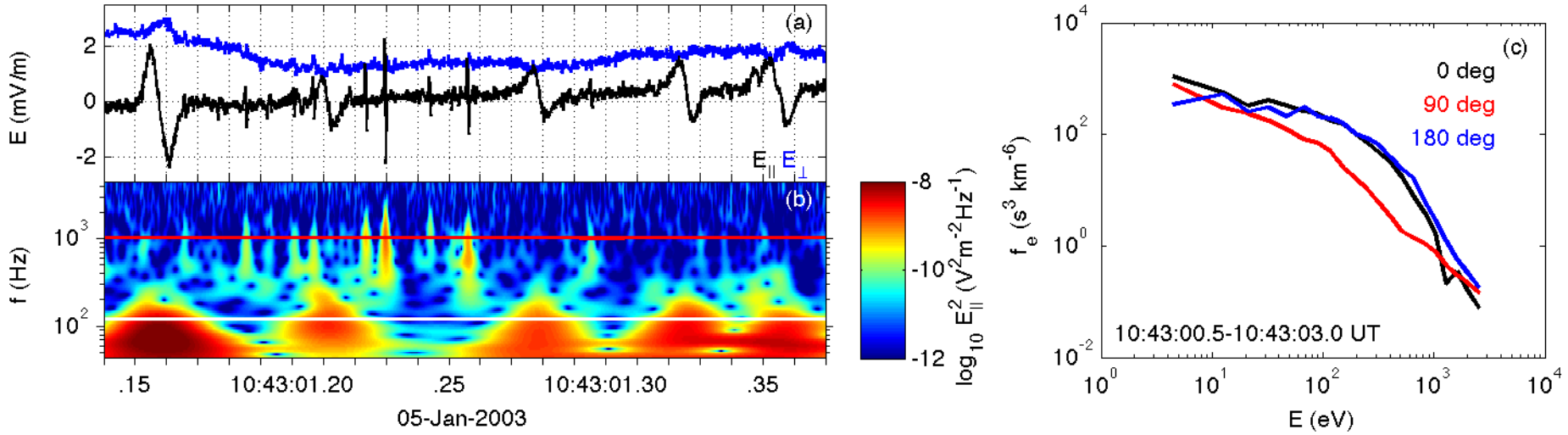
- Fast and slow ESWs are observed close to the magnetopause.
- Assuming $l = 6\lambda_D$, speeds are: v ~ 400-1400 km/s and v >~ 4000km/s.

Green solid – magnetospheric $f_e(E)$

Green dashed – magnetosheath $f_e(E)$

Electron distributions over EFW's internal burst mode interval. Most ESWs correspond to time of (d).

05 January 2003



- Fast and slow ESWs observed together; fast and slow ESWs do not coalesce.
- Electron distribution suggests bistreaming instability.
- Assuming $l = 6\lambda_D$, speeds are $v \sim 300$ km/s and $v \sim 3000$ km/s.

Discussion

- For event $e\phi/k_B T_e << 1$ ➔ narrow range of trapped electron speeds.
- Trapped electrons of fast and slow ESWs don't overlap ➔ fast and slow ESWs do not coalesce.
- For the Buneman instability $v_{\rm ph} = (m_e/2m_i)^{1/3} v_d/2$ We calculate ESW speeds 130, 320, and 290 km/s, consistent with slow ESWs.
- Electron distributions are consistent with the bistreaming instability generating fast ESWs.
- ESW speeds are too small for bump-on-tail instabilities.

Conclusions

- Fast and slow ESWs associated with asymmetric reconnection are observed ➔ multiple instabilities in the same region.
- Slow ESW speeds are consistent with the Buneman instability.
- Fast ESWs are consistent with electron bistreaming instabilities.