High Frequencies and Small-Scales in the Solar Wind

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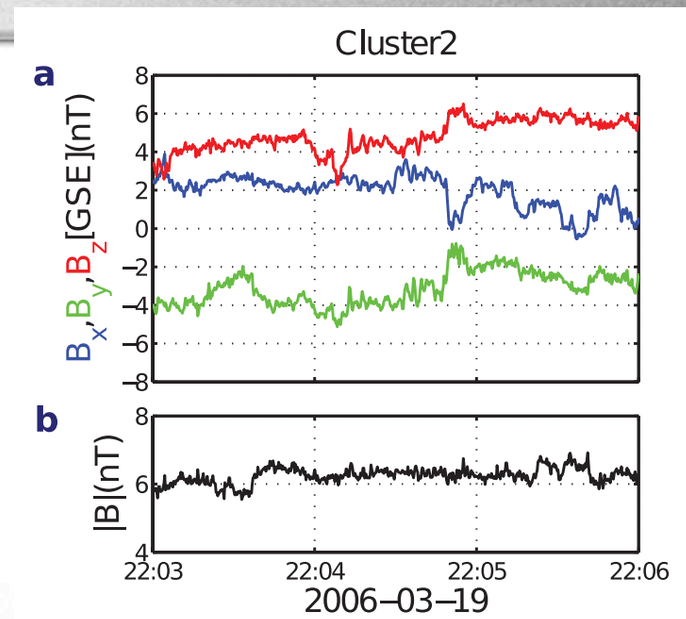
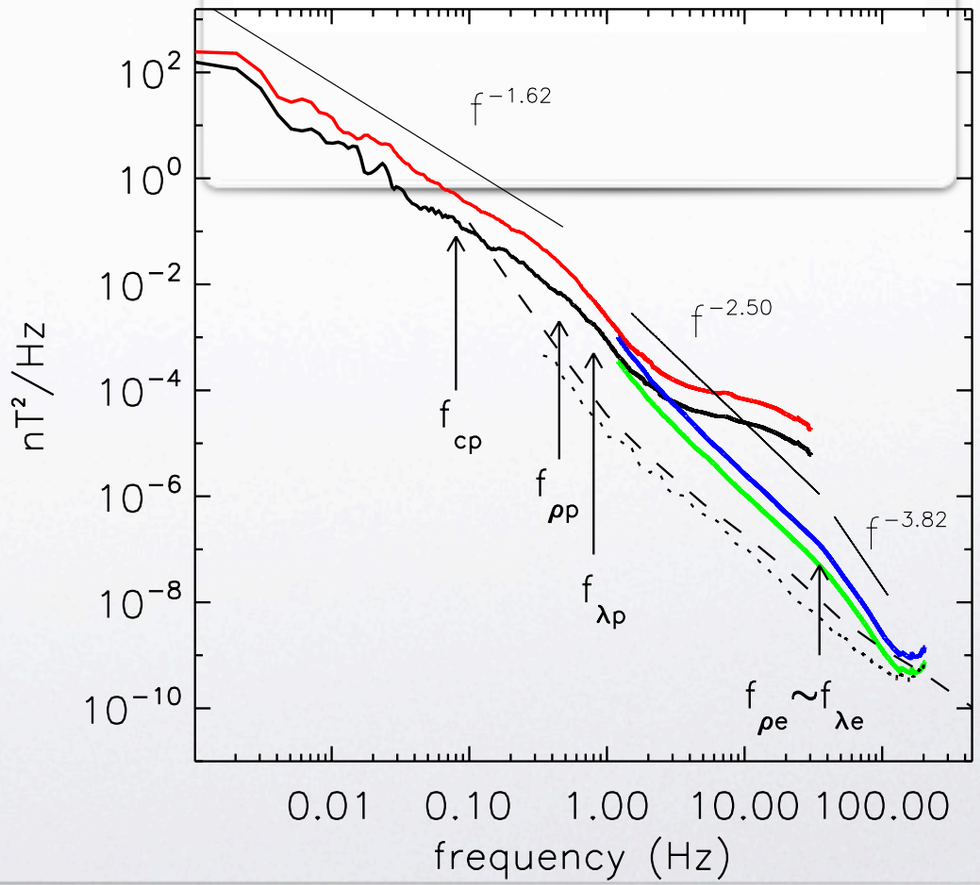
19 March 2006 Overview of the Magnetic Field from the Flux Gate Magnetometer

Fast wind (640 km/s)
No macroscopic current sheets (i.e., no anti-parallel reconnection)
The four Cluster spacecraft were separated by approximately 10,000 km
Plasma density was ~3 particles/cm^3
$\beta_p \sim 2.75$, $\beta_e \sim 0.7$
Burst mode data (66 samples/s—FGM 450 samples/sec—STAFF)
This spectrum is from B_z



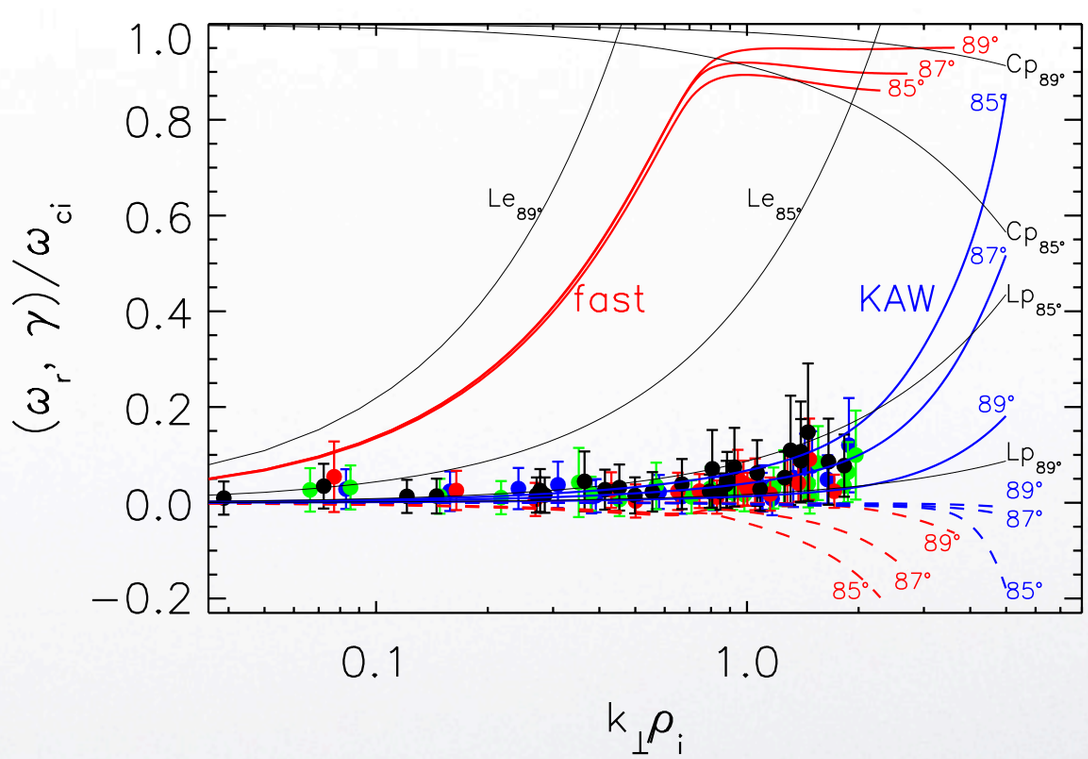


Results of the k-filtering

Frequency is ~0 (limited by statistical errors in determining the solar wind speed from the proton instrument, CIS/HIA)

Wave number tends to follow the dispersion curve of (highly oblique) Kinetic Alfvén Waves.

(Red) dashed lines are the (linear) damping rates

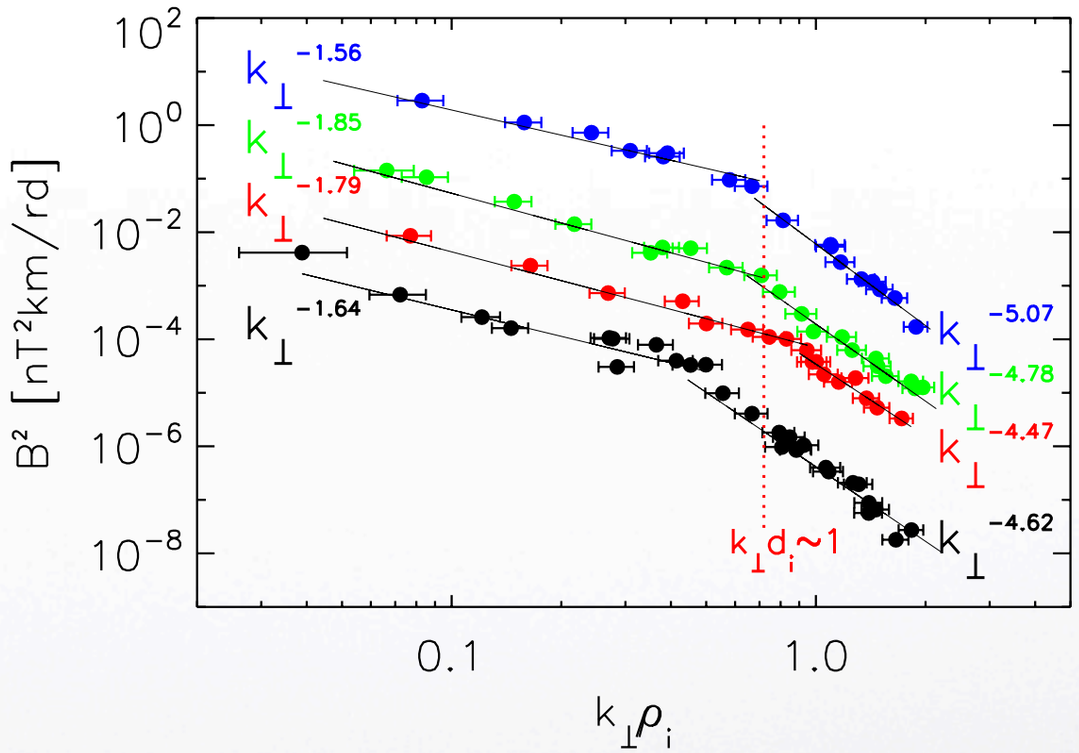


Sahraoui et al., 2010

Spectrum of the Perpendicular (to the local magnetic field) Power

Wave number spectra with estimated error bars for the four time intervals.

The vertical dotted line shows the proton inertial length.



Sahraoui et al., 2010

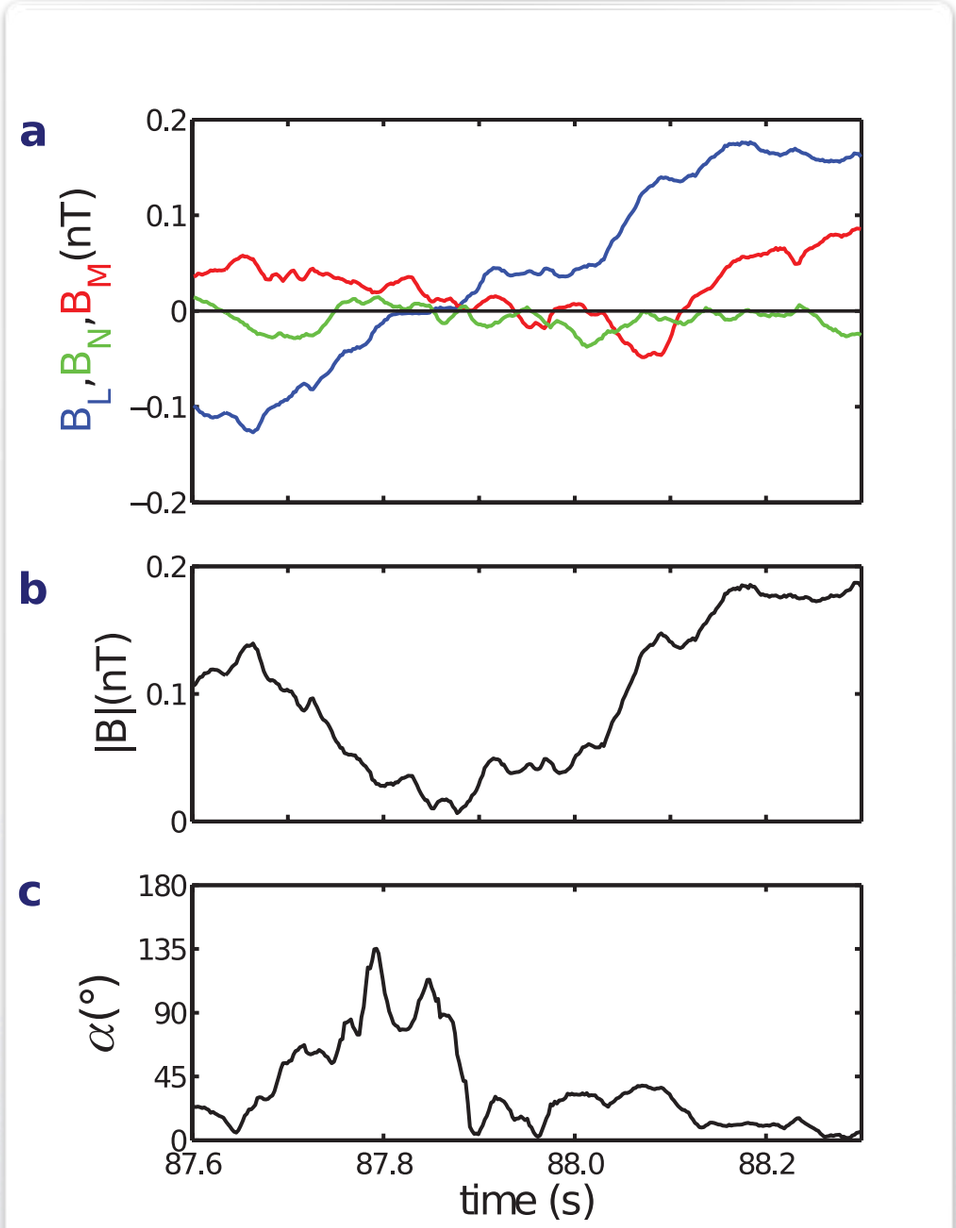
View #2
March 19, 2006
~ 1 sec of STAFF data

STAFF-C2 detection of a thin current sheet. B is plotted in the local current sheet reference frame from a minimum variance analysis.

Panel a: B_L component is along the current sheet;
B_N is parallel to the normal to the current sheet
B_M is the out-of-plane component. The bipolar signature suggests a "Hall" magnetic field.

Panel b: |B|

Panel c: Angle of rotation of **B** computed as the angle between **B**(t) and **B**(t + τ), with time lag τ = 0.1 s



Perri et al., 2012, PRL, in press

Multiple Spacecraft Detection of a Thin and Small Current Sheet

STAFF-C2 and C4 observations of a thin current sheet

(a): |B| at C2 (red) and C4 (blue)

(b): B_L component

(c): B_M out-of-plane component

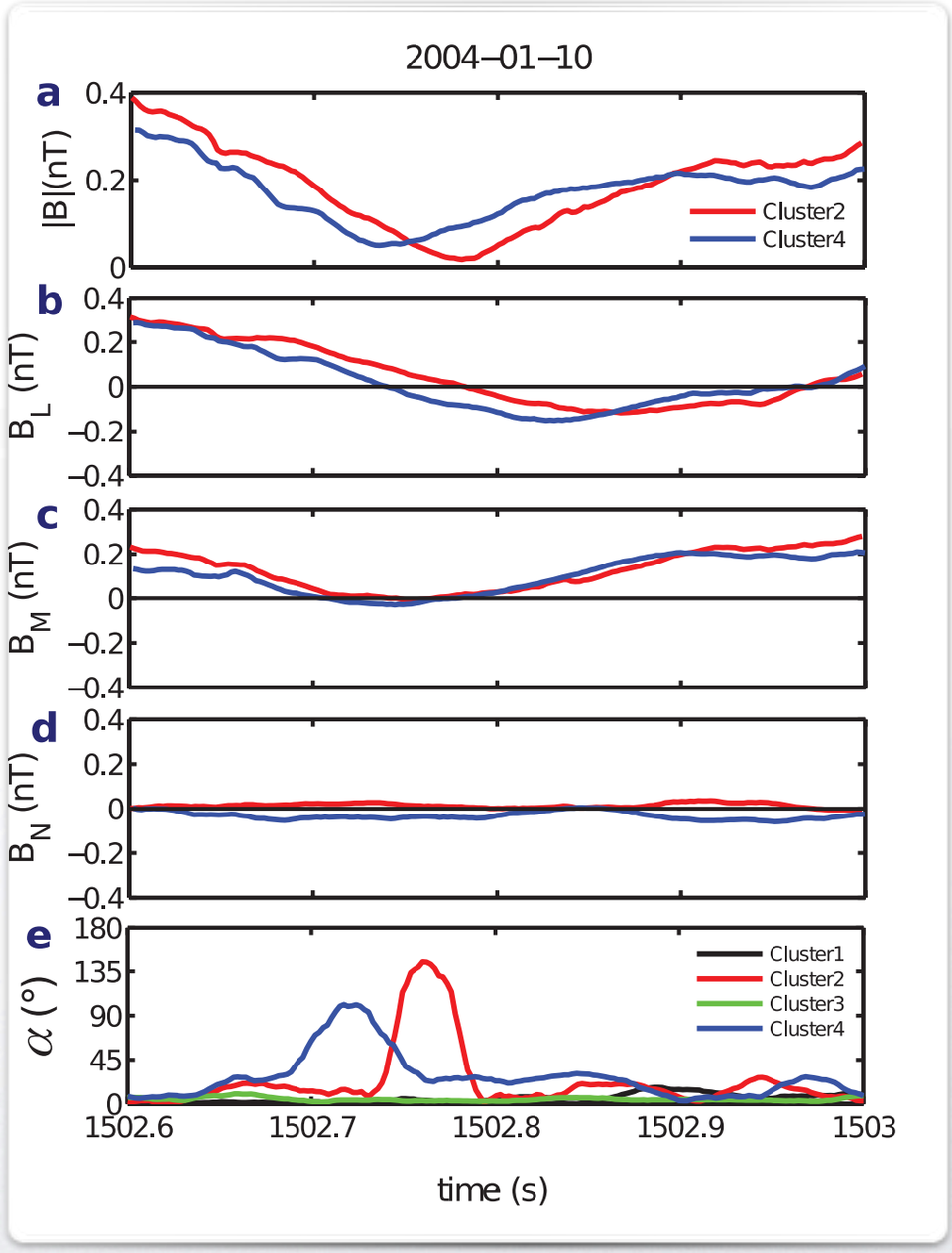
(d): B_N component normal to the current

(e): angle of rotation of **B** computed from the four Cluster satellites with τ = 0.035 s.

C2 and C4 were ~20 km apart along the x-direction

C4 observed it first, then C2 after $\Delta t \sim 0.036$s.

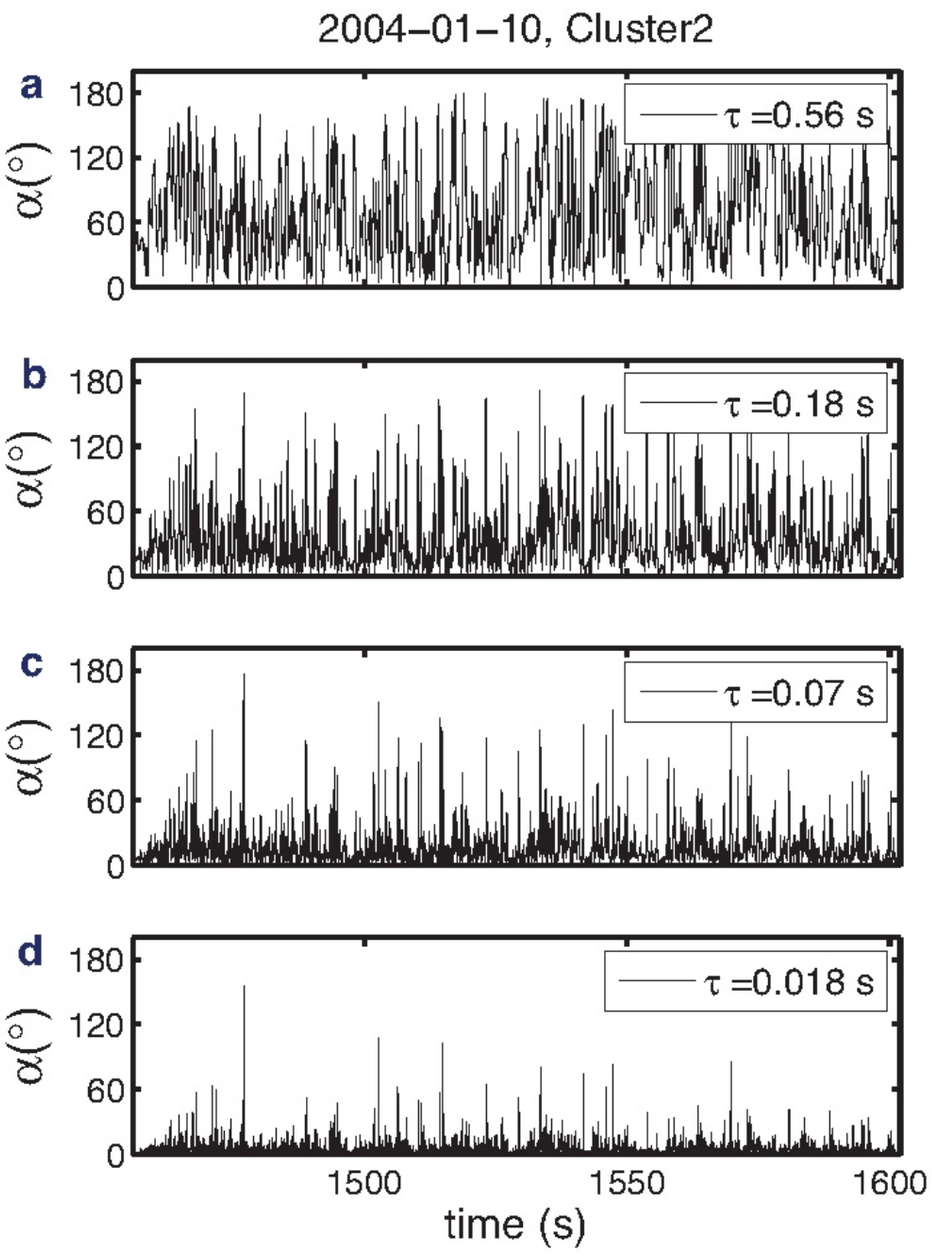
Assuming that the current sheet advects with the plasma, Δt corresponds to a size $d = V\Delta t \sim 20$ km.



Perri et al., 2012, PRL, in press

Space Filling?

Maybe at ion scales, but not at electron scales (with respect to the *local* field—this is only from STAFF data)



Things to Keep in Mind…

- The magnetic field *spectrum* in fast solar wind at small scales resembles a spectrum of highly oblique kinetic Alfvén waves, linear waves, random phased weak turbulence, ….
- But the "wave" phases are not random (Solar Wind 12).
- The spectral breaks are found in models that have no kinetic Alfvén waves (e.g., Hall MHD).
- Including the phases is equivalent to having the entire wave form, which we *can* plot. The wave-form data shows that the coherence consists of very thin (less than a d_i) two-dimensional current sheets and other small-scale discontinuities, suggestive of intermittency.