Measuring the Correlation Scale of Turbulence?

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scales of turbulence

- **Outer (driving) scale** - energy input
- **Taylor scale** - gradient fluctuation scale
- **Inner (dissipation) scale** - requires E and hi-res particle measurements (Solar Orbiter?)
scales of turbulence

\[ \lambda \sim 1100 \text{ Mm} \ (186 \text{ Re}) \]
\[ \lambda_t \sim 2500 \text{ km} \]

If inertial range is scale-free, this analysis is constrained by the measurement time...

FIG. 2. Estimates of correlation function from ACE-Wind data (as in Fig. 1), supplemented by two sets of Cluster data, a set (1) with separations 0.4–1.2 \( R_E \) from data in 2003, and a set (2) with smaller separations 0.02–0.04 \( R_E \), from 2004 data.

(Matthaeus et al, PRL, 2005)
Outline

- IMPACT/MAG and SWAVES/APM and Wind 3DP/SWE data
- Early orbit - separations 4.7 to 5800 Mm
- Haar wavelet transform
- Cross-correlations vs separation for different wavelet scales
- Correlation length vs ‘wavelength’
IMPACT/MAG data

- magnitude $|B|$ - a so-called ‘passive scalar’ in ideas about turbulence
- boxcar-averaged down to 3 seconds (for later correlative studies with Wind/MFI)

Wind/SWE and 3DP data

- solar wind velocity to ‘deconvect’ the data
- proton densities to calibrate S/WAVES APM
orbit

- separations from 4.7 to 5800 Mm (0.7 to 900 Re)
- separation along the mean Parker spiral
orbit

- separations from 4.7 to 5800 Mm (0.7 to 900 Re)
- separation along the mean Parker spiral
• sums and difference
• orthogonal
• 13 (pseudo-log) wavelet scales
  – from 16s to 65536s (16s to 18h)
cross-correlations - 24756 s
cross-correlations - 6143 s
cross-correlations - 1535 s
cross-correlations - 384 s
Spectrum of shifted cross-correlations
correlation wavelength

correlation time $\delta t$
- 3dB of XCC

correlation wavelength
- $v_{sw} \delta t$
correlation wavelength

correlation time $\delta t$
- 3dB of XCC

correlation wavelength
- $v_{sw} \delta t$

A broken power-law?
summary

• Conclusion: correlation length is a function of wavenumber - there is no apparent ‘single’ value

• Much more work to do…
  – vector B, S/WAVES APM
  – angle to Parker spiral
  – dynamic wavelength correction (for $v_{sw}$)
  – interpretation…