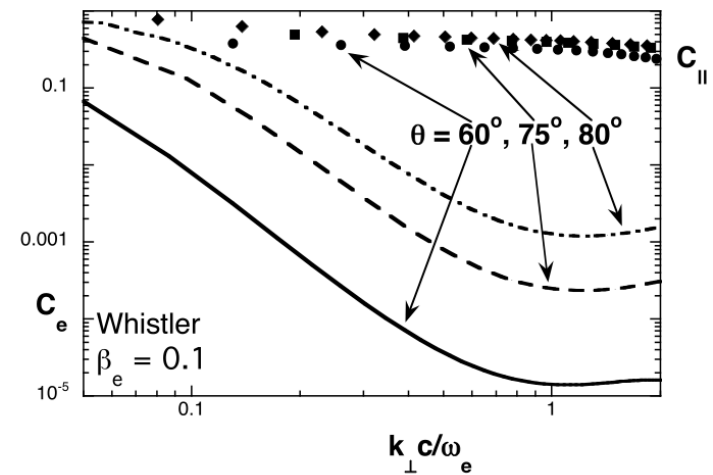


# Nature of Subproton Scale Fluctuations

- In strong turbulence linear and non-linear terms are comparable → may see some qualitative linear properties
- Are KAW or whistlers relevant?
- One qualitative difference:
  - KAW are low frequency so ions are dynamically relevant
  - Whistlers are high frequency, ions are stationary, so negligible  $\delta n$  and  $\delta E_{\parallel}$
- Previous works considered ion scale fluctuations, here we consider between ion and electron scales  $1/\rho_i < k < 1/\rho_e$



Gary & Smith 2009 JGR

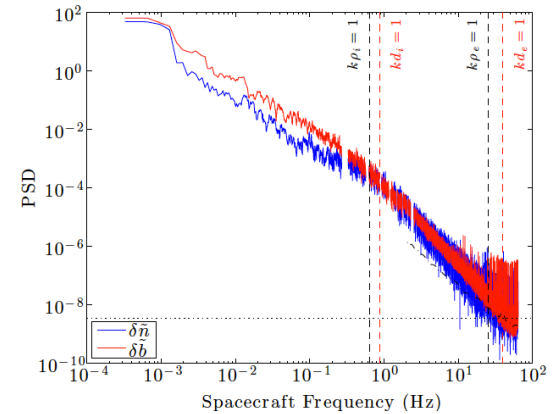
# Kinetic Alfvén Turbulence

- In the KAW  $\delta\tilde{n} = \delta\tilde{b}_\perp$  if

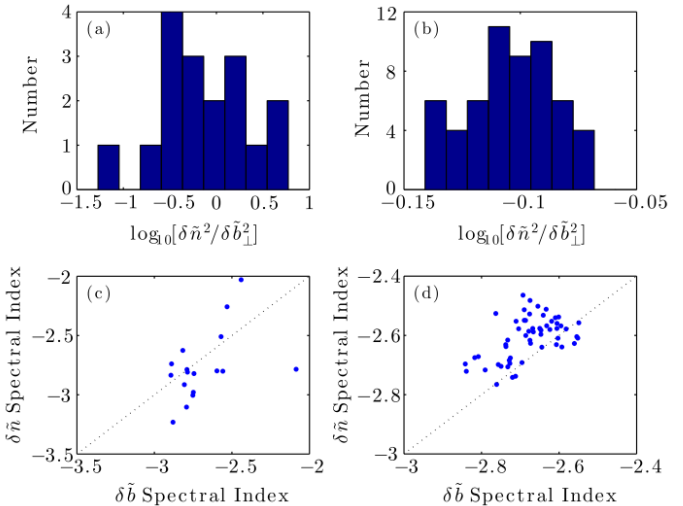
$$\tilde{n} = \left(1 + \frac{T_i}{T_e}\right)^{\frac{1}{2}} \frac{v_s}{v_A} \left[1 + \left(\frac{v_s}{v_A}\right)^2 \left(1 + \frac{T_i}{T_e}\right)\right]^{\frac{1}{2}} \frac{n_e}{n_0}$$

$$\tilde{\mathbf{b}} = \mathbf{B}/B_0$$

- Normalized spectra approx equal  
→ strong evidence for kinetic Alfvén turbulence (rather than whistler)
- Slight magnetic dominance:  
 $(\delta\tilde{n}/\delta\tilde{b}_\perp)^2 = 0.75$  (like in MHD), also seen in simulations
- Strong turbulence qualitatively similar to linear modes but quantitative differences



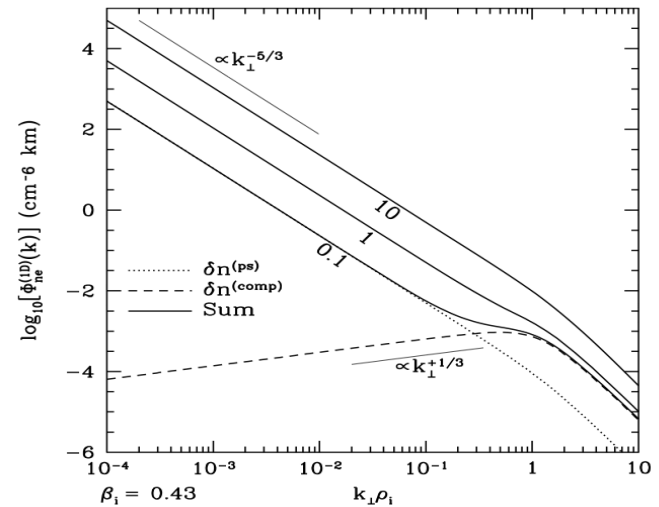
Chen et al. 2013 PRL



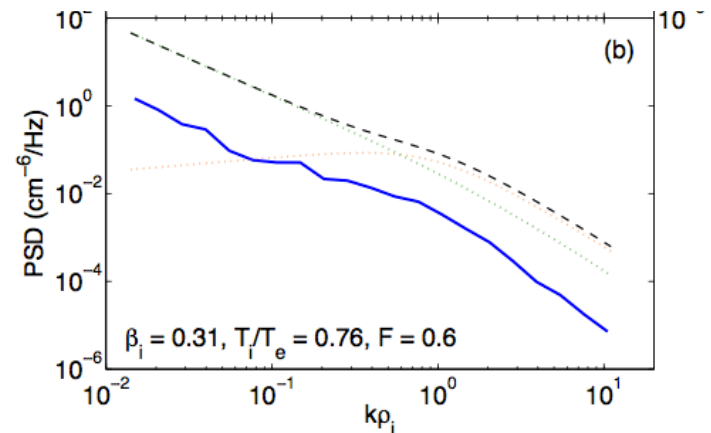
Chen et al. 2013 PRL

# Ion Scale Flattening

- Density spectrum can be modeled as passive scalar + active kinetic Alfvén turbulence
- Leads to “bulge” in spectrum before ion scales, depending on plasma parameters
- Compare model with measured parameters to shape → good match
- Will be a feature to look for with Solar Orbiter / Probe since effect enhanced when  $\beta_i \ll 1$



Chandran et al. 2009 ApJ



Chen et al. 2012 SW13 arXiv:1210.0127