Waves and Turbulence Around ion kinetic scales

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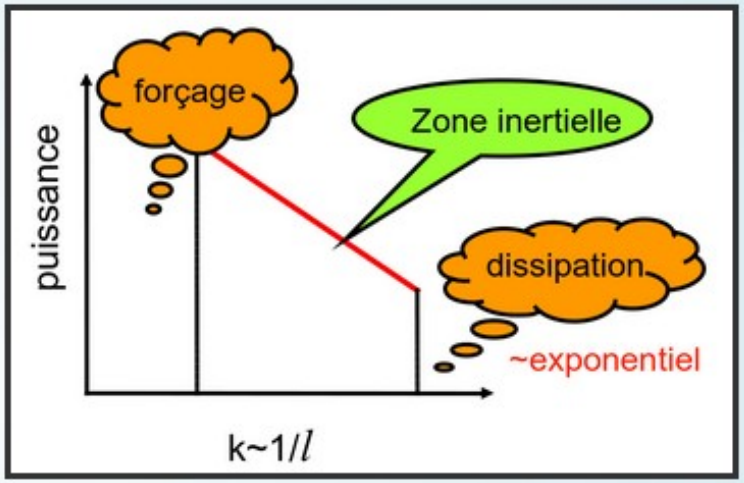
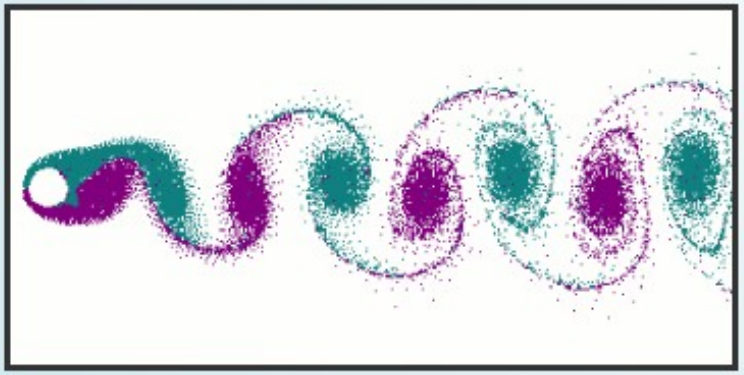
Concept of turbulence

Nonlinear process in fluids:

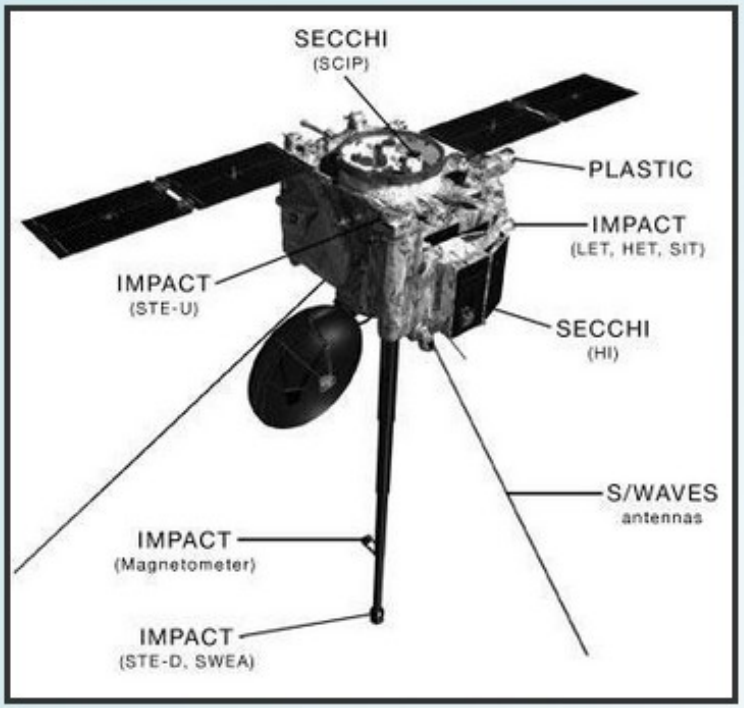
- Unreproducible locally
- BUT universal statistical properties

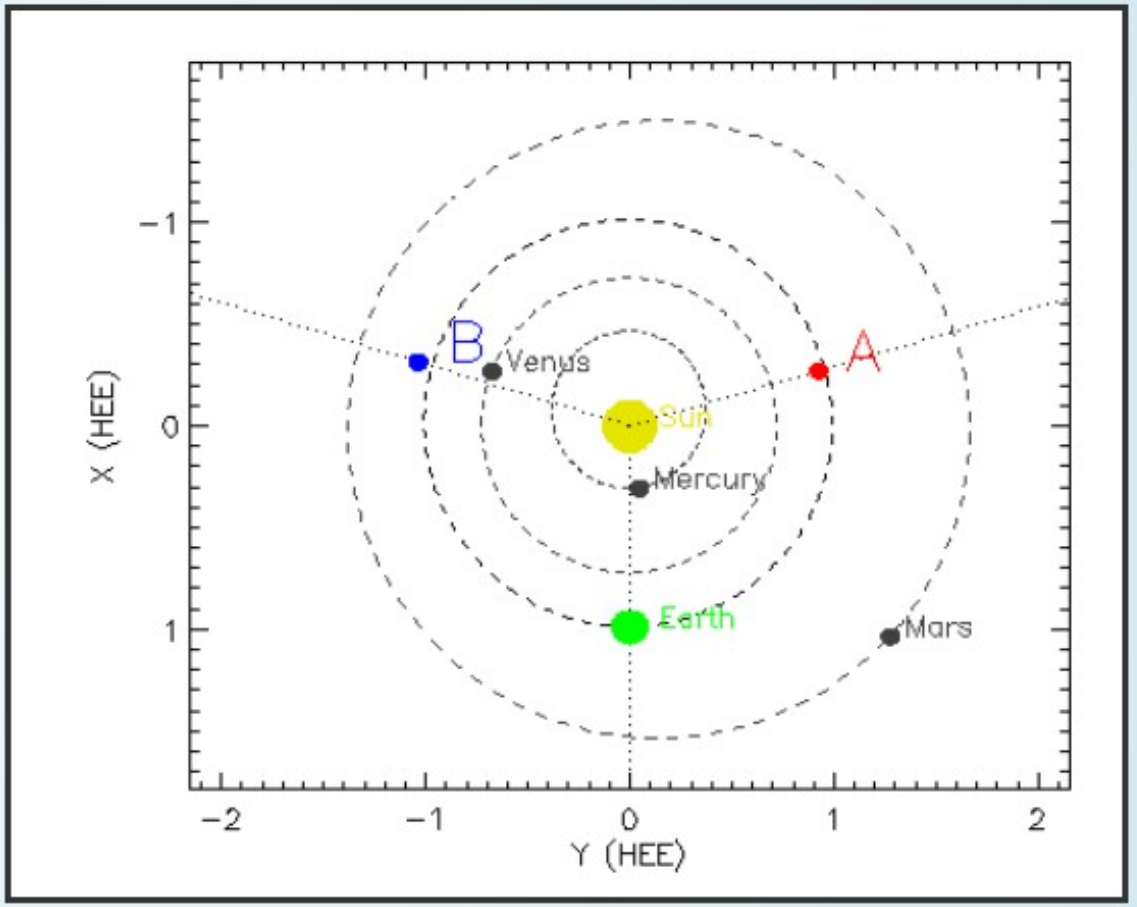




- The solar wind is a collision-less plasma
- There are characteristic scales in plasmas

Stereo A & B

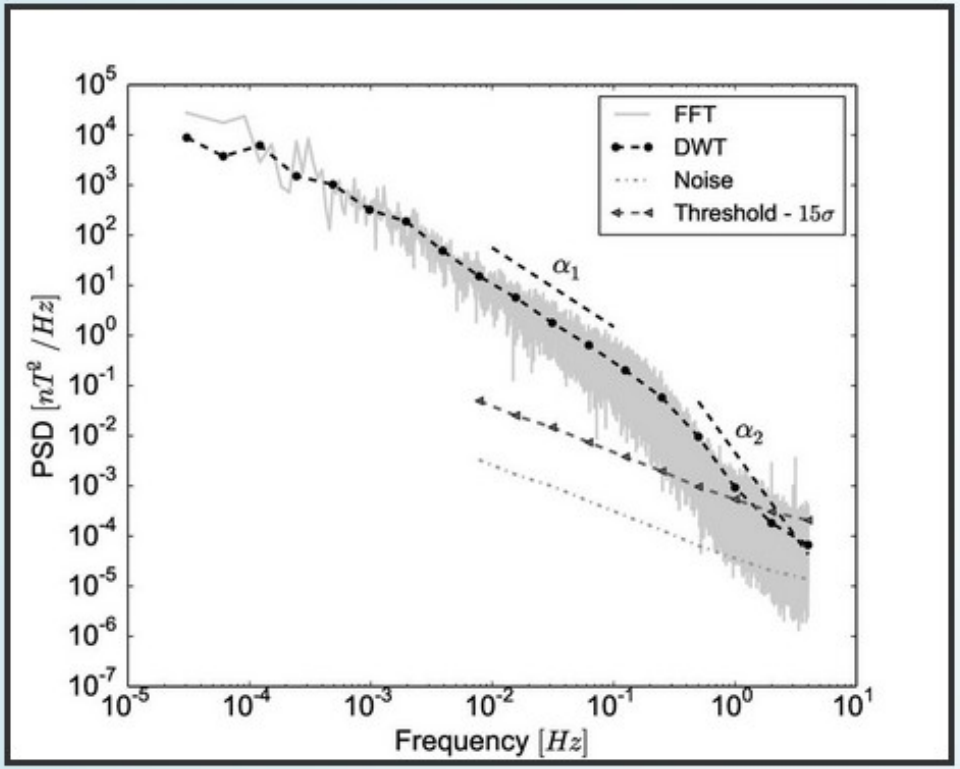


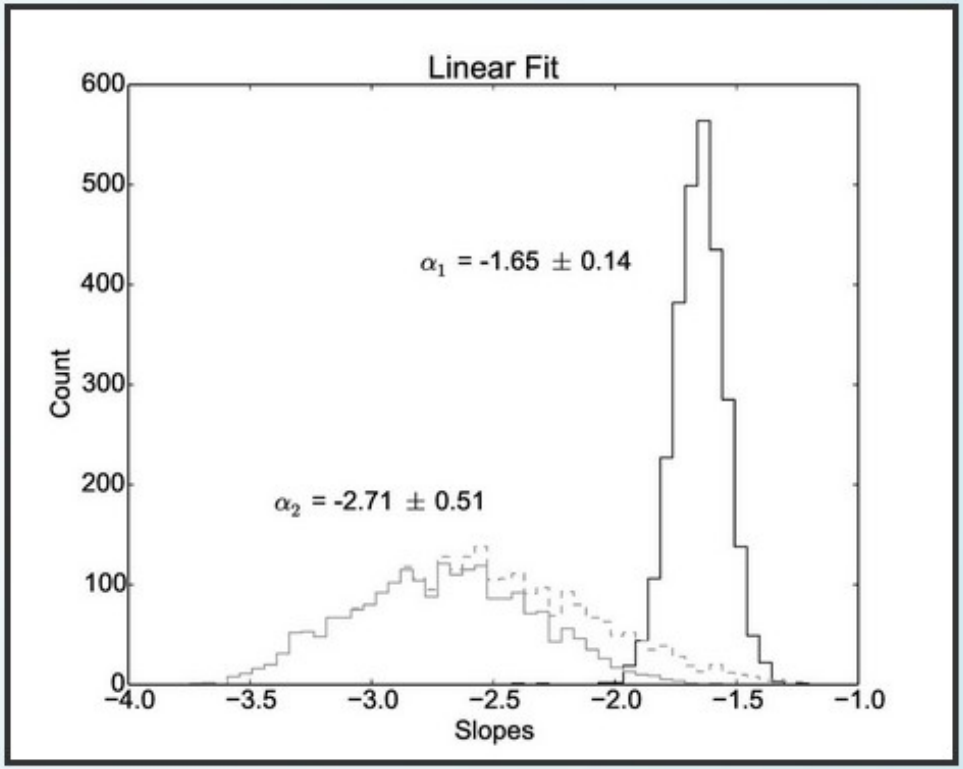


- Impact/Mag: 8 Hz - magnetic field
- Plastic: 1/60 Hz - Plasma parameters

Classical Approach

9 h/spectrum and around 4380 spectra/probe





How to define a spectral break?

- Intersection between the two slopes

A characteristic scale

for a specific mechanism

- Ion cyclotron frequency f_{ci}

➡ Dumping of Alfvèn waves

- Inertial length λ_i

➡ Limit between MHD and Hall MHD

- Larmor radius ρ_i

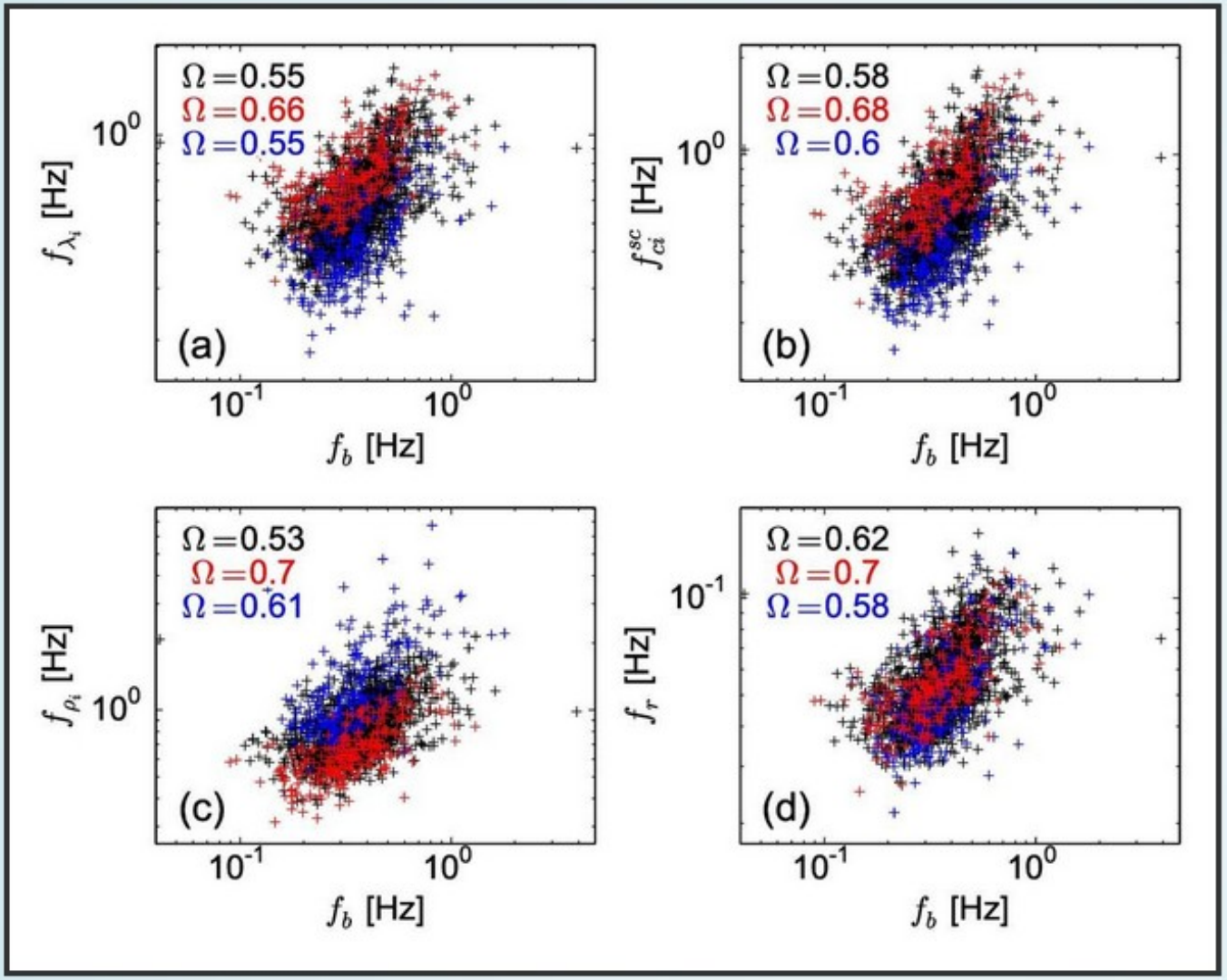
➡ Kinetic Alfvèn waves

- Resonance wave vector $k_r = f_{ci}/(V_A + V_{th})$

➡ Resonant condition for Parallel propagating Alfvèn waves

Taylor hypothesis: $f = \vec{k} \cdot \vec{v}/(2\pi)$

Correlations with f_b



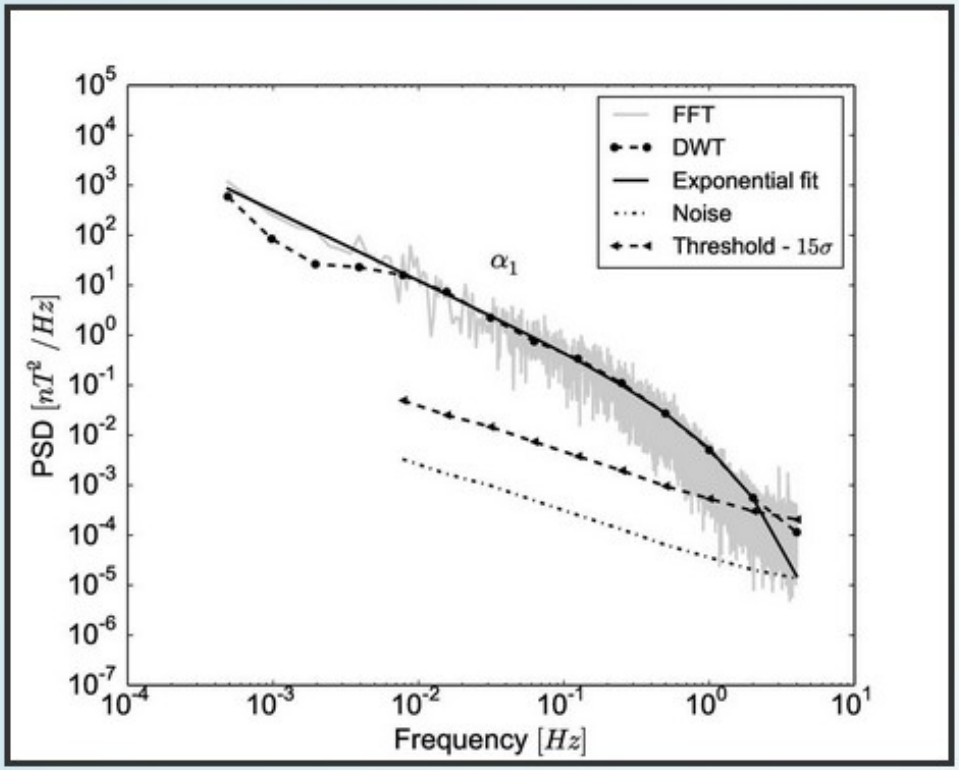
$$\beta = \rho_i^2 / \lambda_i^2$$

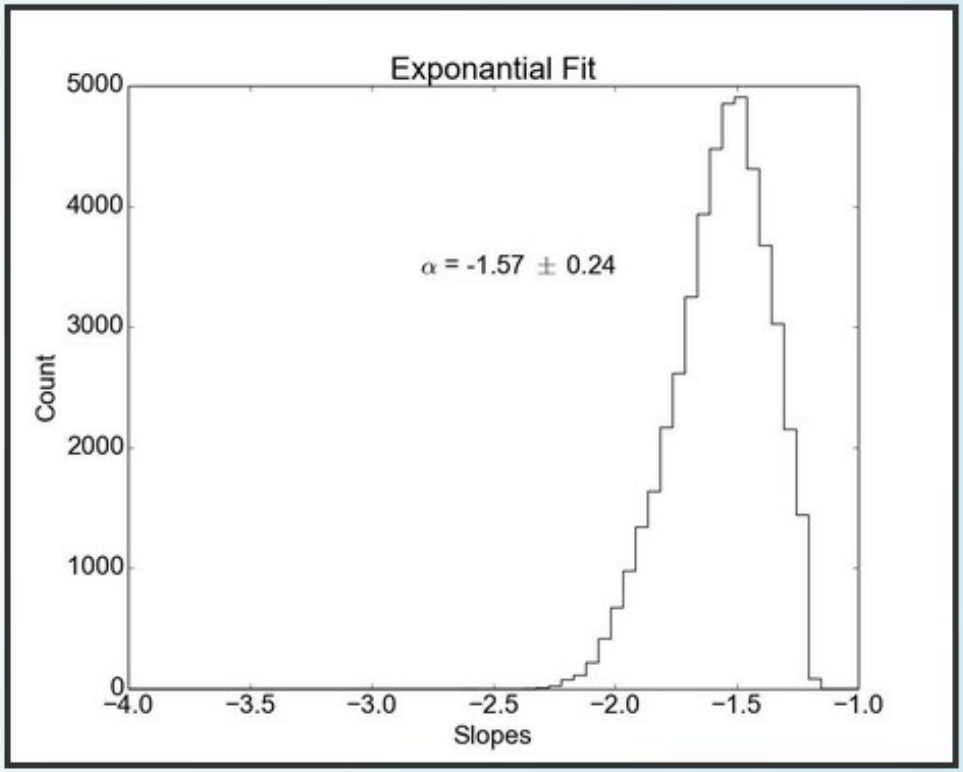
- All Beta
- Beta>1
- Beta<0.2

Better correlation with f_r but no significant difference between the different scales.

New approach

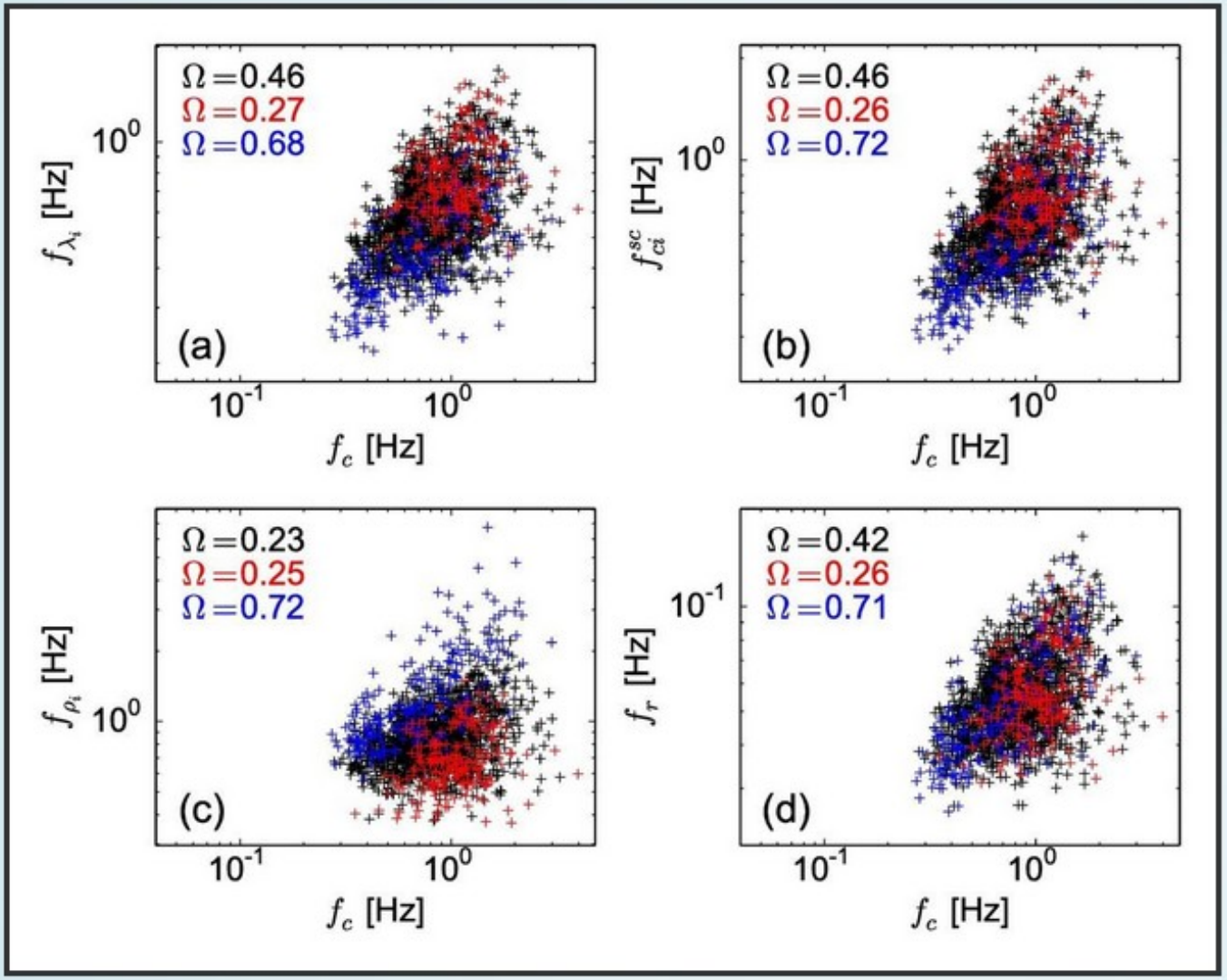
Exponantial fit: $E(f) = (f/f_0)^{\alpha} exp(-f/f_c)$





The break can also be defined as the cut-off frequency of the inertial range

Correlations with f_c

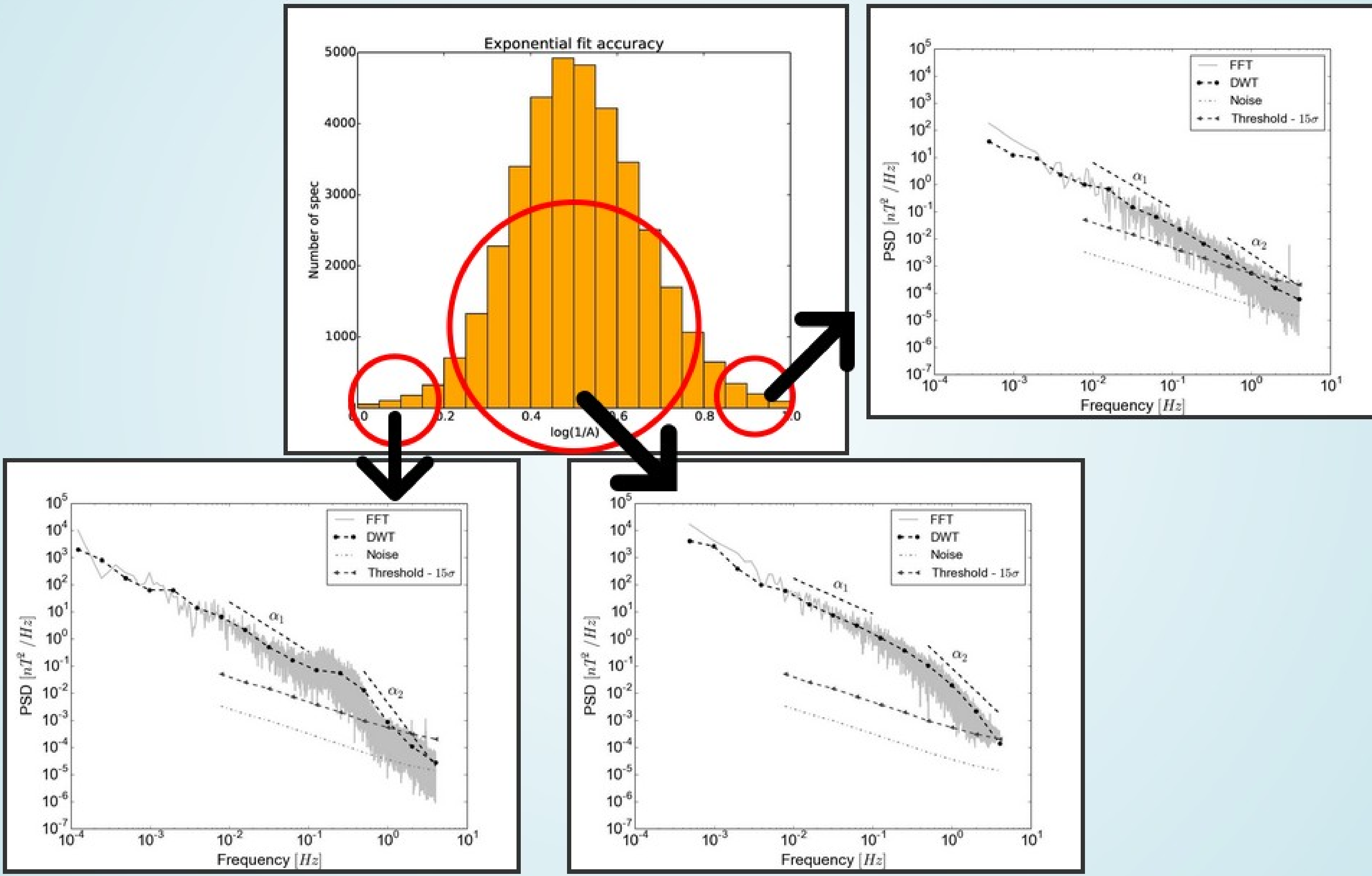


$$\beta = \rho_i^2 / \lambda_i^2$$

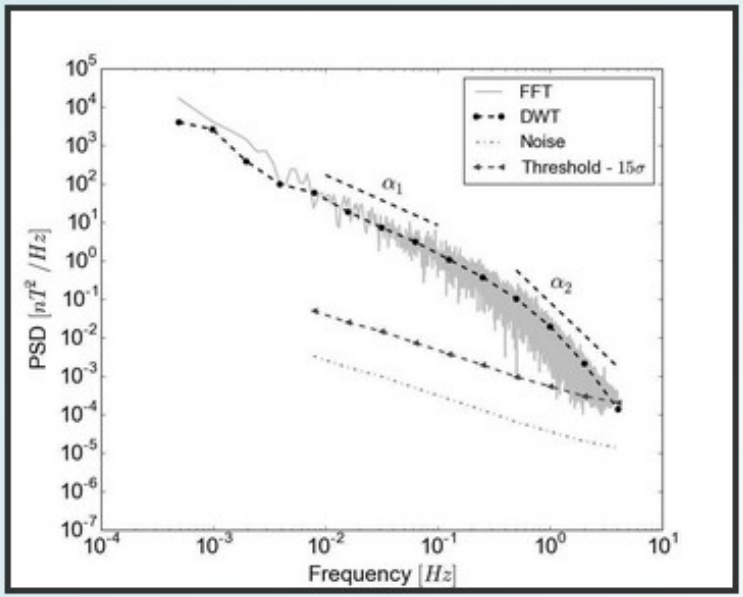
- All Beta
- Beta>1
- Beta<0.2

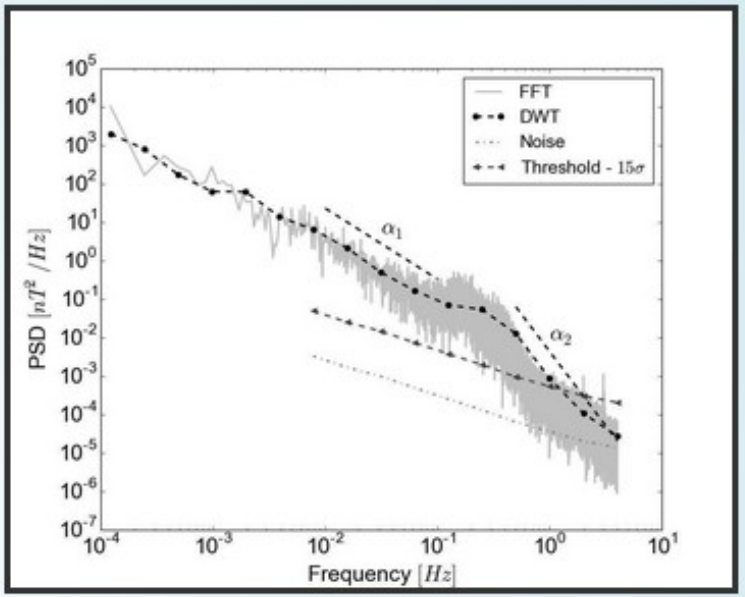
Again no significant difference between the different scales except a very low correlation coefficient for the Larmor radius.

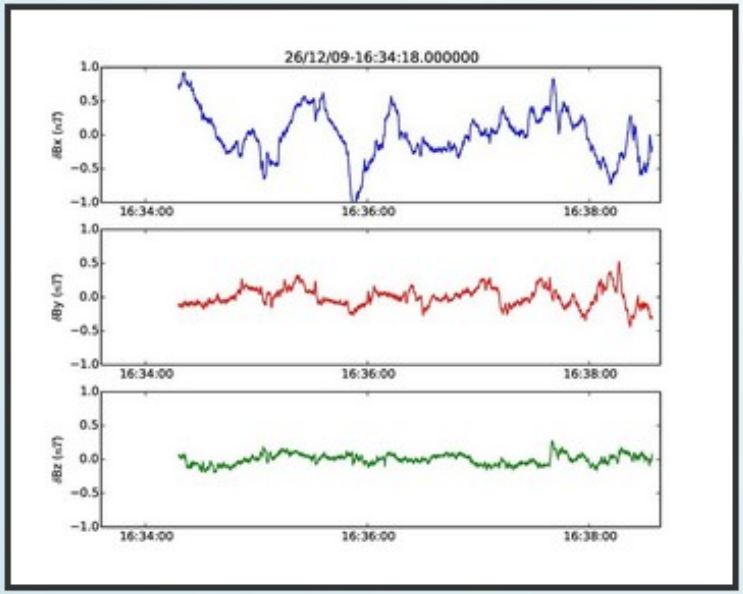
Various spectral shape

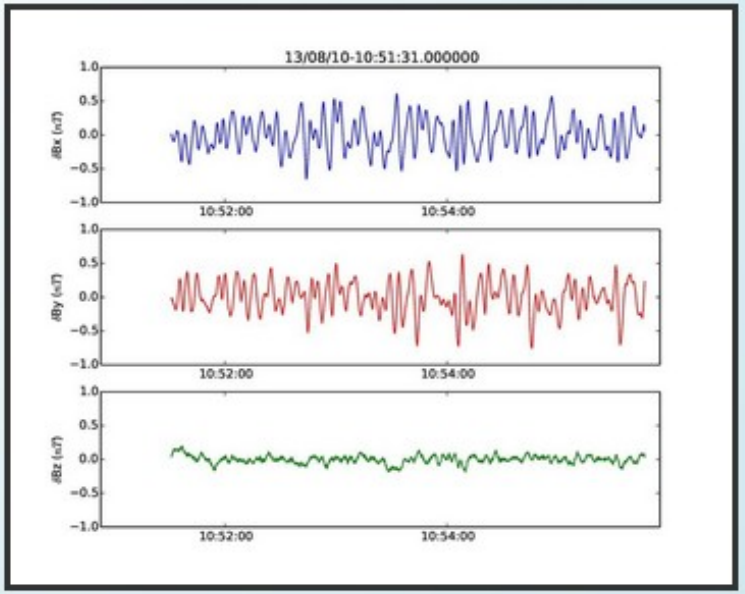


Corresponding waveforms

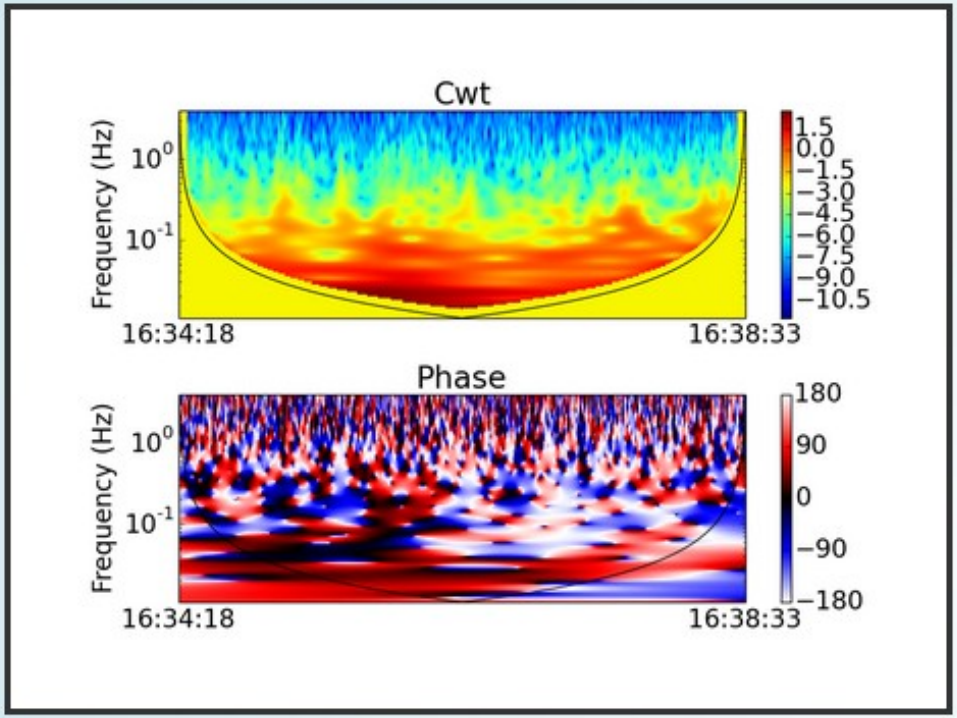


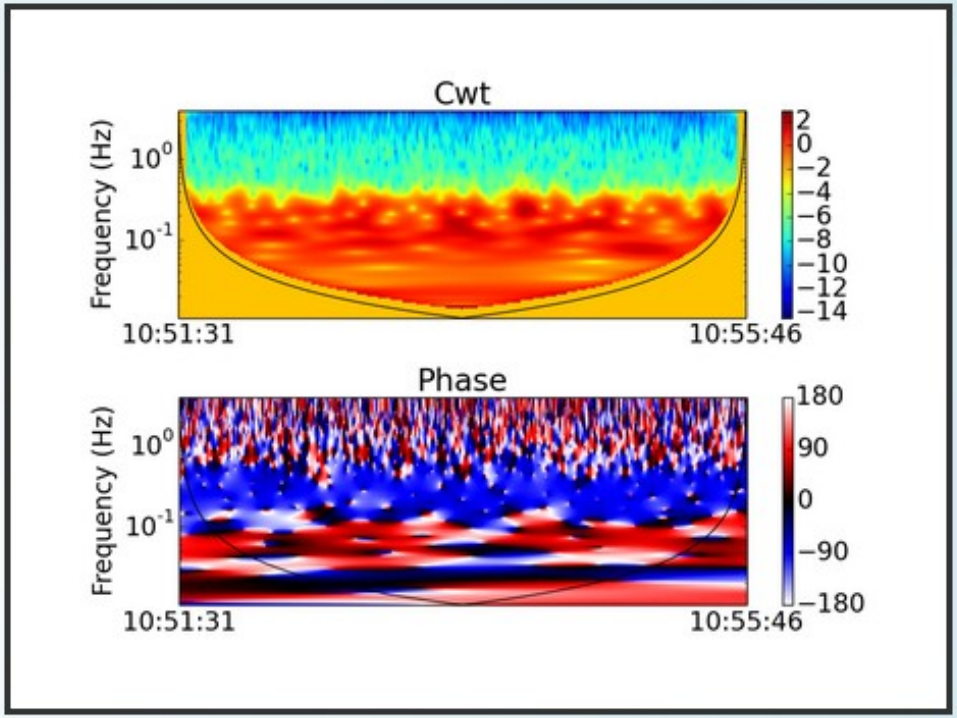






Scalograms and polarization





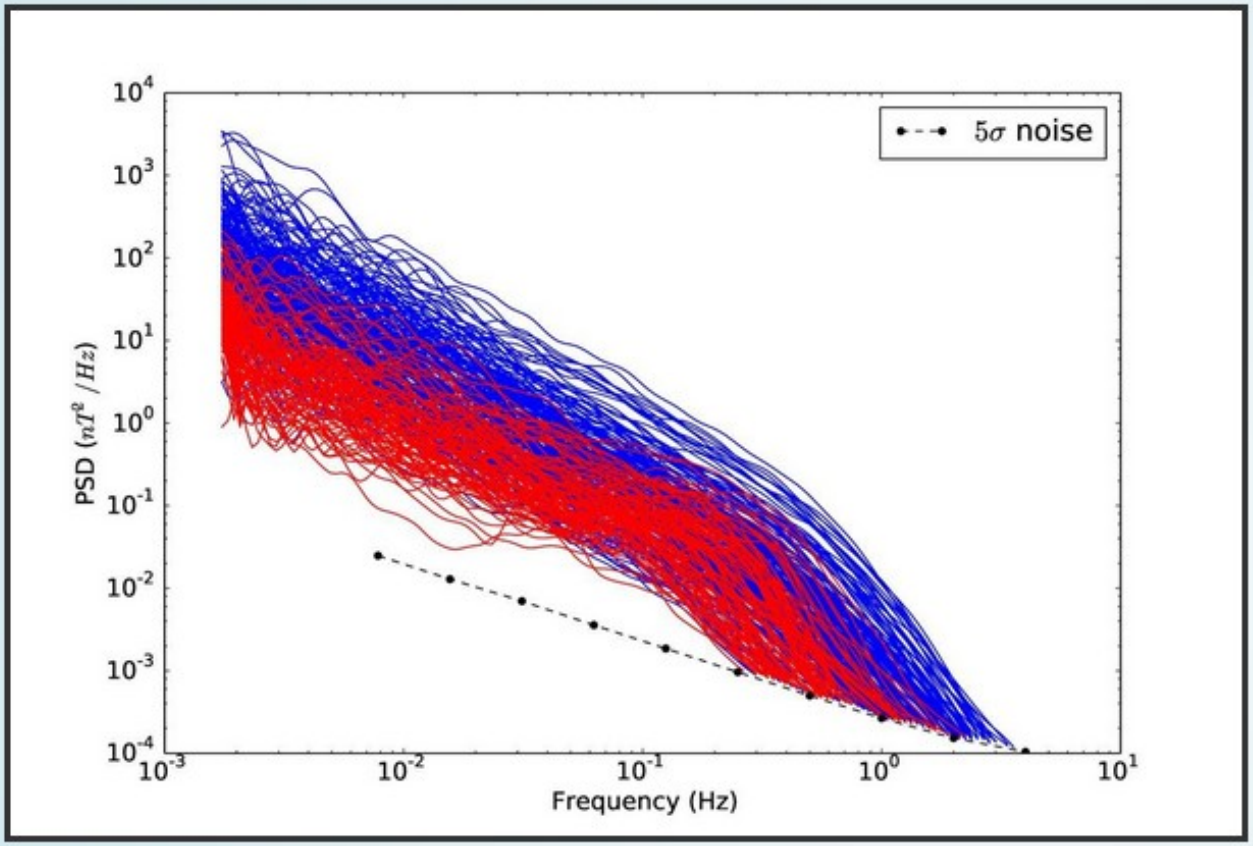
Transition shapes:

- Wide frequency structure, localized in time
- Quasi random polarization

Bump shapes:

- Constant phase in time over a range of frequencies
- Elliptical polarization

Distribution of spectra



- If the turbulence is too high, there is no visible bump.

- But if the level of turbulence is low it does not necessarily imply the wave/structure existence.
- The spectra with bumps appear less steep within the inertial range.

Conclusion

- The transition between the inertial and kinetic range is not always clear.
- Better correlation with f_r but no significant difference between the different scale.
- There are several spectrum families (bump, with or without transition...) with different characteristics.
- Bumps are observed for about one percent of the observation time and may have an important role in the mechanisms related to ion instabilities