Survey of whistlers waves parameters in the pristine solar wind from the first PSP orbit:
wave amplitude, polarization, and collocation with magnetic dips

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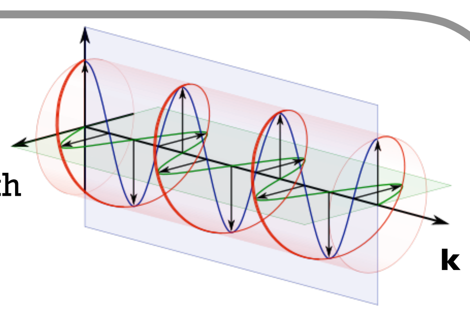
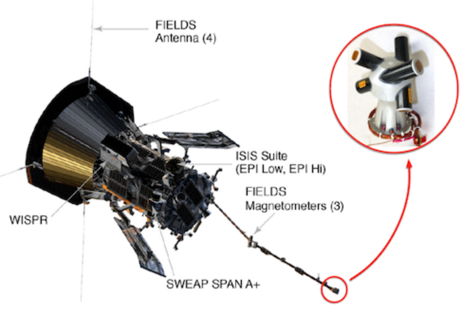
Whistler waves in the solar wind



- Whistlers are right-hand circularly polarised electromagnetic waves with frequencies between the lower hybrid f_{lh} and the electron cyclotron frequency f_{ce}
- We analyse the observations of the first encounter of Parker Solar Probe with the Sun: from October, 31 to November, 11 2018, i.e. from 54 to 35.7 Rs

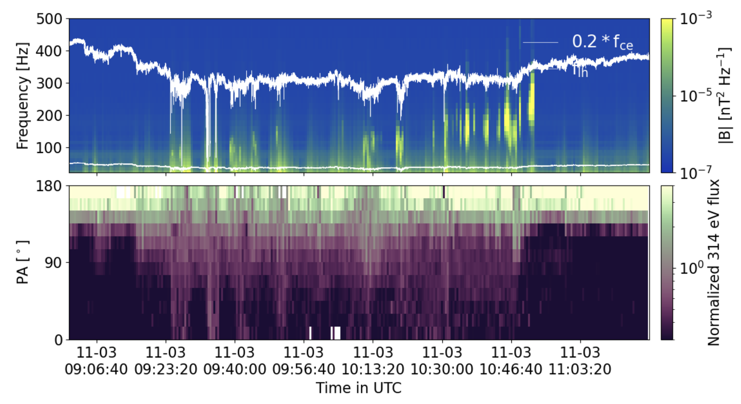


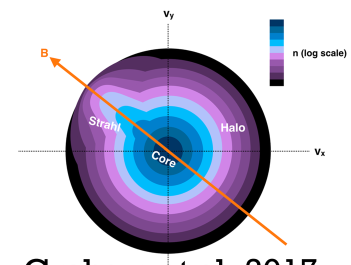
The Search-Coil Magnetometer (SCM; Jannet et al. 2020) is part of the FIELDS experiment (Bale et al. 2016)

- measures the fluctuations of the magnetic field > 3 Hz
- SCM measurements are digitised and processed by 3 instruments, here we use the Digital Fields Board (DFB; Malaspina et al. 2016)

Interaction with the electron populations

- Whistler waves are suspected to play a role in scattering the strahl into the halo population & breaking the heat flux
- Consistent with Parker Solar Probe first observations:



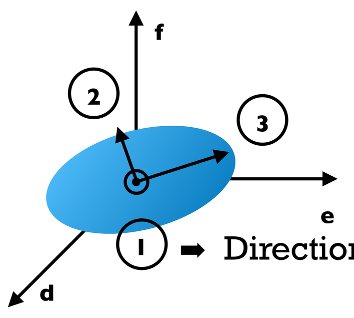


Graham et al. 2017

- Broadening of the strahl when the whistlers are observed (Jagarlamudi et al. 2021, Cattell et al. 2021)
- Fan instability (producing highly oblique whistlers) threshold constraining the dependence of the heat flux with β_e

Detection and determination of the wave normal angle

Polarisation and obliquity obtain from the analysis of the spectral matrices produced on board: Singular Value Decomposition (SVD; Santolík et al. 2003)



Planarity: $1-\sqrt{w_1/w_3}$

Ellipticity: w_2/w_3

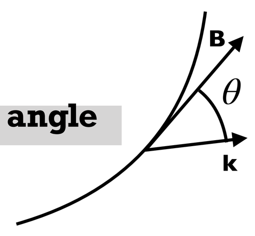
(1) ➡ Direction of the k-vector

Important parameter for understanding the whistler generation mechanisms

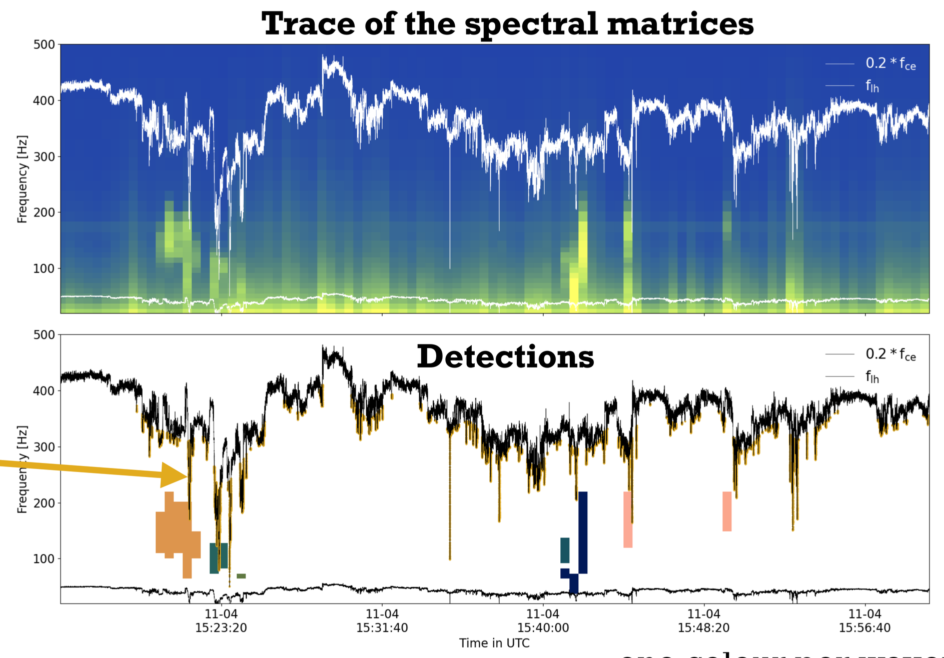
Detection criteria

- Power Spectral density $\geqslant 4$ times the ambiant fluctuation level
- Planarity and ellipticity $\geqslant 0.6$

Wave normal angle



Trace of the spectral matrices



Collocation with magnetic dips (similar to the cases reported by Agapitov et al. 2020)

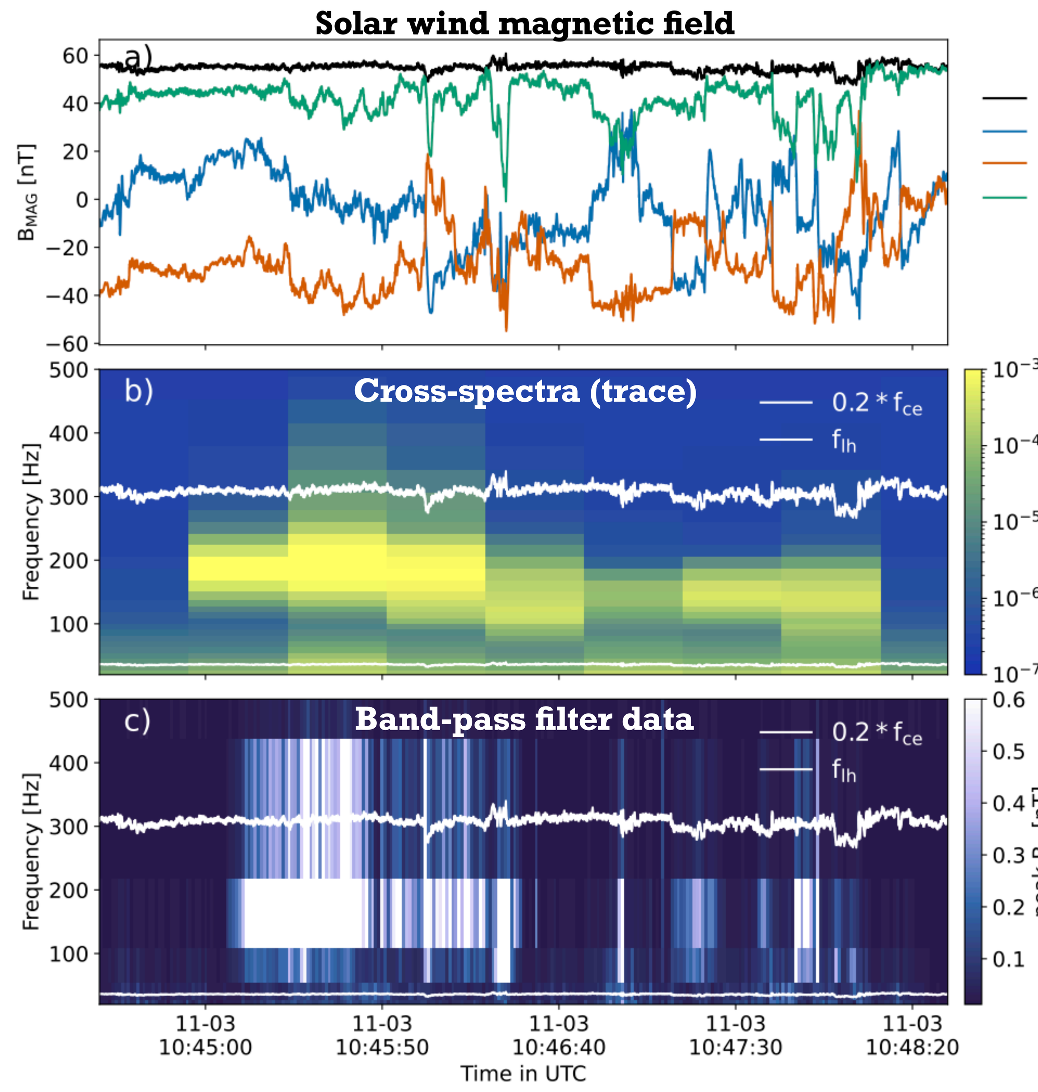
one colour per wavepacket

Need to better locate the wavepackets in time in order to get a accurate estimation of the background magnetic field

Why:
- High intermittency of the whistlers (Jagarlamudi et al. 2021, Cattell et al. 2021)
- The background magnetic field can substantially evolve during one single 28-second bin

Solution:
- weigh the average background magnetic field by the power spectral density estimated from the peak value of the band-pass filter measurements

Solar wind magnetic field

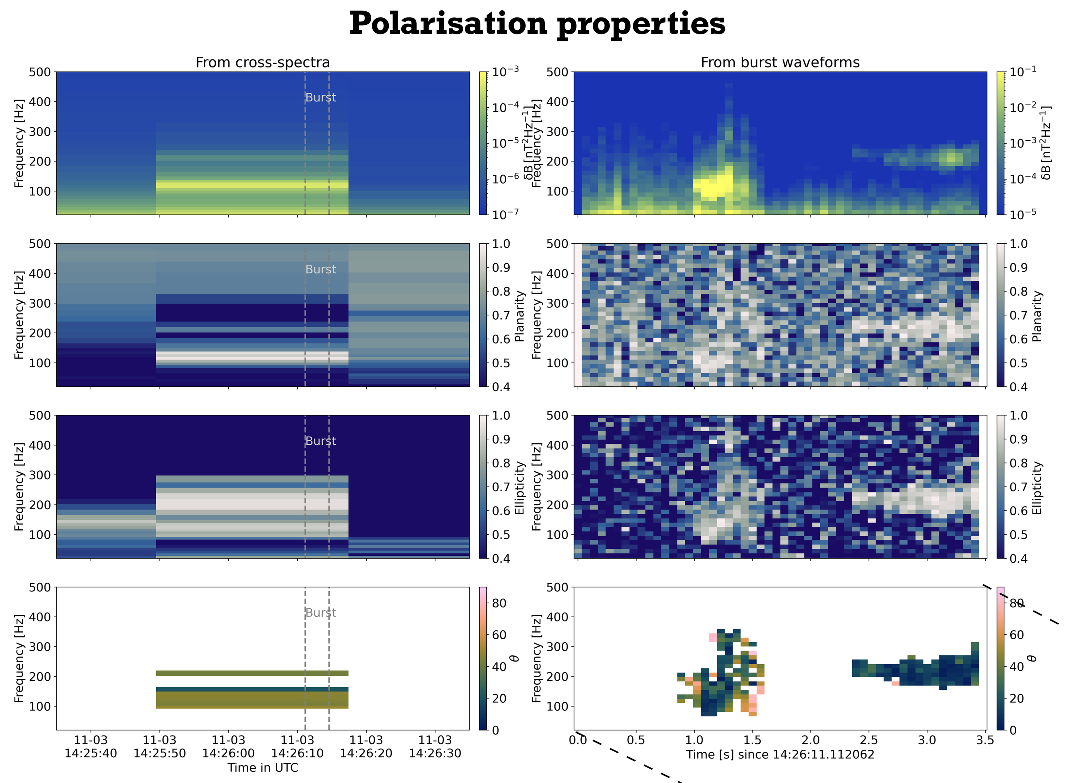


Band-pass filter data amplitude of the wavefield in specific spectral bands, one spatial component (B_u), cadence of 0.87 seconds

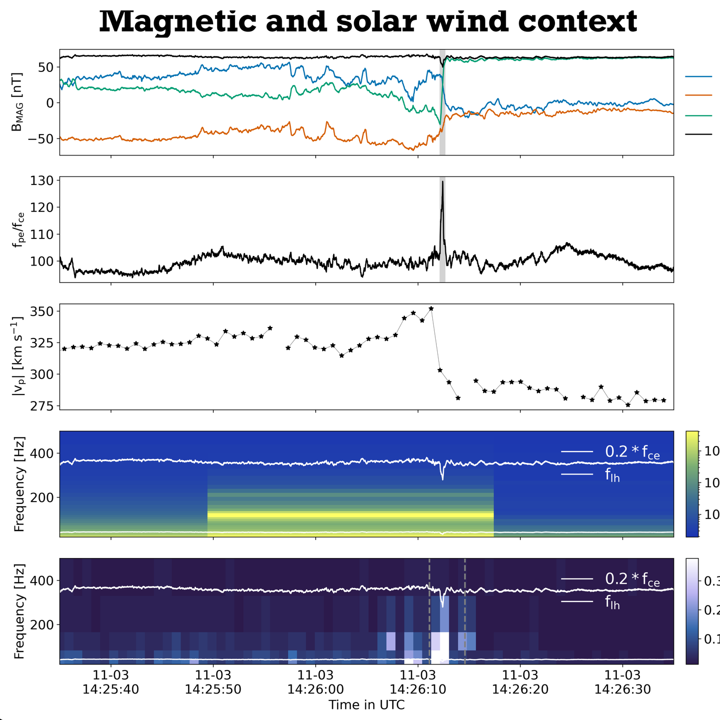
Validation of the cross-spectral analyses and statistics

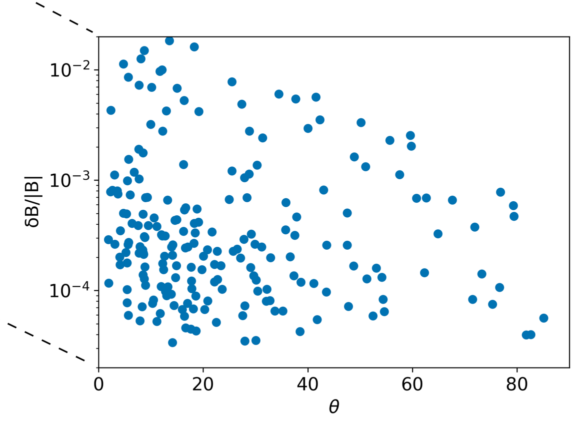
Sample event: quasi-parallel and oblique whistlers collocated with a magnetic dip at the boundary of a magnetic switchback

Polarisation properties



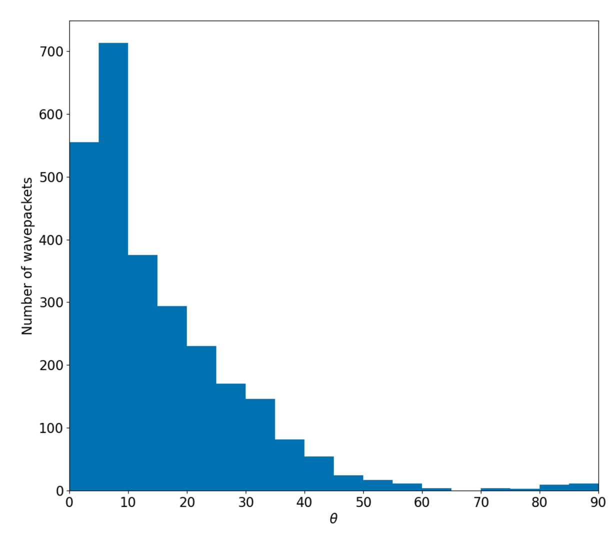
Magnetic and solar wind context

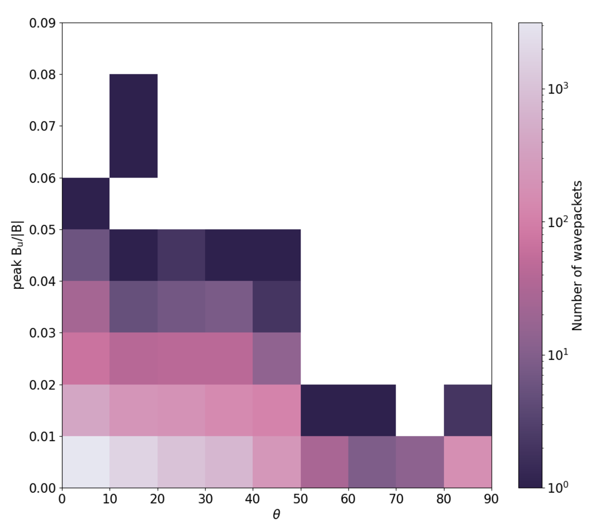




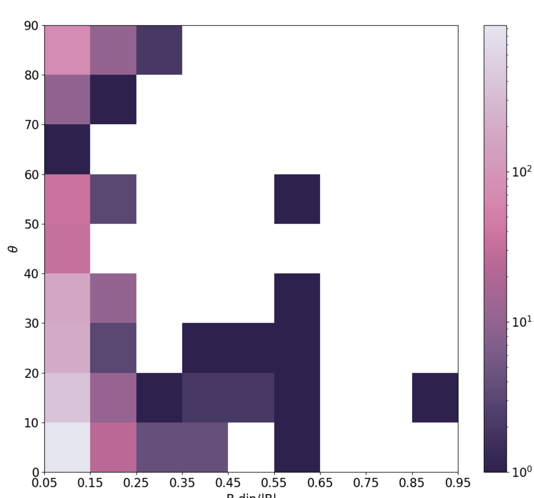
- Coherent wave, showing as oblique in the cross-spectra, mix of wave normal angle when compared with a burst waveform interval (at 150k samples/seconds)
- A few examples detected in the cross-spectra can be analysed with waveforms: validation of our results

- About 2700 wavepackets detected in the cross-spectra
- Most are quasi-parallel, but a significant part is oblique





- About half of the events are co-temporal with magnetic dips
- Both quasi-parallel and oblique whistlers can be find in dips, in large dips: only quasi-parallel



Main takeaways

- The wave normal angle vary:
  - The main part of observed whistlers were quasi-parallel to the background magnetic field but a significant part (3 %) of observed waves had oblique (> 45°) wave normal angles (which is important for the scattering of strahl electrons);
  - This is a lower limit, burst waveforms analyses show more oblique wavepackets
- The results based on the spectral matrices data were validated with the waveforms (burst and survey)
- 52 % of the whistler wave bins in the spectral matrices are associated with magnetic dips, soon to be compared with simulation results
- Paper in prep, first results can be find in Dudok de Wit et al. 2022, JGR