The role of whistler-mode waves in electron scattering: Comparison of Parker Solar Probe observations with particle tracing simulations

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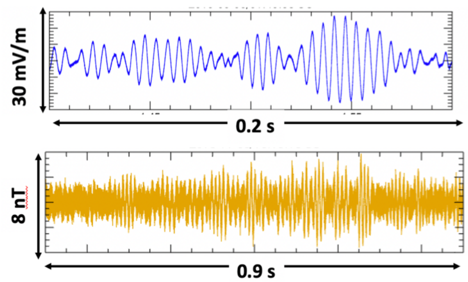
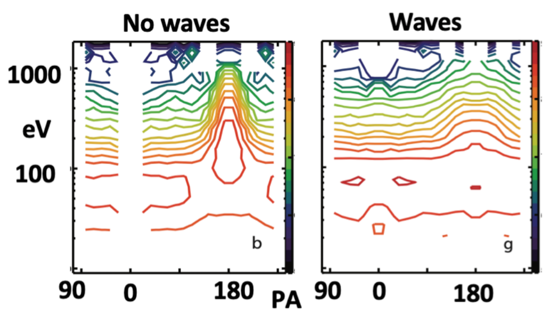
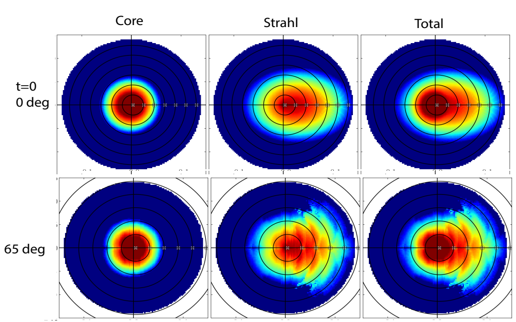
Summary



Large-amplitude narrowband whistler-mode waves are common in the solar wind from <.3 AU to 1 AU [1,2,3]



Electron distributions provide evidence for strong scattering by the waves. [4]



Particle tracing results show features consistent with observations and PIC simulations. [5,6,7] Heat flux control relevant in other astrophysical settings

Motivation

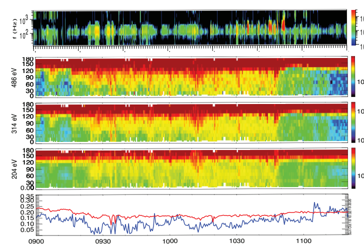
Motivation: Inside ~.2 AU, strahl which carries heat flux is very narrow and there is almost no halo. Outside ~1 AU, strahl is often gone; halo dominates suprathermal population Heat flux is reduced. If magnetic moment conserved, strahl would become more field-aligned with distance from the Sun, but instead it becomes broader.

What mechanisms scatter strahl to reduce heat flux and produce the halo?

1. Coulomb scattering – effective only for low energies (and close to the Sun where sw density is higher)
2. Wave scattering is required.

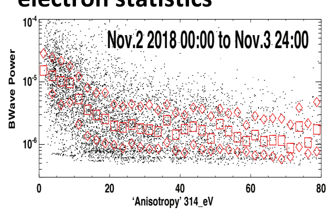
PSP Observations

PSP Observations: Broadened strahl and reduced heat flux associated with large whistlers.



Whistlers seen in dE bandpass filter (BPF) and pitch angle dfs (486, 314 and 204 eV plotted) demonstrate broadening of strahl with intense waves.

Norm. heat flux (black) < fan instability limit [8] (red) during waves, consistent with electron statistics [9]

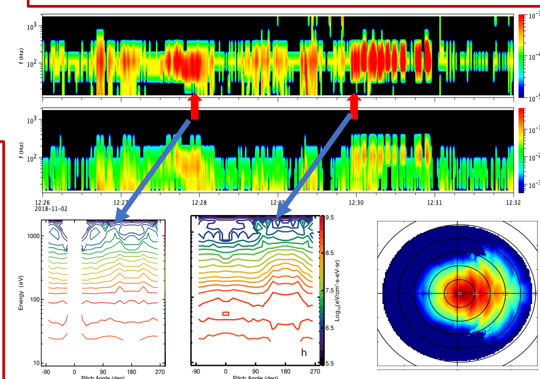


Broadening can been seen in comparison of individual dfs to BPF and waveform capture data, and in statistical comparisons of wave power to measures of pitch angle width (see 3 day plot of 'anisotropy'

Particle tracing code and results

Particle tracing code and results: Using a full 3d particle tracing code, we modeled interactions of electrons from 0 eV to 4 keV with whistlers based on observations (both single waves and packets) with wave angles of 0, 65 and 180° . Results show kinetic effects of resonant interactions, with features such as peaks not parallel to the SW magnetic field, consistent with PSP data.

Strong scattering and energization for some initial energy and pitch angle ranges occurs for both counter-propagating and obliquely propagating waves.



References:

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