Whistler Waves in the Young Solar Wind from Parker Solar Probe Measureemtns

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Observations by the Parker Solar Probe mission of the solar wind at ~35.7 solar radii reveal the existence of whistler wave packets with frequencies below 0.1 f_{ce} (20-80 Hz in the spacecraft frame). These waves often coincide with local minima of the magnetic field magnitude or with sudden deflections of the magnetic field that are called switchbacks. These whistler waves are found to propagate sunward. Their phase velocity is in the range of 300-500 km/s, which leads to a significant Doppler frequency downshift from 200-300 Hz in the solar wind frame to 20-80 Hz in the spacecraft frame. This downshift allows these waves to be resolved by waveforms from magnetic (SCM and MAG) and electric (EFI) sensors, which are sampled at 292.97 Hz at perihelion. Their sunward propagation leads to a significant Doppler frequency downshift from 200-300 Hz to 20-80 Hz (from 0.2 f_{ce} to 0.5 f_{ce}). The polarization of these waves varies in different wave packets from quasi-parallel to significantly oblique and close to the resonance values of wave normal angle (presumably due to the propagation in inhomogeneous background magnetic field). The wave amplitude reaches 2 to 4 nT, which corresponds to up to 10% of the background magnetic field. This amplitude is much larger than what is observed in the solar wind at 1 a.u. Such waves are very effective in scattering the Strahl population of solar wind electrons as shown recently in numerical simulations by Roberg-Clark et al. (2019). We conjecture that these whistler waves play a significant role in scattering the Strahl population and breaking the heat flux in the inner heliospheric solar wind. Recent numerical studies show that such waves may potentially play a key role in breaking the heat flux and scattering the Strahl population of suprathermal electrons into a halo population.