Electrostatic Waves with Rapid Frequency Shifts in the Solar Wind from PSP observations

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During its first five orbits, the FIELDS plasma wave investigation on board Parker Solar Probe (PSP) has observed a multitude of plasma waves, including electrostatic whistler and electron Bernstein waves (Malaspina et al. 2020), sunward propagating whistlers (Agapitov et al. 2020), ion-scale electromagnetic waves (Verniero et al. 2020, Bowen et al. 2020) and Alfven, slow and fast mode waves (Chaston et al. 2020).

The importance of these waves lies in their potential to redistribute the energy of the solar wind among different particles species (wave-particle interactions) or different types of waves (wave-wave interactions). The abundance of waves and instabilities observed with PSP points to their central role in the regulation of this energy exchange.

Here we present first observations of an intermittent, electrostatic and broadband plasma wave that is ubiquitous in the range of distances that PSP has probed so far ([30,140] solar radii away from the Sun). A unique feature of these waves is a frequency shift that occurs on millisecond timescales. In the frame of the spacecraft, they usually appear between the electron cyclotron and electron plasma frequencies.

We develop a detection algorithm that identifies the waves in low cadence spectra and use machine learning to discover them in high cadence spectra. We analyze them using various statistical and analytical techniques. We establish their phenomenology and compare the power contained in the background magnetic field at times of waves and at times without the waves under study. We establish their polarization with respect to the background magnetic field and search for correlations with various plasma parameters and features in the electron, proton and alpha particle distributions. We also investigate possible plasma wave modes that could be responsible for the observations and the instability mechanisms that could be generating them.