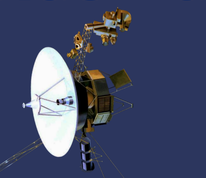
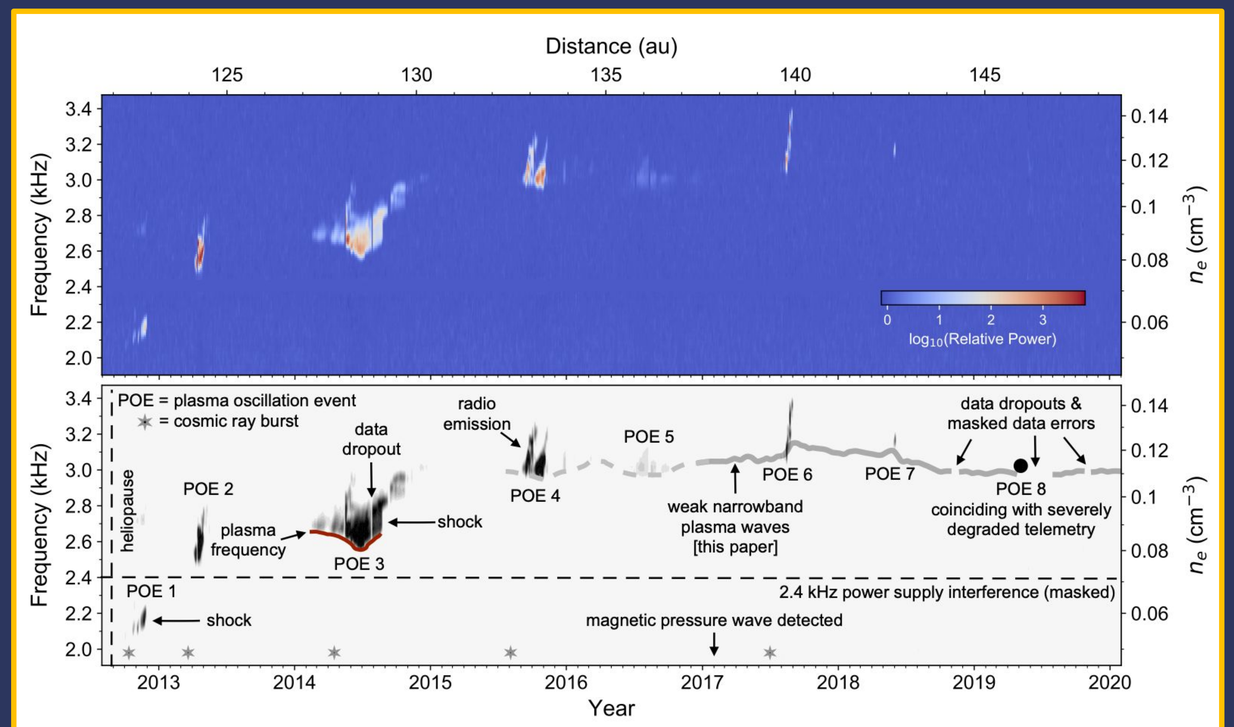
Voyager 1 detects persistent plasma waves in interstellar space.



The discovery opens a new avenue to explore structure in the nearby interstellar medium from sub-AU to tens of AU scales.



Top: Frequency-time dynamic spectrum showing all of the Voyager 1 PWS wideband data available since Voyager 1 crossed the heliopause on August 25, 2012. Time resolution: 3 days. Frequency resolution: 0.011 kHz. **Bottom:** Schematic showing relevant features in the spectrum, including previously detected plasma oscillation events (POEs). The lower cutoff frequency of the plasma oscillations corresponds to the local plasma frequency. The model of the new plasma wave emission presented here is in solid gray, and the frequency inferred from POEs between 2015 and 2017 in dashed gray.

This work is in press and under media embargo.

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Voyager 1 is now an interstellar probe

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BACKGROUND: Until now, Voyager 1 has measured the density of the interstellar medium (ISM) using transient plasma oscillation events that are triggered by shock waves of solar origin. Plasma oscillations are detected in the electric field spectrum at the plasma frequency, which is directly related to the plasma density.

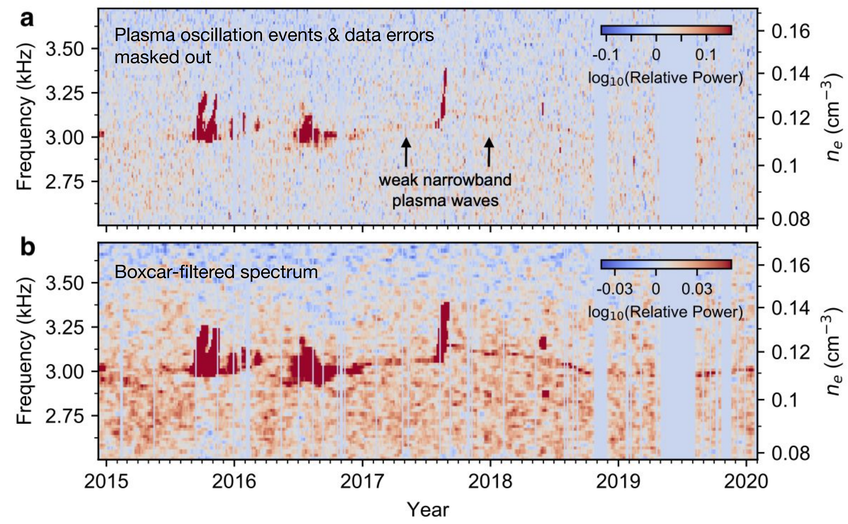
METHODS:

- Plasma Wave System (PWS) wideband receiver
- antenna voltage (rate 28 kHz)
- FFT
- frequency-time electric field spectrum
- mask telemetry errors
- search for new signals
- Plasma frequency = (8.9 kHz) x (plasma density)$^{1/2}$

RESULTS: A New Class of Plasma Wave Emission in the ISM

- ➔ Weak (requires averaging >1 epoch)
- ➔ Narrowband (<0.04 kHz)
- ➔ Persistent (~2017 to early 2020)
- ➔ Raises interesting possibilities for a future interstellar probe!

Physical Origin Unclear:
- ➔ Thermal density fluctuations?
- ➔ Quasi-thermal noise?

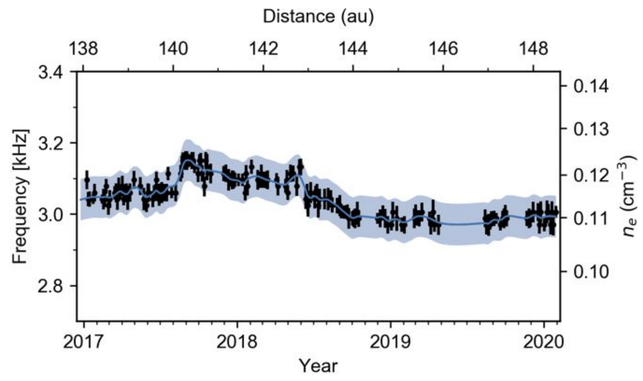


INTERSTELLAR TURBULENCE

Right: Plasma frequency extracted using a friends-of-friends algorithm (black), and a Gaussian process model fit to the data (blue). The variance of the density fluctuations is directly related to the amplitude of the turbulence wavenumber spectrum:

$$P_{\delta n_e}(q) = C_n^2 q^{-\beta}, \; q_o \le q \le q_i$$

	Very Local ISM	Local ISM
C_n^2	$10^{-1.64 \pm 0.02}$	$10^{-3.5}\ \mathrm{m}^{-20/3}$



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