Listening to Satellite Measurements: Citizen Science Analysis of ULF Wave Events

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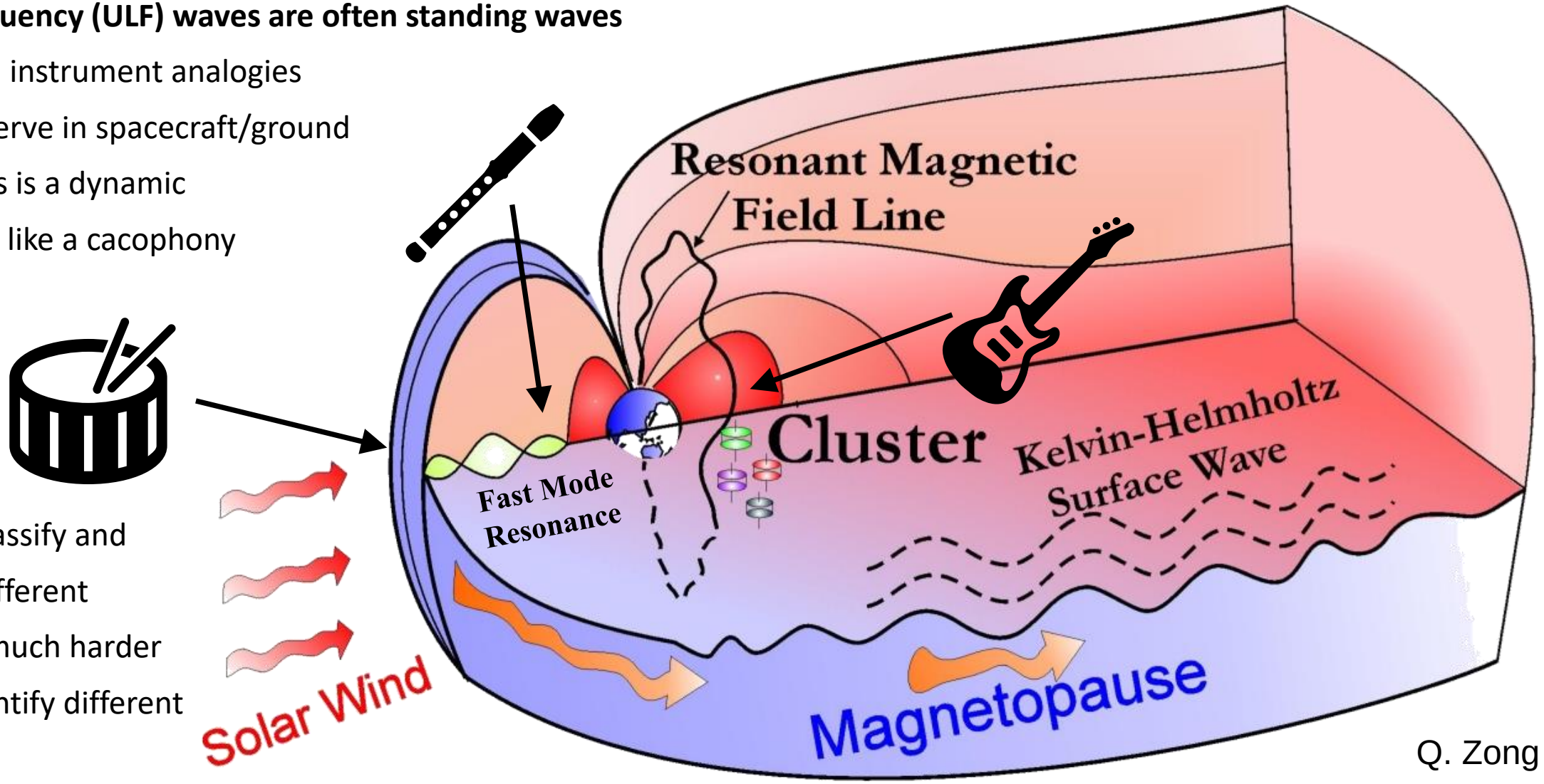
Ultra Low Frequency waves in the Earth's magnetosphere

Ultra-low frequency (ULF) waves are often standing waves

-Many musical instrument analogies

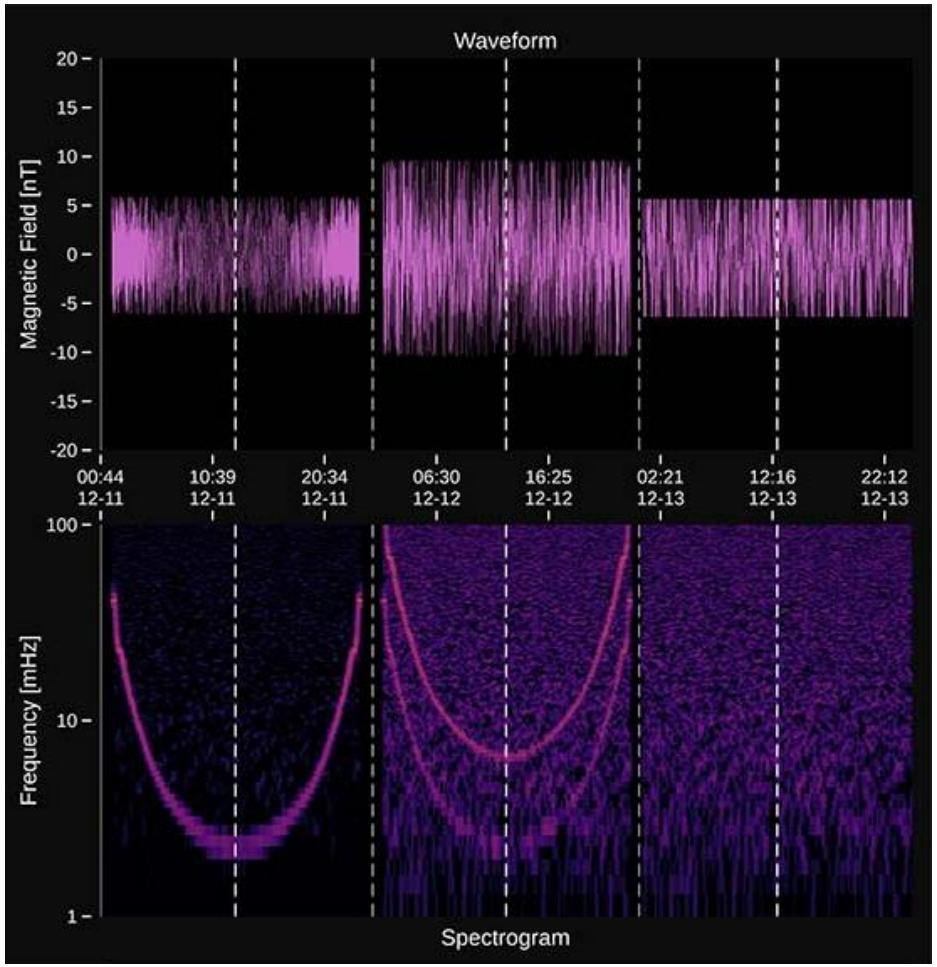
-What we observe in spacecraft/ground measurements is a dynamic superposition, like a cacophony

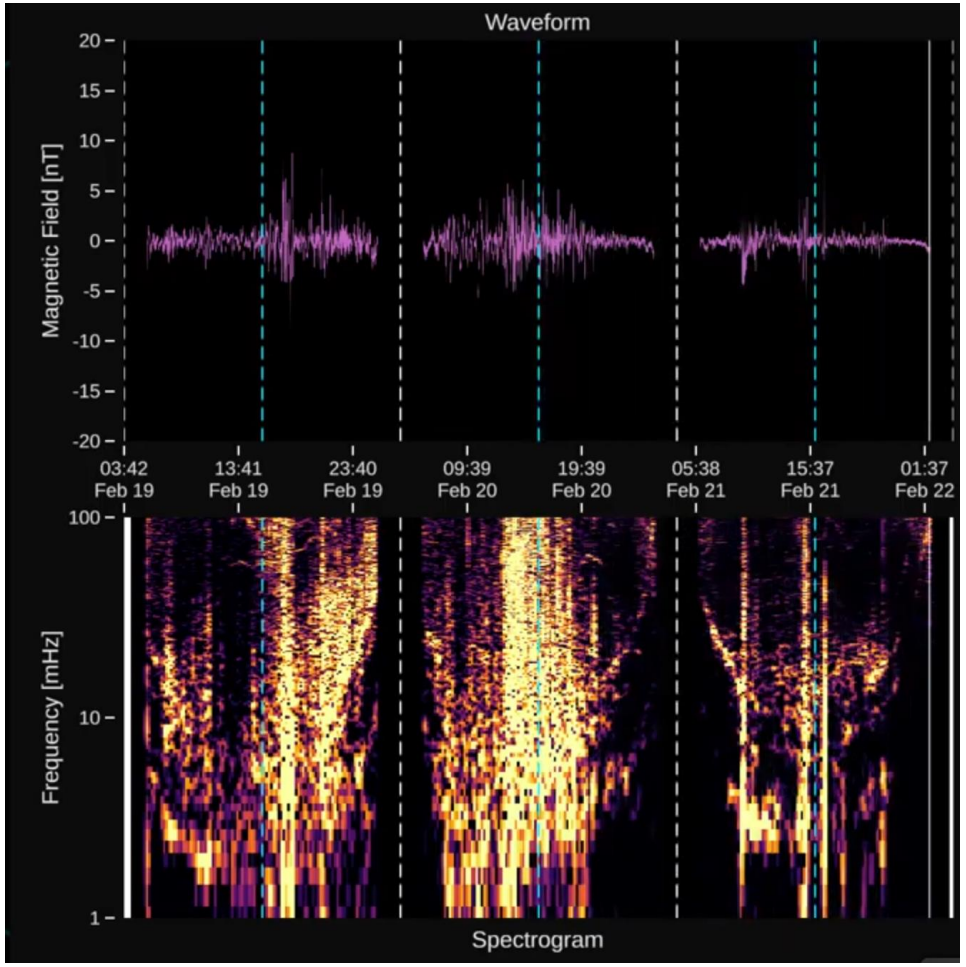


-Possible to classify and identify the different instruments, much harder to classify/identify different cacophonies

Q. Zong

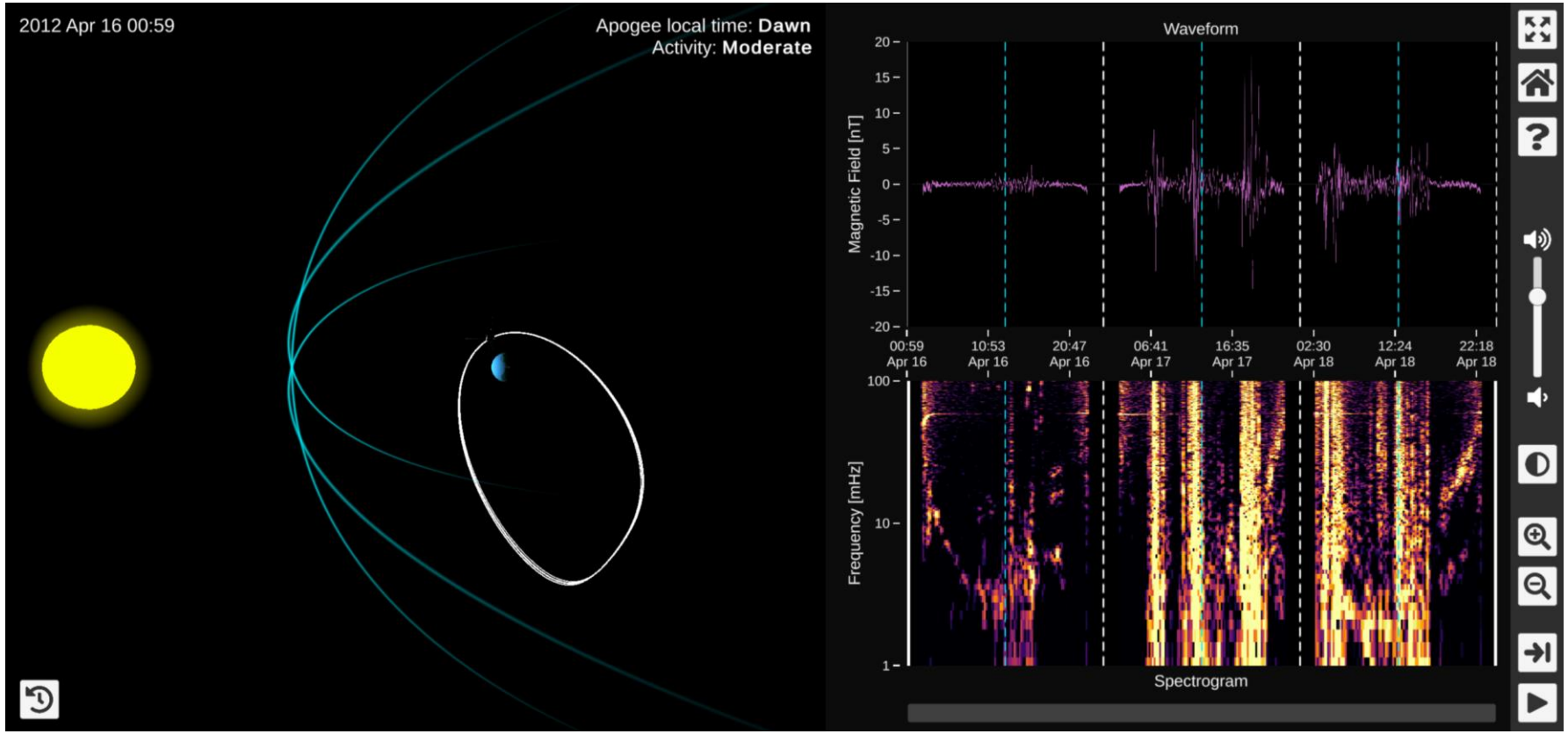
With "big data" we can improve wave event classifications





Idealized Model vs. Real Data

- Audification – one-to-one mapping of data to audio samples – complements automated/visual detection methods, enables rapid exploration of large datasets and has led to new information about ULF waves [Archer et al., 2018]
- Citizen scientists can efficiently analyze large time-series datasets. Hands-on research and meaningful application to real problems can inspire students to pursue science careers and attract diverse groups interested in space science.
- First beta test of HARP GUI with SSI-affiliated Science Teen Library program in Oct/Nov 2021 (UCLA IRB# 21-001709)
- Users listen to audio and box visible waveforms, adding comments. Submissions are reviewed/compared across users.



The HARP GUI, v1.0

Graphical User Interface Design:

- Created in Unity based on previous experience with SSI education tools such as “Magnetic Golf” and “Magnetic Bowling.” Web browser interface does not require any special software to use.
- Simultaneous audio playback with waveform and frequency spectrum view, with rendered Sun, Earth, and satellite orbit for context.
- Quick Start tutorial mode briefly explains key concepts and analysis tools. Demonstrates identification process for ULF wave fundamental frequencies and harmonics using idealized simulation data, with added white noise to resemble actual satellite observations.