Sounds of Space

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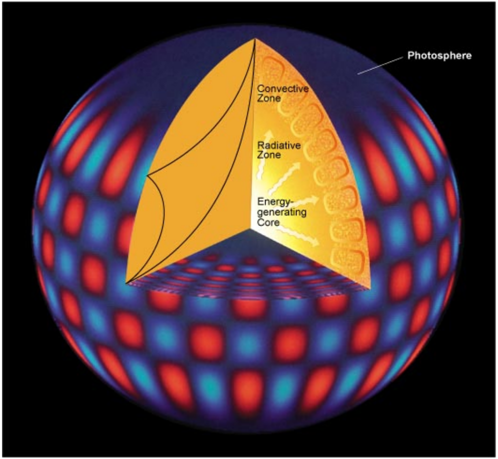
But, we can take other things from space and make them into audible frequencies. Still not screams though.

- turning electromagnetic waves/frequencies into audible frequencies enables us to learn more about the interior, atmosphere, and nature of celestial bodies/objects

Helioseismology

- The study of the Solar interior based on observations of vibrations on the surface
- While it takes 170,000 years for radiation to travel from the surface to the core, acoustic waves take only a few hours to travel through the Sun
- Acoustic waves get trapped in the photosphere and cause surface oscillations
- Causes the Sun to constantly vibrate in a superposition of acoustic normal modes
- Mode lifetimes range from hours - months and can be excited various times per lifetime
- Thought to be re-excited by turbulence in convective zone



"Helioseismology is rather like trying to understand how a piano is built from the sounds that it makes when you drop it down a flight of stairs."

Sun Singing!

`http://soi.stanford.edu/results/sounds.html`
taken over 40 days, sped up by a factor of 42,000

- hearing a few dozen of the 10 million resonances echoing in the Sun

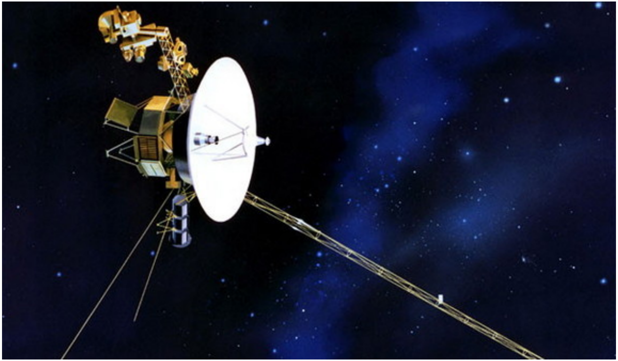
Galileo

- launched in 1989
- goal to study Jupiter and its moons
- included the Plasma Wave Experiment which used an electric dipole antenna to record the magnetosphere

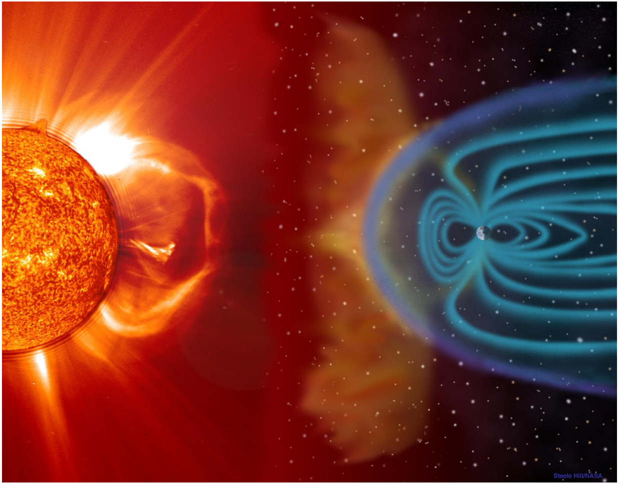
Data Sonification

- takes electromagnetic waves in the radio frequency and turns them into sounds to better understand the signal
- `http://solarsystem.nasa.gov/galileo/multimedia/gantest.mov` - from 1996
- 45 minutes of PWS data sonified and compressed
- initial strong tone marks entry into Ganymede's magnetosphere
- the irregular tone's pitch measures the density of charged particles near Ganymede

Voyager 1



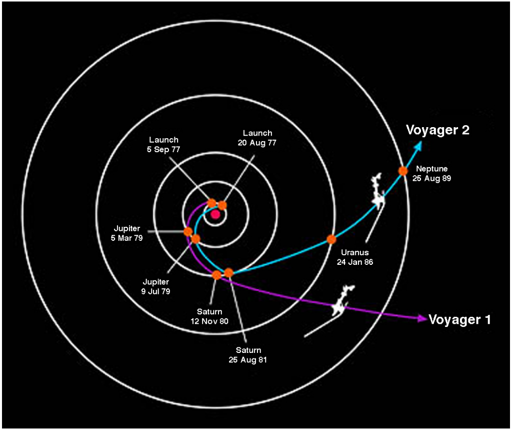
- launched by NASA in 1977
- Explored Outer Solar System
- Furthest human-made object from Earth
- Flyby of Jupiter: March 1979


Steele Hill/NASA

Crossing Jupiter's Bow Shock

- bow shock form from solar winds passing over planets
- nature's way of slowing, deflecting, and heating the solar wind as it approaches an object
- the waves heard here are partly responsible for heating solar wind as it is slowed and deflected around Jovian magnetosphere
- can be compared to a sonic boom (though supersonic)
- `http://solarsystem.nasa.gov/galileo/multimedia/v1-jup-bowshock.wav`
- initial chirps are electrons coming from bow shock and moving upstream to approach solar wind
- static-y sound is when Voyager 1 has enter the bow shock and is surrounded by turbulence

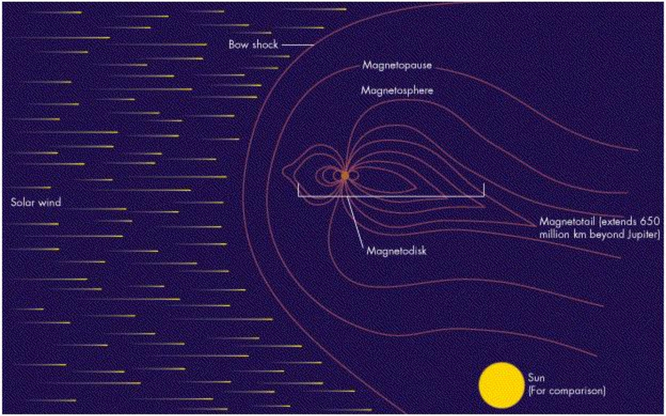
Voyager 2



- launched by NASA in 1977
- Flyby of Jupiter: July 1979

Passing Through Jovian Outer Magnetosphere

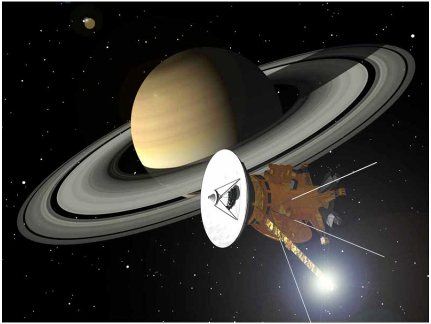
- `http://solarsystem.nasa.gov/galileo/multimedia/jovefuh-dag.wav`
- tones all created by frequency generated by plasma in a magnetic field
- the frequency is set by the electron density and strength of magnetic field
- upper hybrid waves: provide very accurate measure of plasma, a fundamental Jovian environment propety


Bow shock
Magnetopause
Magnetosphere
Solar wind
Magnetotail (extends 650 million km beyond Jupiter)
Magnetodisk
Sun
(For comparison)

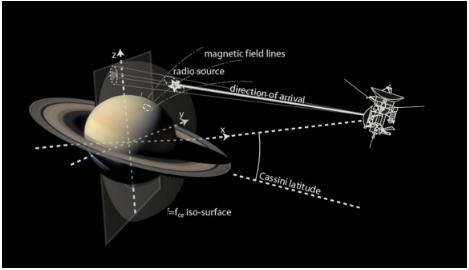
Jupiter's Lightening!

- `http://solarsystem.nasa.gov/galileo/multimedia/jwhist-dag-short.wav`
- very faint whistling sound confirmed lightening in Jupiter's atmosphere: 'whistler' emission
- part of EM spectrum of lightening stokes that occur when propagating away from planet into magnetized plasma above
- when plasma is reached, higher frequency waves travel faster along field lines than lower frequency
- when detected from afar, high frequencies are picked up first then pick up lower ones from individual lightening stokes, causing the whistling tone
- first confirmation and evidence of lightening on a planet other than Earth

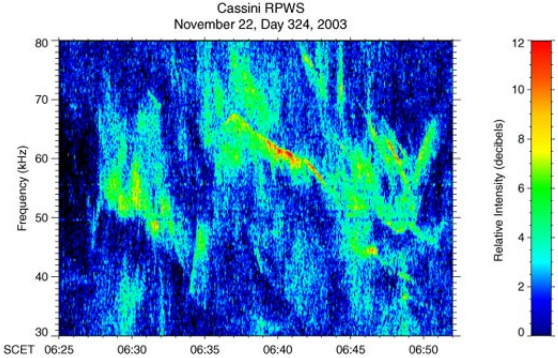
Cassini



- launched 1997
- main mission to investigate Saturn system
- began collecting radio emission in 2002
- also included PWS as well as "Cassini Radio"



- intense radio emissions, mostly at poles
- radio spectrum exhibits rising and falling tones, meaning numerous small radio sources are moving along the magnetic field lines around the aurora region



- http://www.nasa.gov/wav/123163main_cas-skr1-112203.wav
- 73 seconds corresponds to 27 minutes, shifted downward by a factor of 44

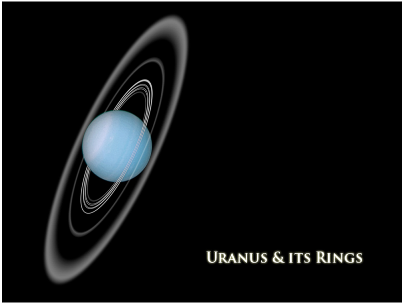
Titan

- Largest moon of Saturn
- very dense atmosphere
- only object besides Earth known to have stable surface liquid

Titan Radar Echoes

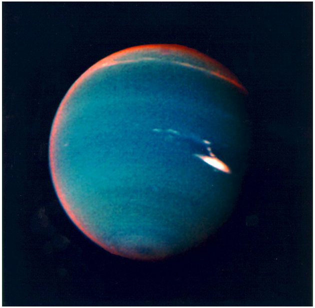
- `https://solarsystem.nasa.gov/multimedia/audio1.cfm`
- radar (Radio Detection and Ranging) data taken from Huygens, a probe from Cassini,
- as probe approaches the ground, pitch and intensity increase
- `https://solarsystem.nasa.gov/multimedia/audio2.cfm`
- provided insight on terrain elevation, mountain heights, helped map out Titan's surface

Uranus Rings



- http://www.youtube.com/watch?v=4mqQPl2r1io
- from Voyager 2, 1986
- radio observations revealed nine Rings around Uranus titled along with Uranus
- variations in radio signals suggest the rings vary in shape and may vary in eccentricity

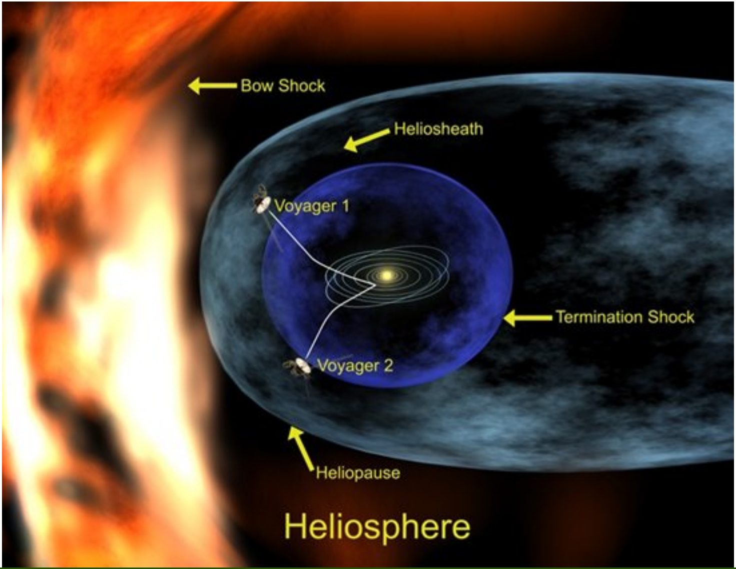
Neptune



- http://www.youtube.com/watch?v=cq1QW1U1wiM
- from Voyager 2, 1989
- radio observations revealed an active atmosphere, with high wing velocities
- periodic pulses of radio energy generated by rotation of interior

- Mercury: http://www.youtube.com/watch?v=894Aejo-R0U
- Venus: http://www.youtube.com/watch?v=lIZPpLbYPzU
- Mars: http://www.youtube.com/watch?v=bvnhDJn3c8c

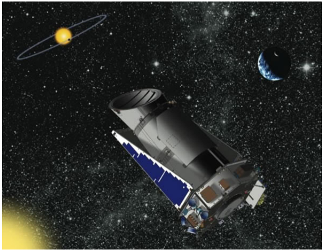
The Heliosphere



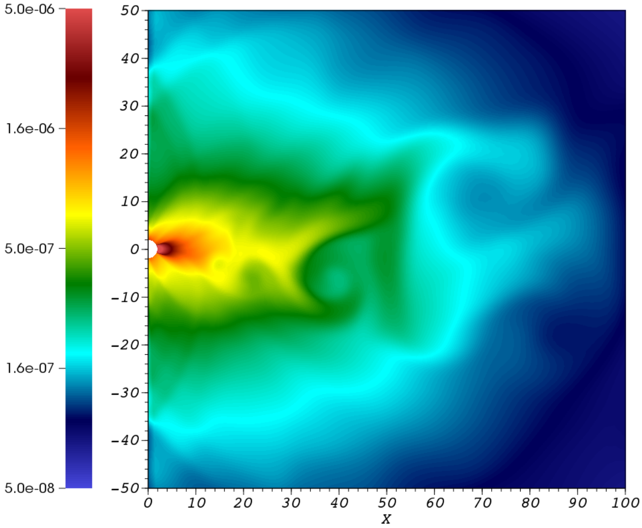
The Heliosphere

- A coronal mass ejection erupted in March 2012, then detected by Voyager 1's PWS in April 2013
- pitch of vibrations determined the density of the plasma, which was 40x greater than in the heliosphere
- http://www.youtube.com/watch?v=aNB4FaNh0wQ
- https://www.youtube.com/watch?v=L4hf8HyP0LI
- http://www-pw.physics.uiowa.edu/voyager/v1pws_interstellar_epo.html

Kepler



- telescope launched to explore Earth-like planets
- light curves of stars underwent sonification processes to compare to the Sun
- http://kepler.nasa.gov/multimedia/Audio/sonifications/


5.0e-06
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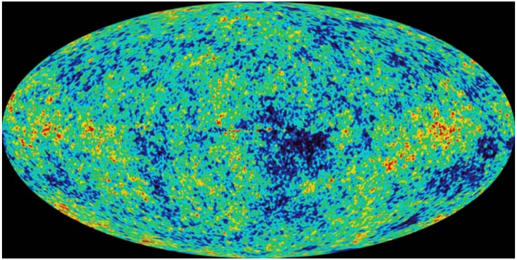
0 10 20 30 40 50 60 70 80 90 100
X

- http://www.youtube.com/watch?v=jYiWNLv-Bgg
- X-Ray Data from GRS 1915+105 translated into audible pulses
- useful to understand entropy of black hole systems

Cosmic Microwave Background



- thermal radiation left over from the big bang
- using radio telescopes we can look back as far as we can to see an isotropic glow
- strongest in microwave
- 1% of all static in television and radio signals is caused by CMB radiation left over from 13.8 billion years ago