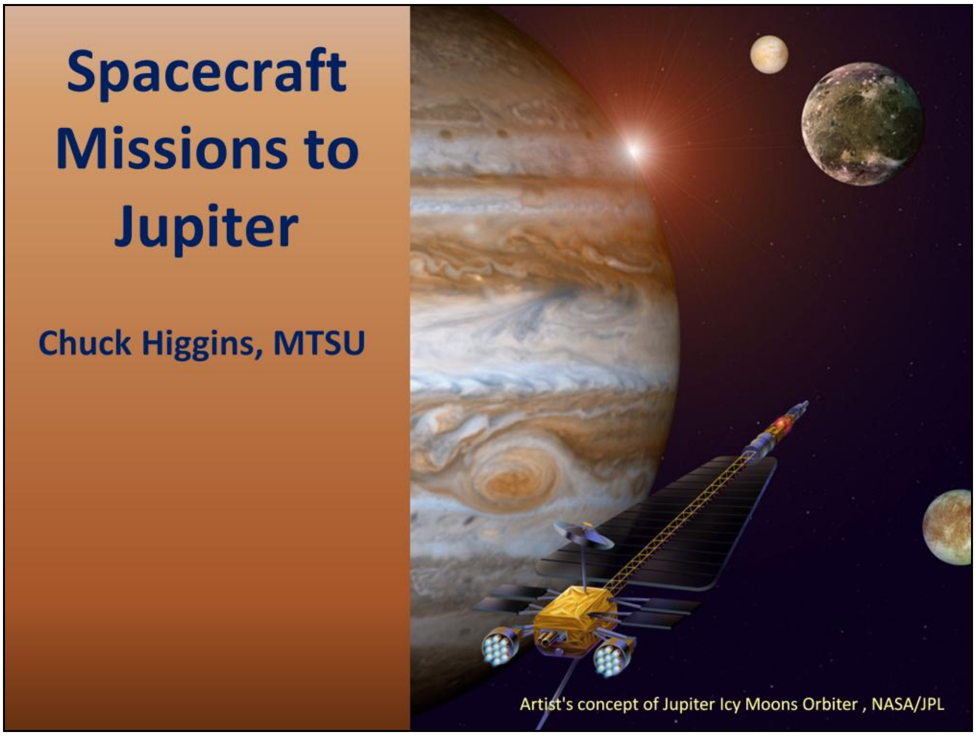
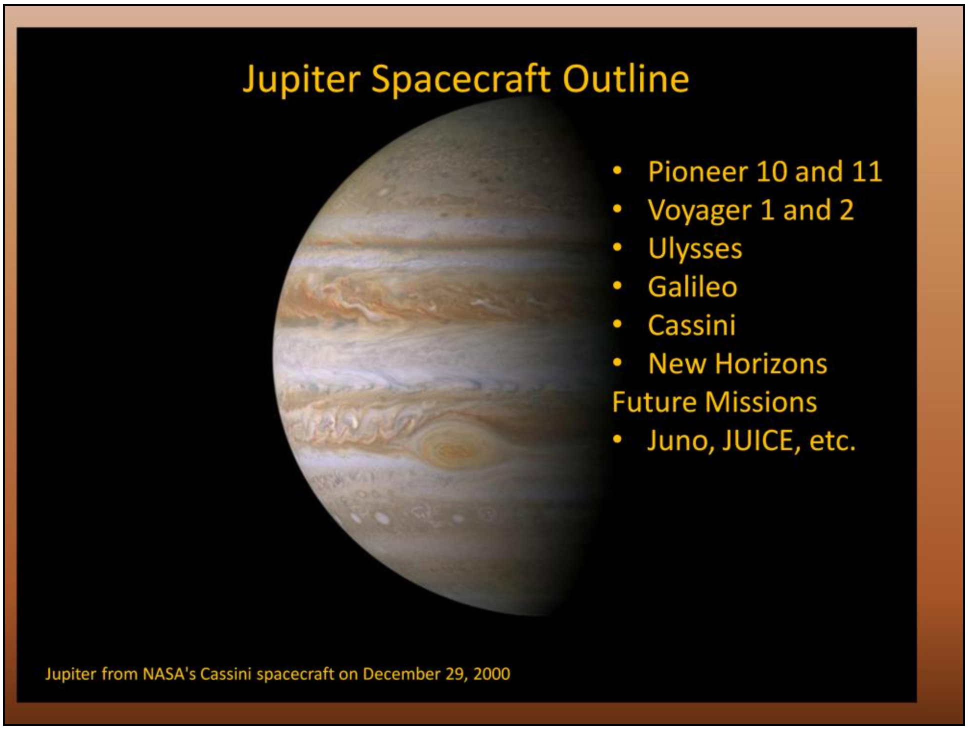
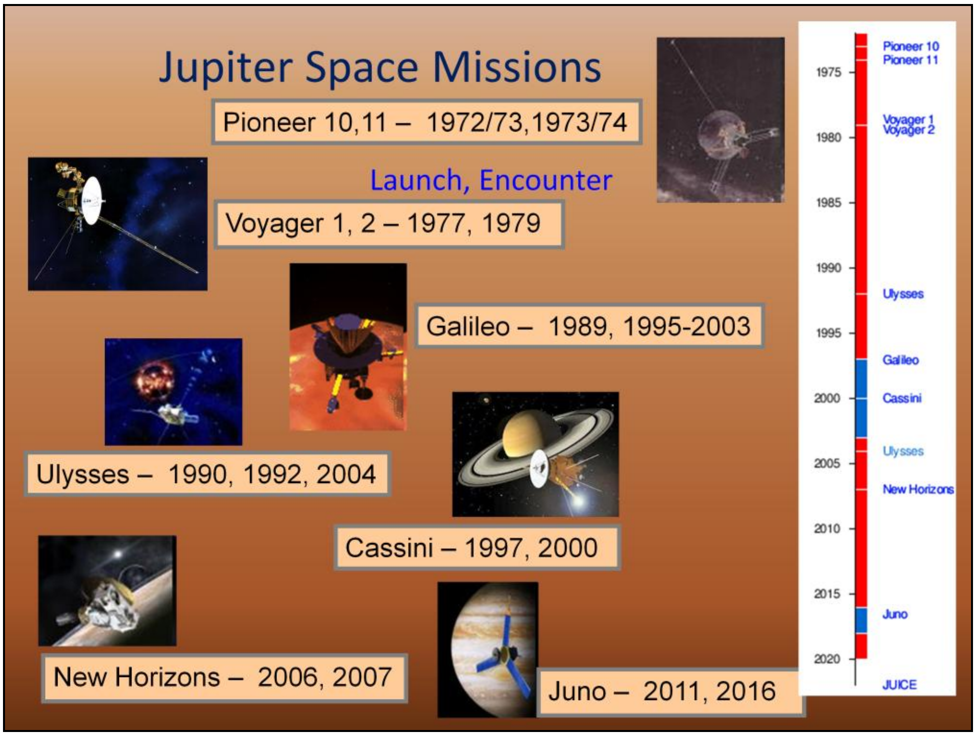


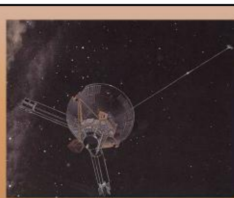
This presentation is an overview of the spacecraft that have visited Jupiter and some of the discoveries made.


Jupiter Spacecraft Outline
• Pioneer 10 and 11
• Voyager 1 and 2
• Ulysses
• Galileo
• Cassini
• New Horizons
Future Missions
• Juno, JUICE, etc.
Jupiter from NASA's Cassini spacecraft on December 29, 2000

Outline



The spacecraft launch and encounter dates.

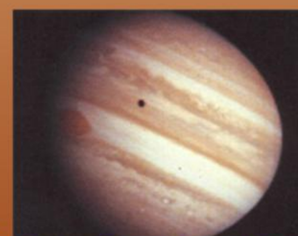


Pioneer 10/11

1973/74

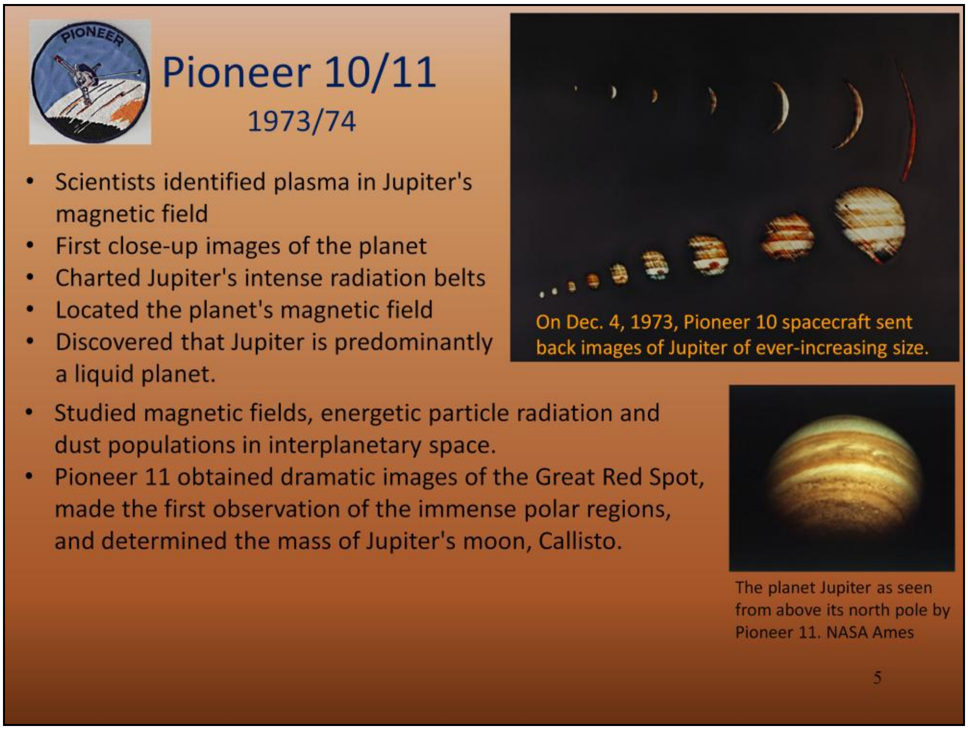
Pioneer mission patch

- Pioneer 10, the first NASA mission to the outer planets
- First vehicle placed on a trajectory to escape the solar system into interstellar space
- First spacecraft to fly beyond Mars
- First to fly through the asteroid belt
- First to fly past Jupiter
- First to use all-nuclear electrical power
- First human-made object to fly beyond the orbit of the outermost known planet in our solar system.

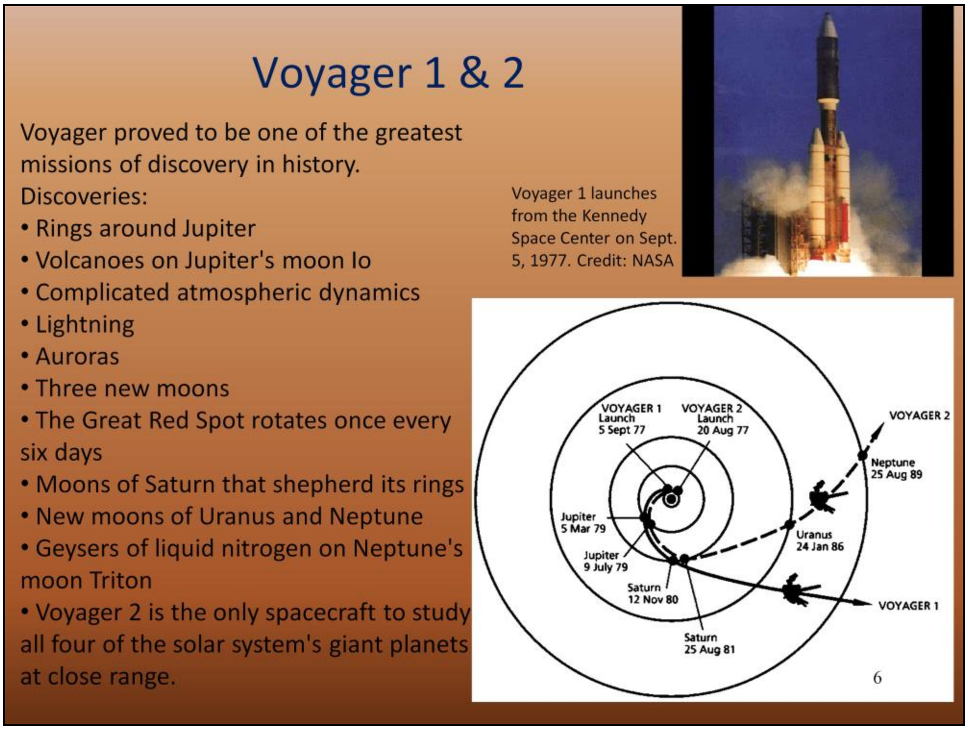


Pioneer 10 image of Jupiter, 1973.

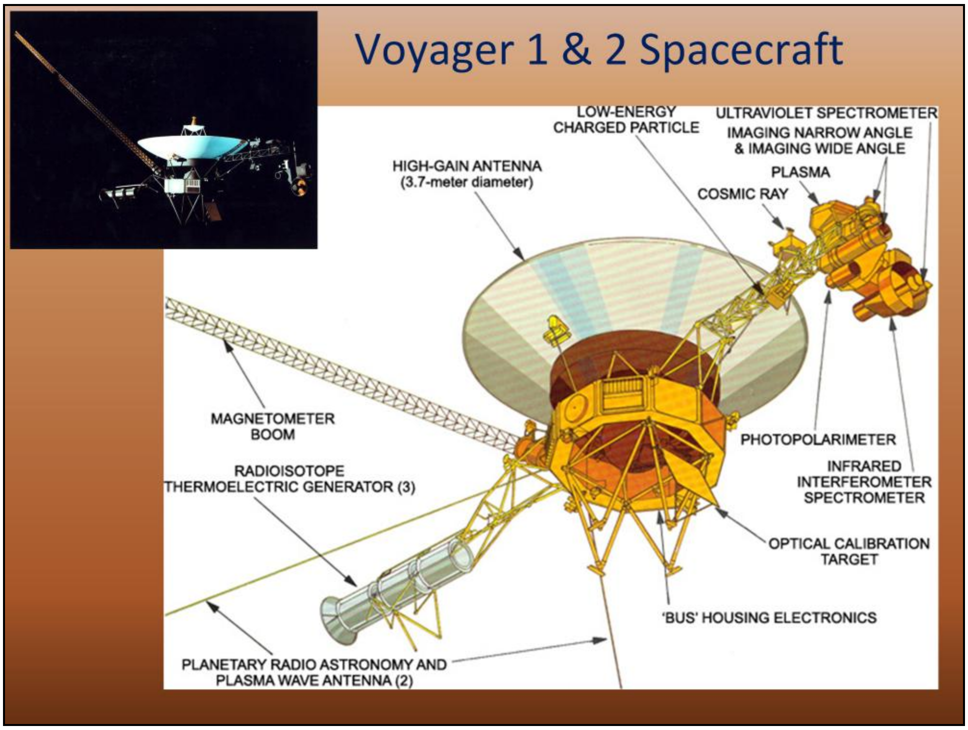
The Pioneers had a lot of "firsts" in their missions.



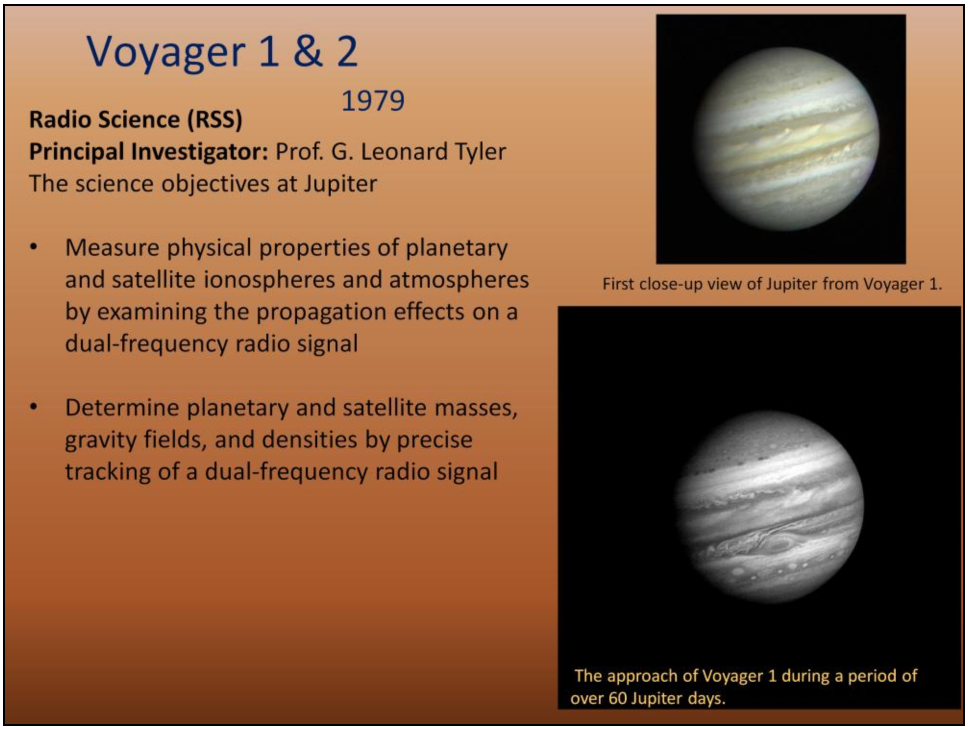
Pioneer 11 allowed a first look at the Jupiter polar regions.



Without a doubt, the Voyagers are the greatest space missions of discovery in history.



An overview of the Voyager spacecraft.



A few details about some of the radio experiments on Voyager.

Voyager 1 & 2

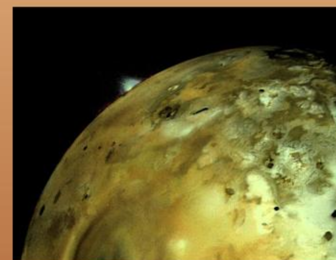
1979

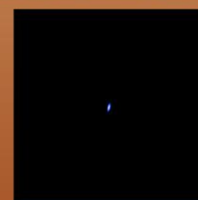
Planetary Radio Astronomy (PRA)
Principal Investigator: Dr. James W. Warwick
Magnetospheric and Radio physics

- Sweep-frequency radio receiver
- Dual polarization states
- 20 kHz and 40.5 MHz
- Orthogonal 10-m monopole antennas

Plasma Wave System (PWS)
Principal Investigator: Prof. Donald A. Gurnett
Electron-density profiles and local wave-particle interactions

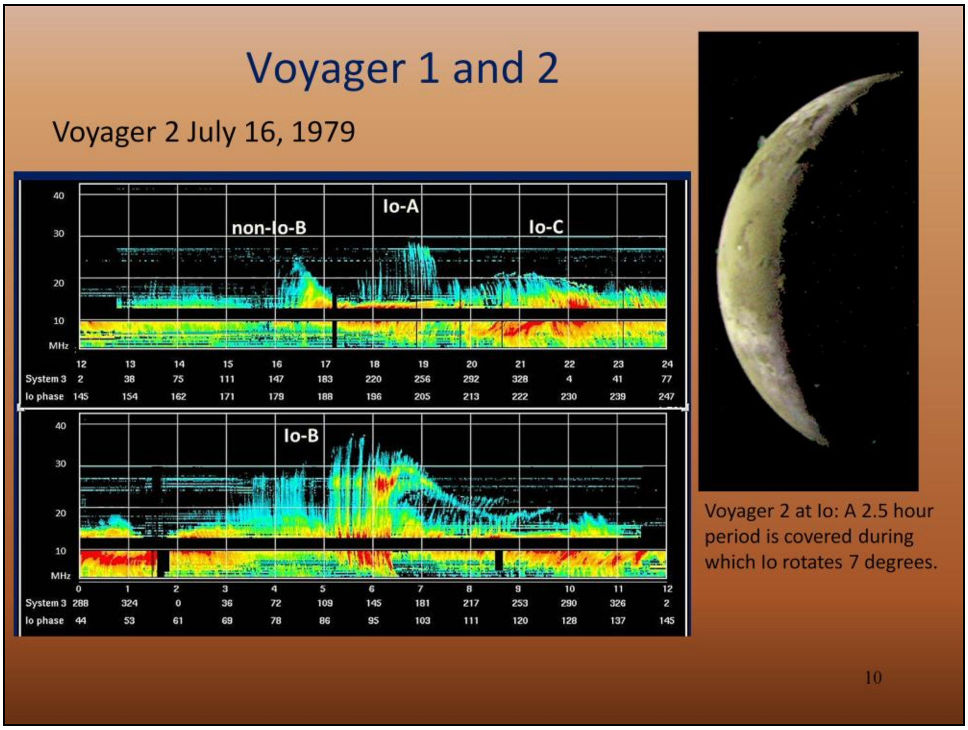
- 16-channel, step-frequency receiver
- low-frequency waveform receiver
- 10 Hz to 56 kHz





The Very Long Baseline Array (VLBA) imaged the signal of NASA's Voyager 1 spacecraft from 11.5 billion miles (18.5 billion kilometers) away. Feb. 21, 2013.

A few details about some of the radio experiments on Voyager.



Voyager showed some incredible radio spectra of Jupiter's decameter, hectometer, and kilometer radio emissions.

Voyager 1 & 2

1979

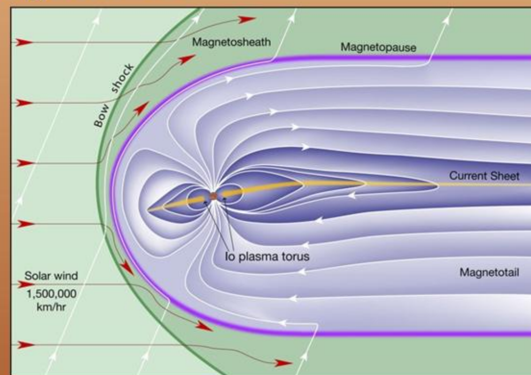
Magnetosphere
Lightning whistlers in the atmosphere

Plasma-electron densities in some regions of the Io torus

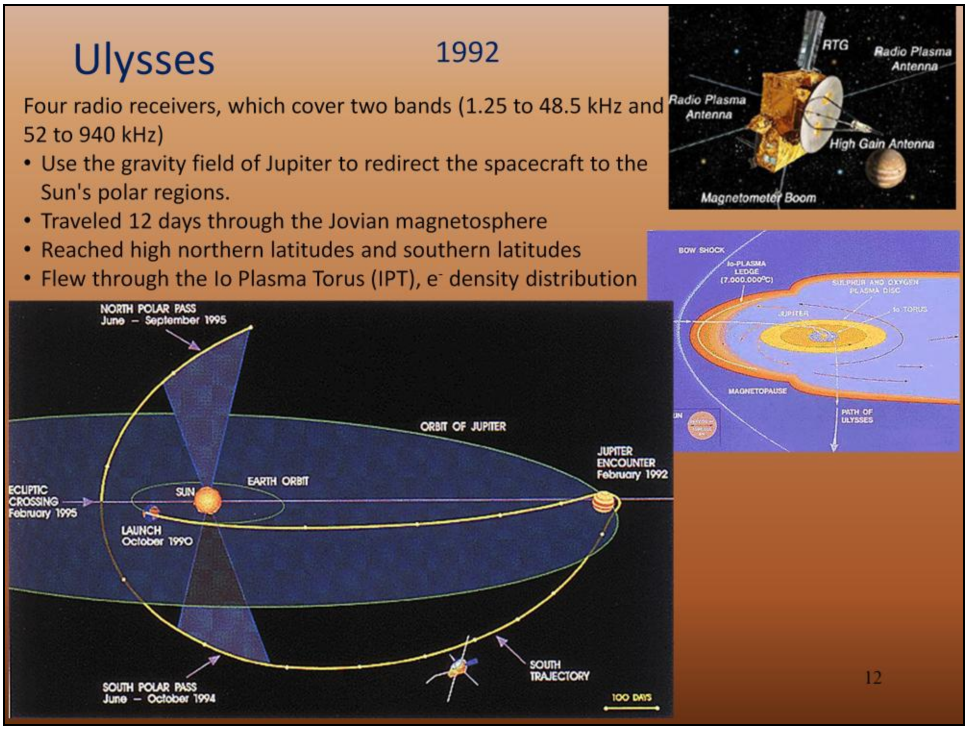
High-energy trapped particles were also detected near Jupiter

Magnetotail extends at least to the orbit of Saturn

Decametric (DAM), Hectometric (HOM), and Kilometric (KOM) radio emission structure



Voyager found that Jupiter’s magnetotail extends at least 5 A.U. from Jupiter.



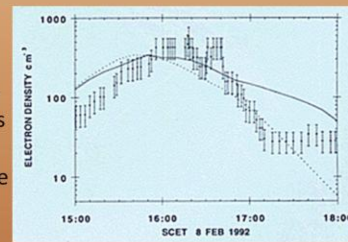
An overview of the Ulysses mission. Too bad the radio instrument peaked at 940 kHz.

Ulysses

Results at Jupiter

- Longitudinal asymmetries in of the lo plasma torus
- Presence of counter-streaming ions and electrons, field-aligned currents, and energetic electron and radio bursts in the dusk sector on high-latitude magnetic field lines
- Identification of the direction of the magnetic field in the dusk sector, which is indicative of tailward convection.

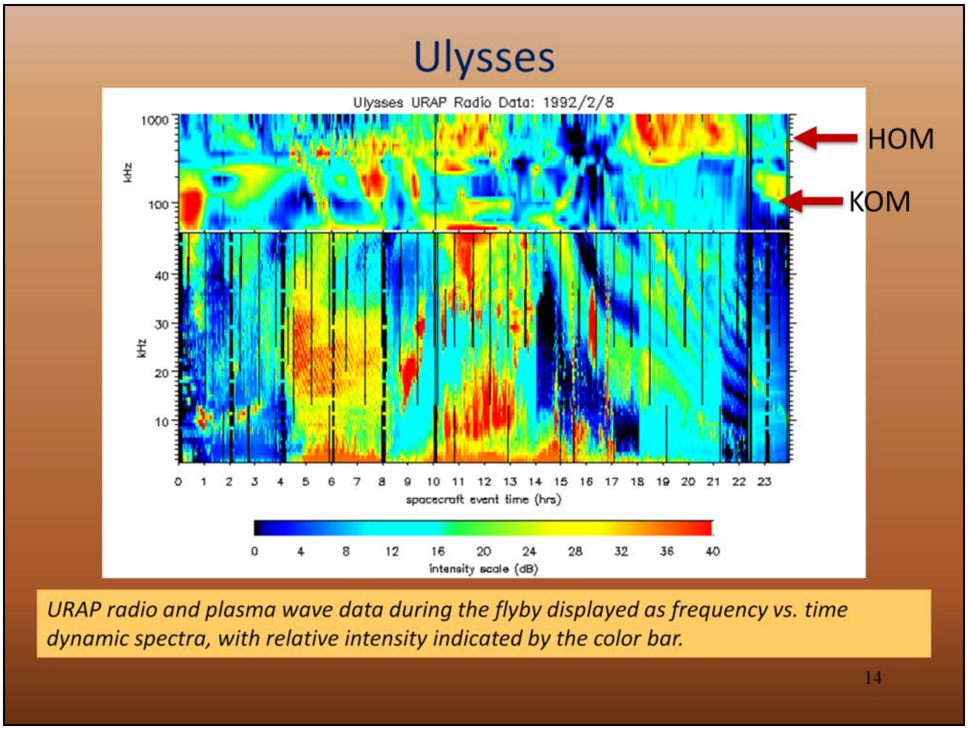
Credit: Science. 1992 Sep 11;257(5076):1503-7.



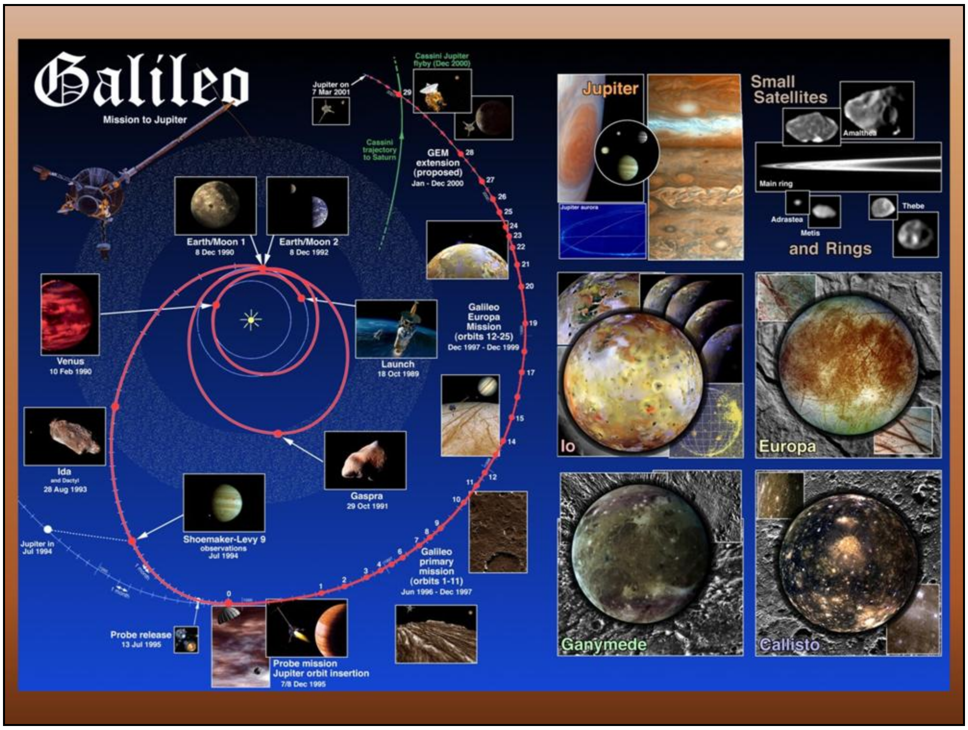
- Unique direction-finding capability for Jupiter’s hectometer (HOM) radio sources
- HOM revealed narrow latitudinal beaming along the magnetic equator
- “Narrow-band kilometric" (nKOM) radiation – originates from the Io Plasma Torus
- "Jovian type III" events showing a characteristic rapid drift in frequency (Voyager, Ulysses)

Credit: ESA Bulletin No.72 November 1992, by R.G. Marsden and K.-P. Wenzel, ESA Space Science Department, ESTEC, Noordwijk, The Netherlands.

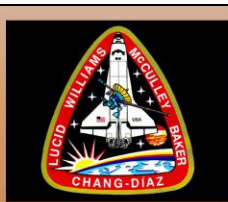
A few good discoveries at Jupiter by Ulysses.



A Ulysses radio spectrum at Jupiter.



The Galileo mission launch and orbital trajectory.



Galileo

1995 - 2003

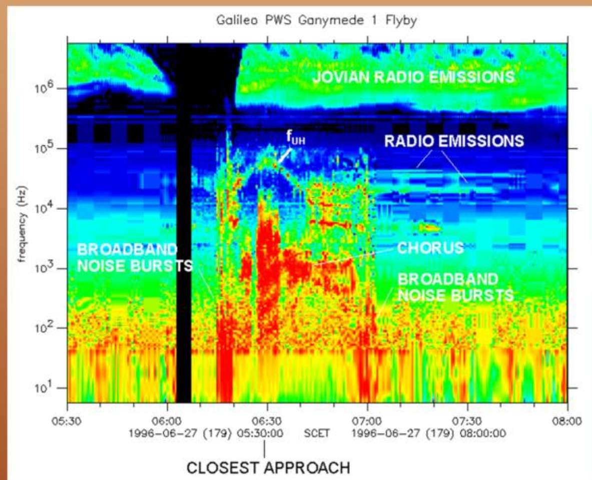
Launch: Oct. 18, 1989 from Kennedy Space Center, Fla., on space shuttle Atlantis on mission STS-34
Primary Mission: October 1989 to December 1997
Extended Missions: Three, from 1997 to 2003
Number of Jupiter orbits during entire mission: 34
Number of flybys of Jupiter moons: Io 7, Callisto 8, Ganymede 8, Europa 11, Amalthea 1

Major scientific results of the *Galileo mission* include:

- First observation of ammonia clouds in another planet's atmosphere
- Confirmation of extensive volcanic activity on Io
- Evidence supporting the theory that liquid oceans exist under Europa's icy surface
- First detection of a substantial magnetic field around a satellite (Ganymede);
- Magnetic data evidence suggesting that Europa, Ganymede and Callisto have a subsurface liquid-saltwater layer
- Formation of the rings of Jupiter (by dust kicked up as interplanetary meteoroids)
- Observation of two outer rings
- Global structure and dynamics of the magnetosphere

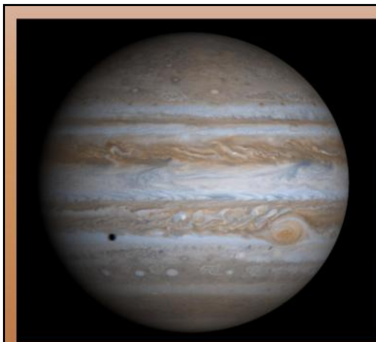
Highlights of the Galileo mission.

Galileo 1995 - 2003



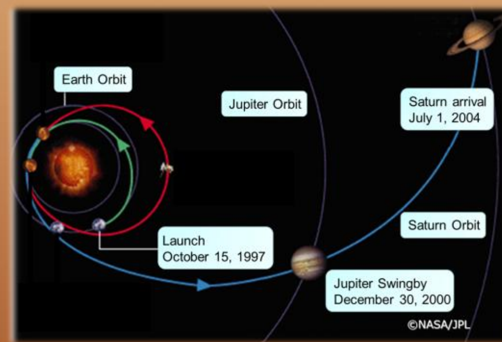
The HFR provides 42 frequencies from 100.8 kHz to 5.645 MHz with a fractional frequency spacing of delta-f/f ~ 10.0% and a bandwidth of 2 kHz. One spectral sweep is provided every 18.67 seconds with a dynamic range of 100 db.

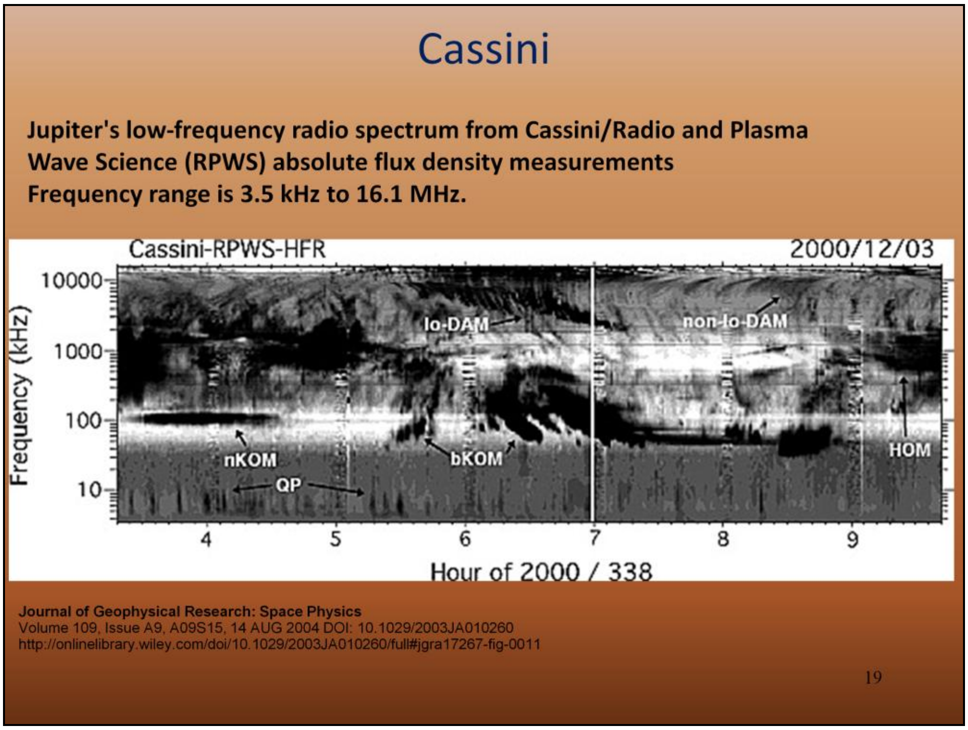
Galileo discovers the moon Ganymede has its own magnetosphere.



Cassini

2000

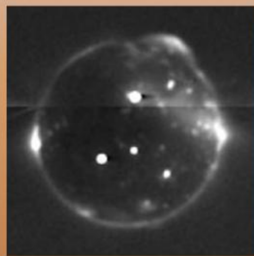




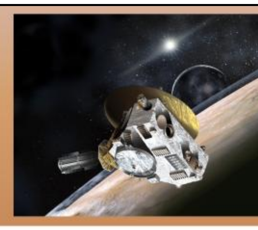
Jovian low-frequency radio emissions detected on 3 December 2000 by the RPWS experiment onboard Cassini approaching Jupiter. Frequency range is 3.5 kHz to 16.1 MHz. The Io-DAM emission appears here down to about 2 MHz, while weaker Io-independent (non-Io-DAM) arcs merge with the hectometer component (HOM) detected down to ~400 kHz. The auroral broadband kilometer component (bKOM) is detected down to ~40 kHz. The narrowband emission (nKOM) about 100 kHz is generated at or near the plasma frequency f_{pe} in Io's torus. The quasi-periodic (QP) bursts, spaced by 5 to >15 min, are detected in the ~5 to 20 kHz range. Distance to Jupiter was 383 R_J (2.7×10^7 km) at the time of this observation.

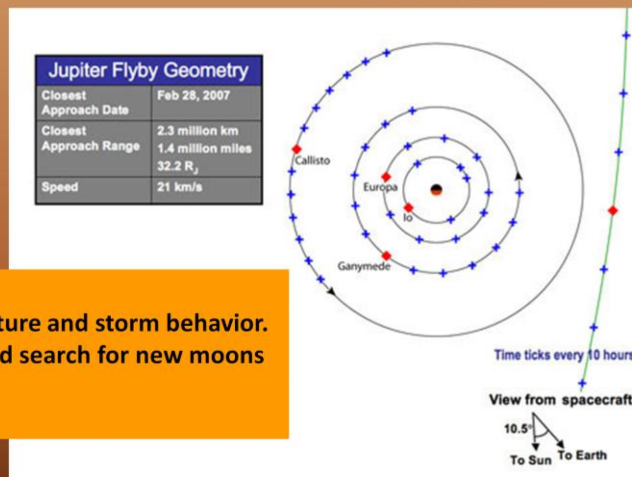
New Horizons

2007



This image of Io eclipsed by Jupiter's shadow, Feb. 27, 2007
Credit: NASA/JHU/APL/SWRI

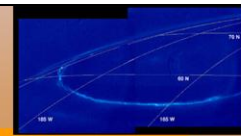




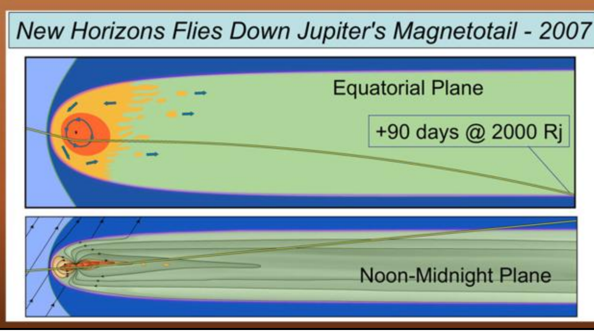
Studies of Jupiter's
1. **Atmospheric structure and storm behavior.**
2. **Major satellites and search for new moons**
3. **Ring composition**
4. **Magnetosphere**

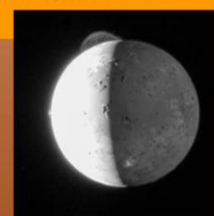
http://pluto.jhuapl.edu/science/jupiterScience.php

New Horizons
2007



• Pictured heat induced lightning strikes in the polar regions and "waves" that indicated violent storm activity
• Imaged up close the Little Red Spot
• Imaged the faint ring system discovering debris left over from recent collisions within the rings
• No new moons discovered
• Magnetospheric “bubbles" of plasma were noticed in the magnetotail, believed to be ejected by the moon Io



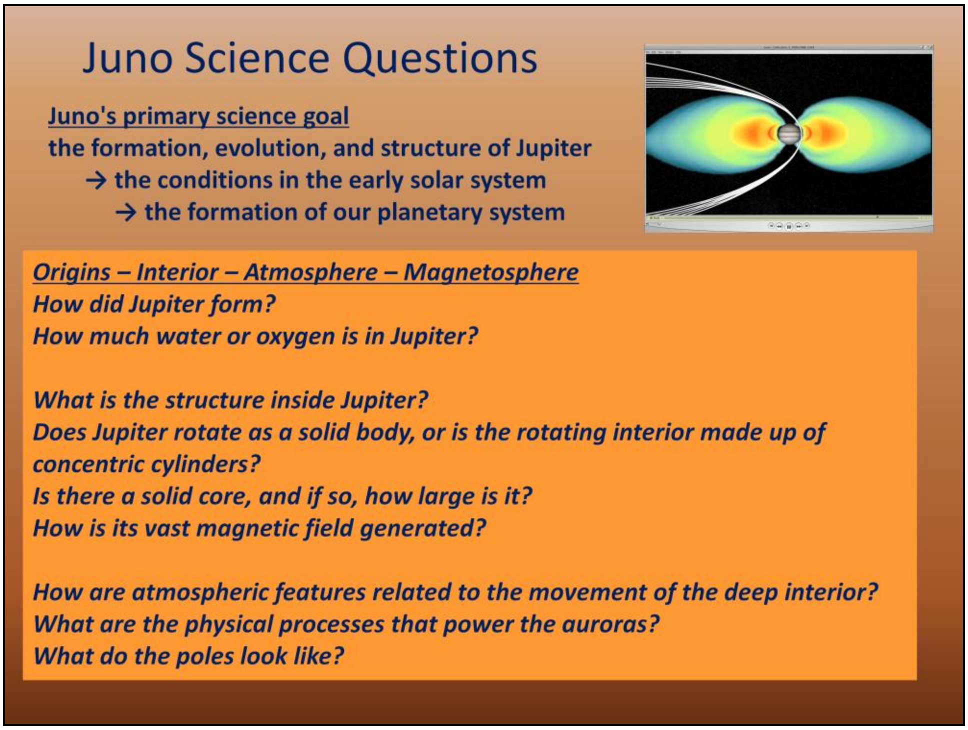


This dramatic image of Io was taken on Feb. 28, 2007
Credit: NASA/JHU/APL/SWRI

New Horizon’s very quickly flew by Jupiter in 2007. On to Pluto!

The Juno mission launch and orbital trajectory.

A summary of the Juno spacecraft.



The major science questions to be addressed by the Juno mission.

A summary of the proposed JUICE mission.