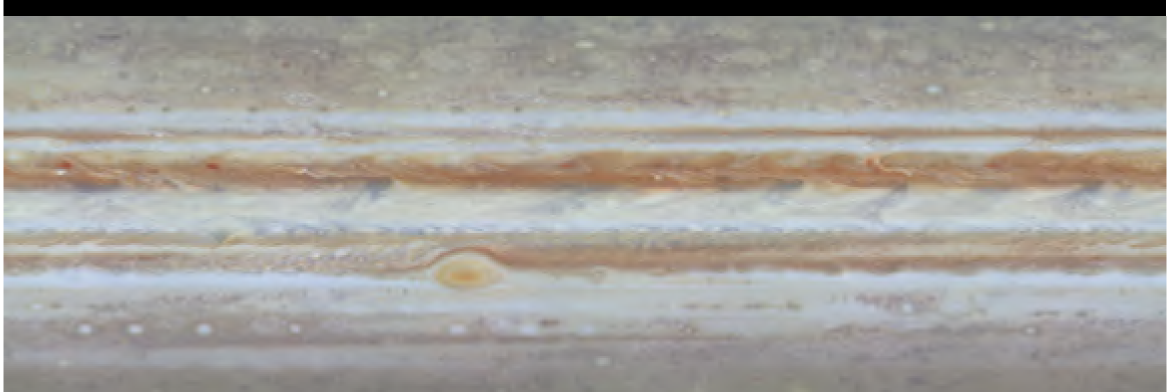
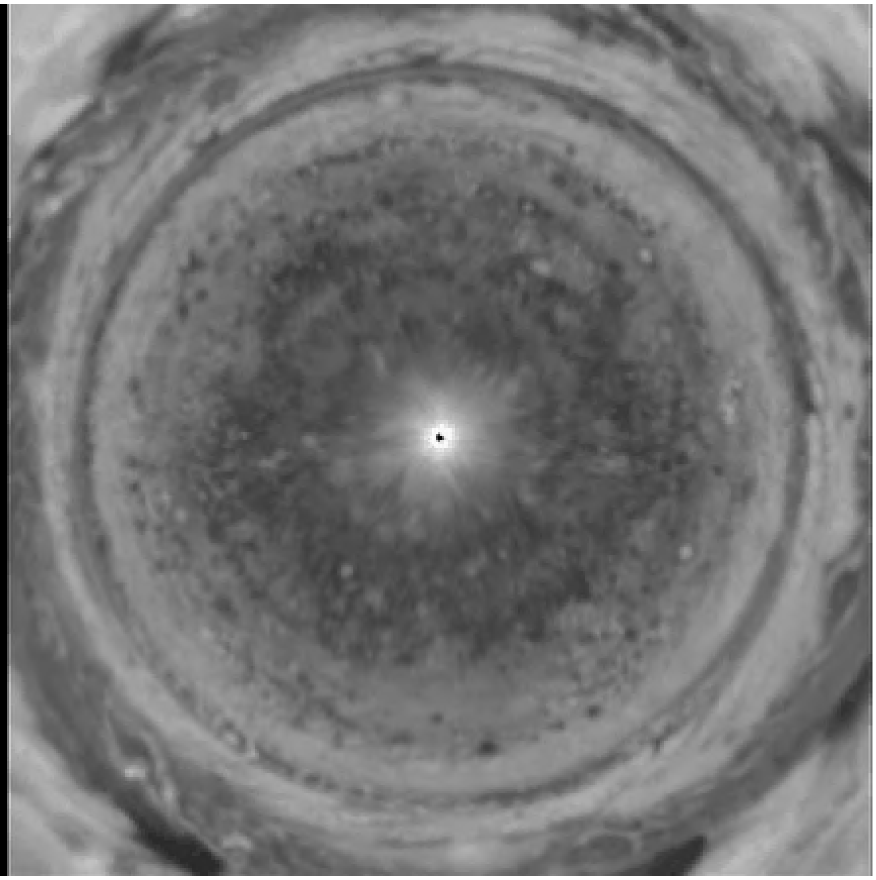
Juno

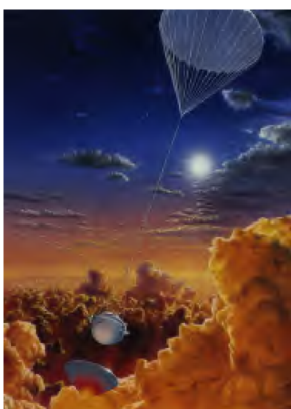
Fran Bagenal
University of Colorado

Cassini 2000



Cassini 2000

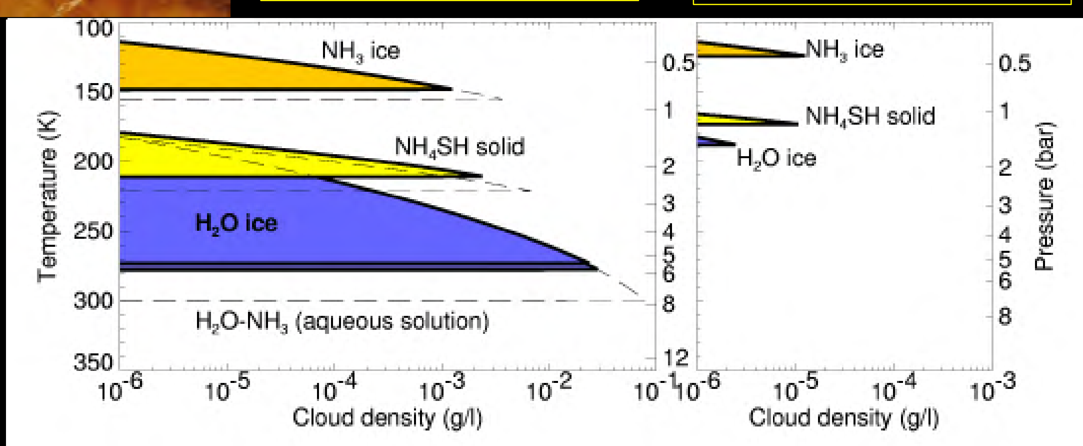


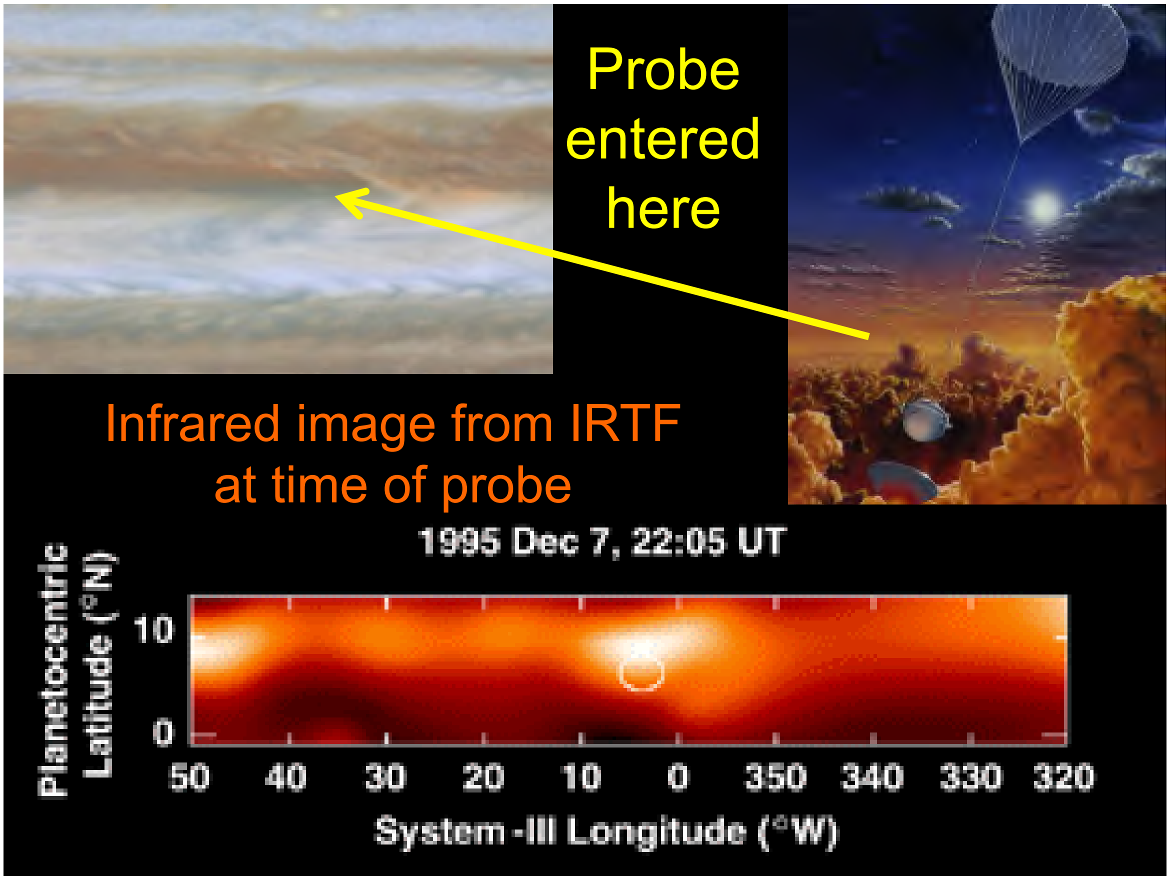


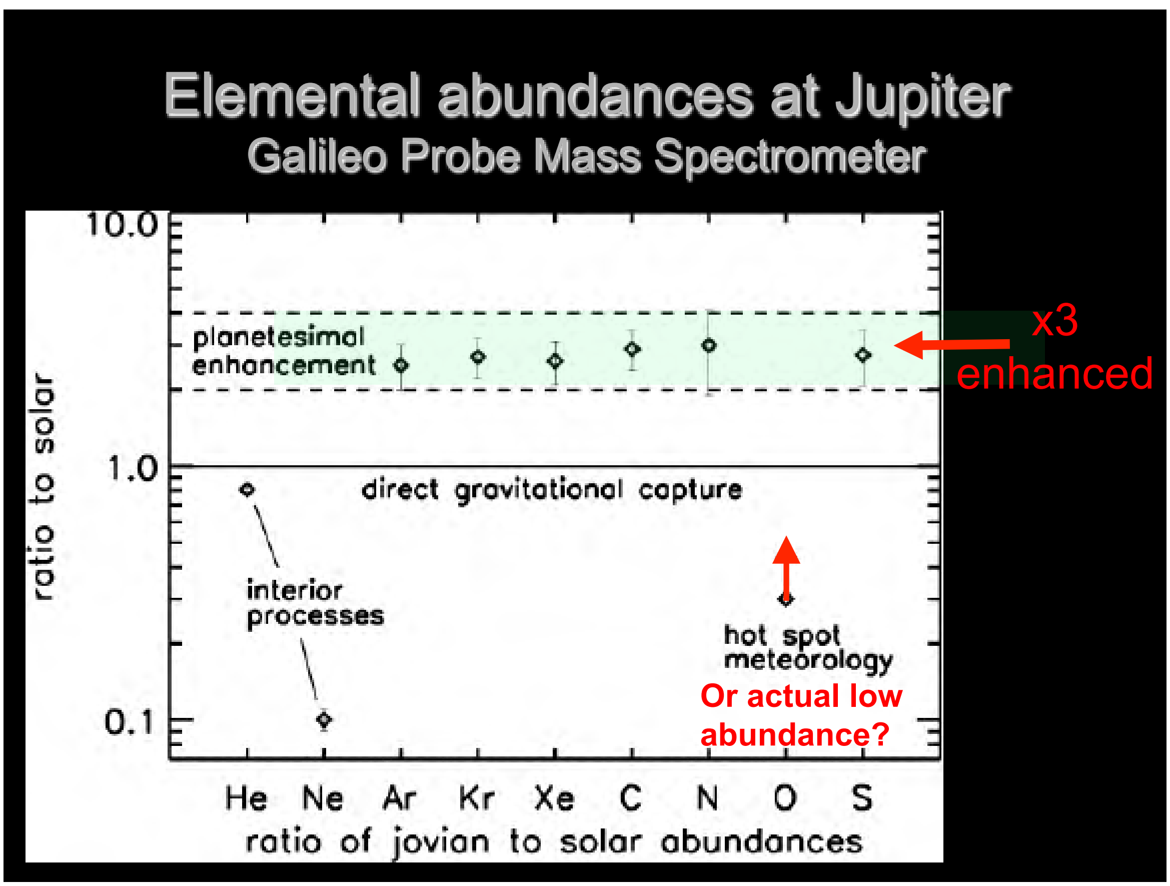
When the Galileo Probe entered Jupiter clouds

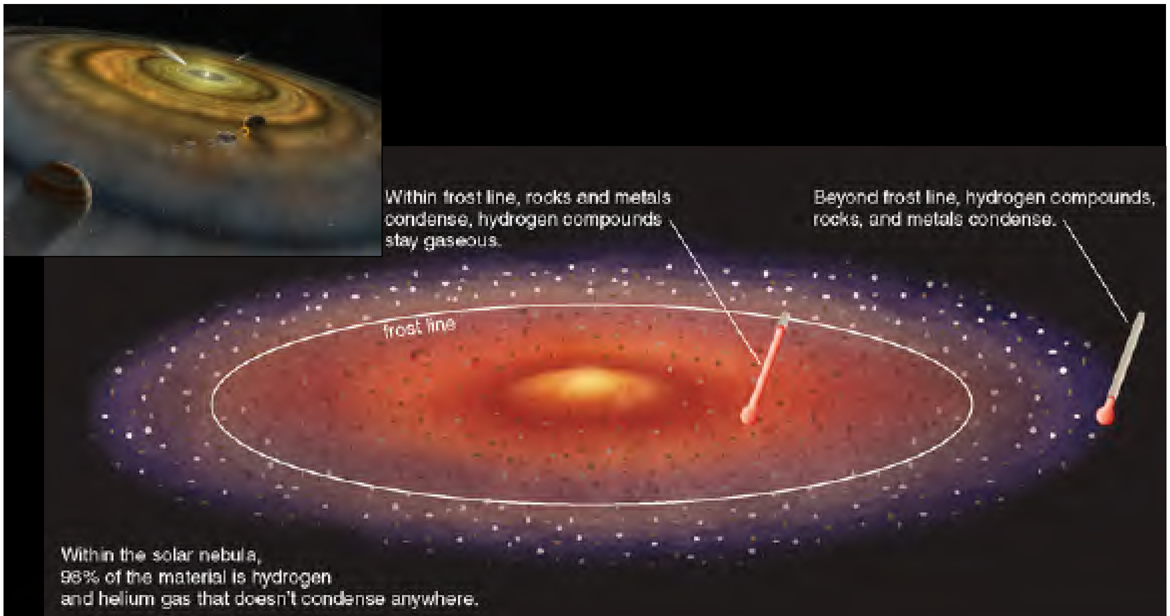
Expected ammonia + water clouds

But found… very few clouds




Probe
entered
here
Infrared image from IRTF
at time of probe
1995 Dec 7, 22:05 UT
Planetocentric
Latitude (°N)
10
0
50 40 30 20 10 0 350 340 330 320
System-III Longitude (°W)


Elemental abundances at Jupiter
Galileo Probe Mass Spectrometer
10.0
1.0
0.1
ratio to solar
planetesimal
enhancement
x3
enhanced
direct gravitational capture
interior
processes
hot spot
meteorology
Or actual low
abundance?
He Ne Ar Kr Xe C N O S
ratio of jovian to solar abundances



Gas giant planets formed beyond the frost line where hydrogen gas captured onto ice core

Where's the water?

How much oxygen is there in the solar system?

How did the gas giant planets form?

Juno Mission Overview

NASA *New Frontiers* mission - competitive
Principal Investigator: Scott Bolton
Southwest Research Institute

First solar-powered mission to Jupiter

- Eight science instruments to conduct gravity, magnetic and atmospheric investigations, plus a camera for education and public outreach
- Spinning, polar orbiter spacecraft launched on August 5th 2011
  - 5-year cruise to Jupiter, arriving July 2016
  - About 1 year at Jupiter, ending with de-orbit into Jupiter in 2017
- Elliptical 11-day orbit swings below radiation belts to minimize radiation exposure
- 2nd mission in NASA's New Frontiers Program

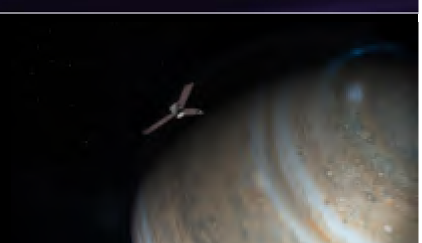
Science Objective: Improve our understanding of giant planet formation and evolution by studying Jupiter's origin, interior structure, atmospheric composition and dynamics, and magnetosphere

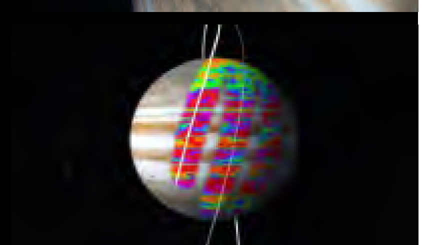
Juno Science Objectives

Origin and evolution of Jupiter: Juno will improve our understanding of the history of the solar system – and planetary systems around other stars

Juno will investigate Jupiter's

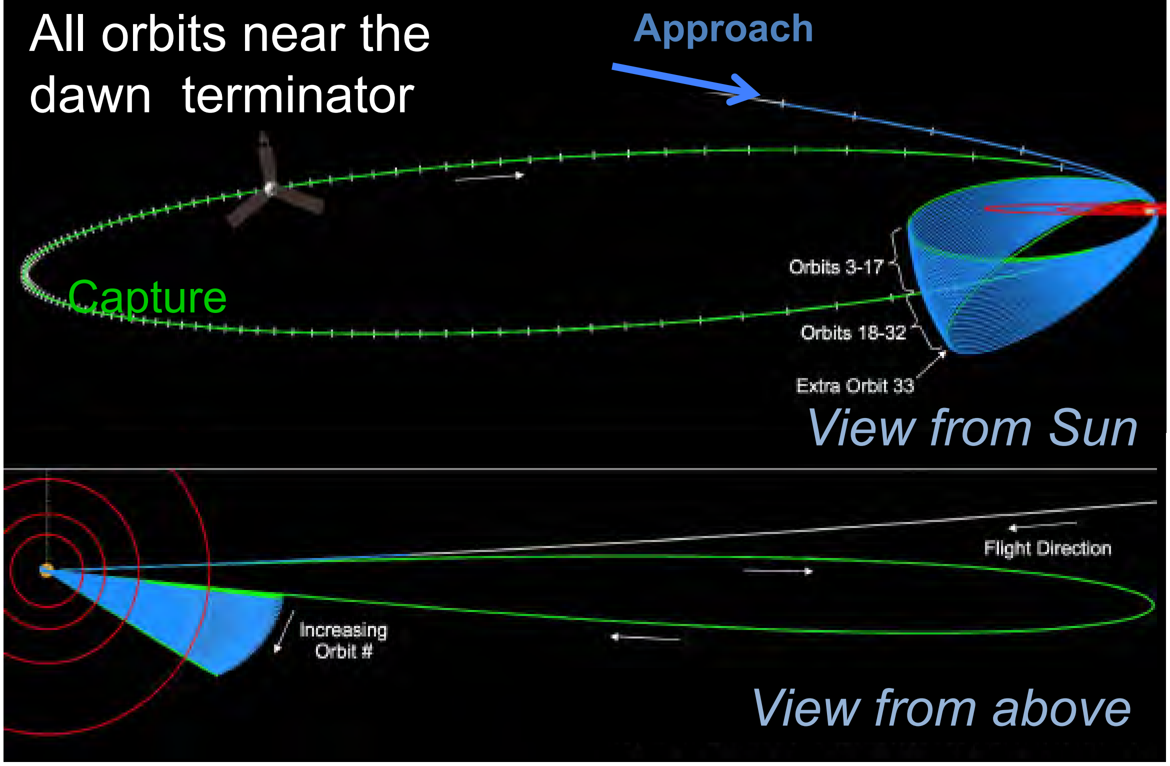
- Origin,
- Interior,
- Atmosphere and
- Magnetosphere.





The orbit: the key to the whole mission

All orbits near the dawn terminator



Juno Baseline Mission

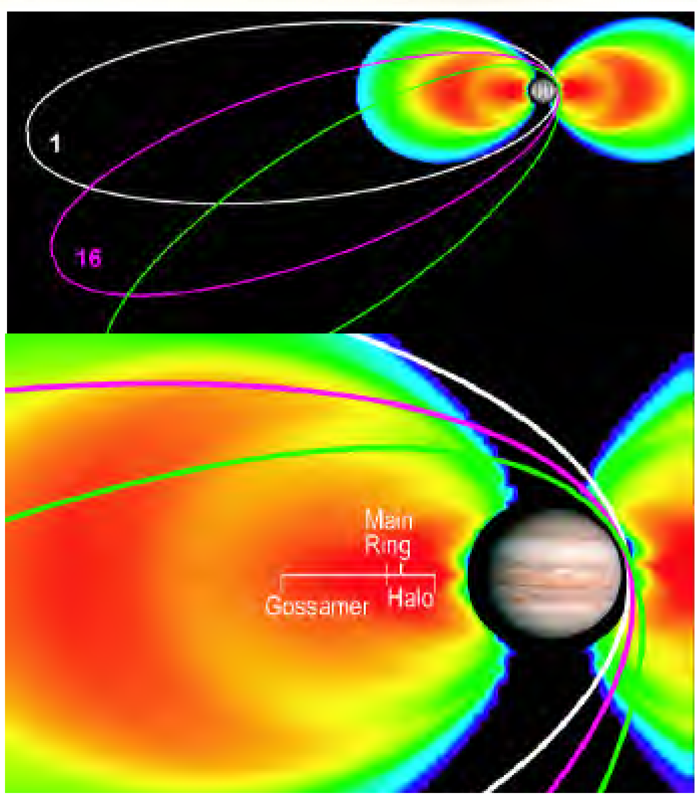
32 polar orbits

Perijove ~5000 km

11 day period

Duck under radiation belts…

Skim above clouds…

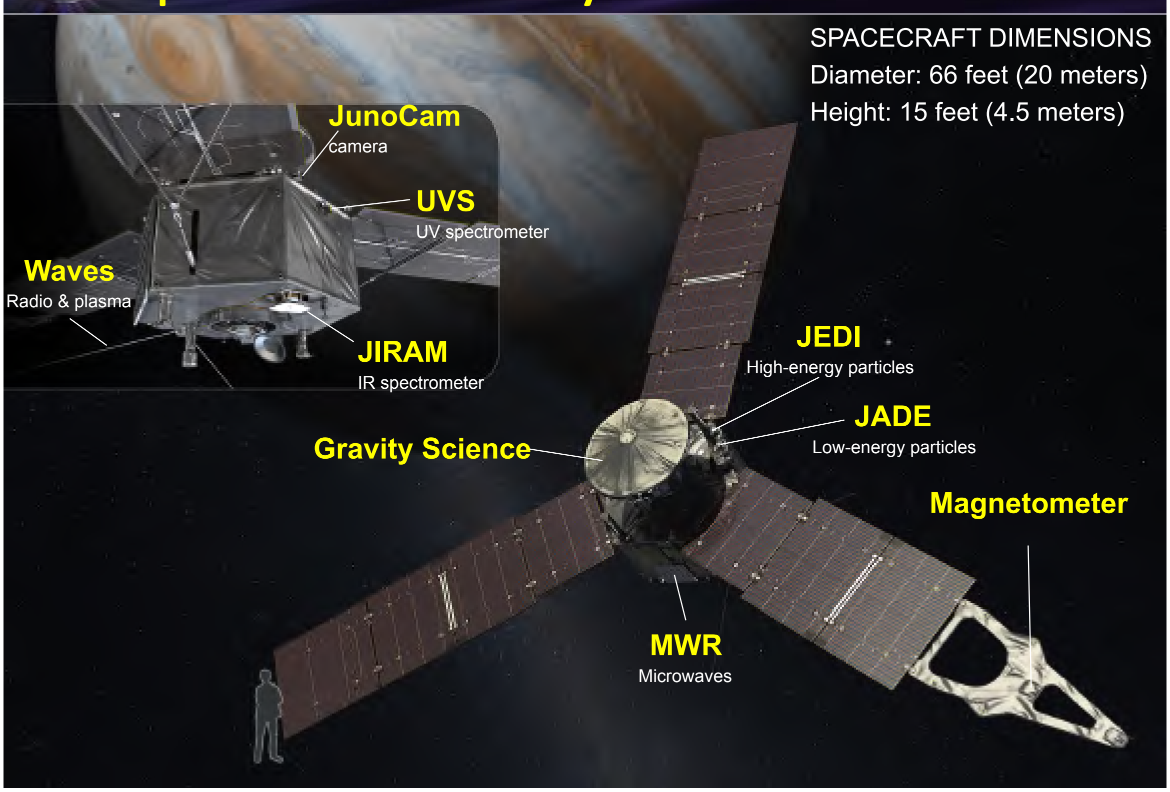


The Juno spacecraft

Juno's key components: **Radiation vault**

Spacecraft & Payload

SPACECRAFT DIMENSIONS
Diameter: 66 feet (20 meters)
Height: 15 feet (4.5 meters)



The Juno spacecraft

Juno's key components: Solar arrays

2m x 7.5m arrays producing ~300 W

Sun-pointed, spinning 3 rpm

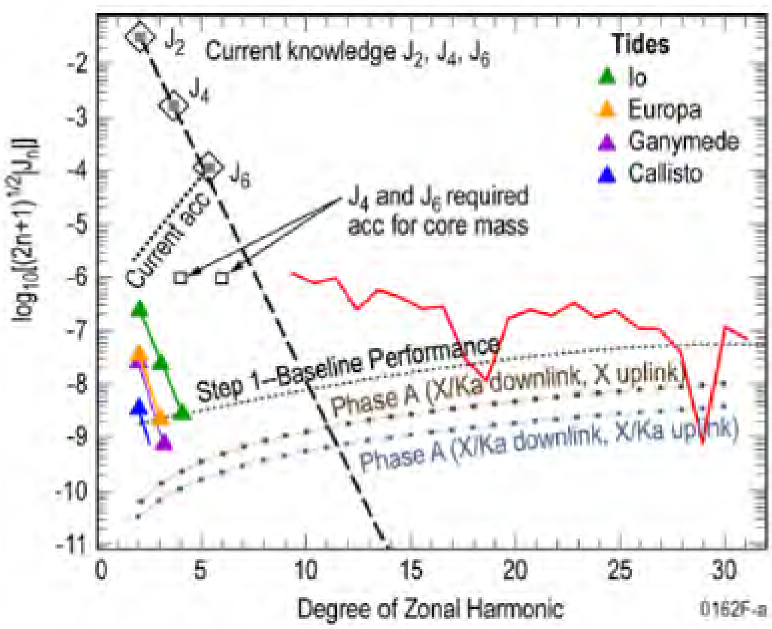
Gravity Determination of Core Mass and Deep Winds

Juno

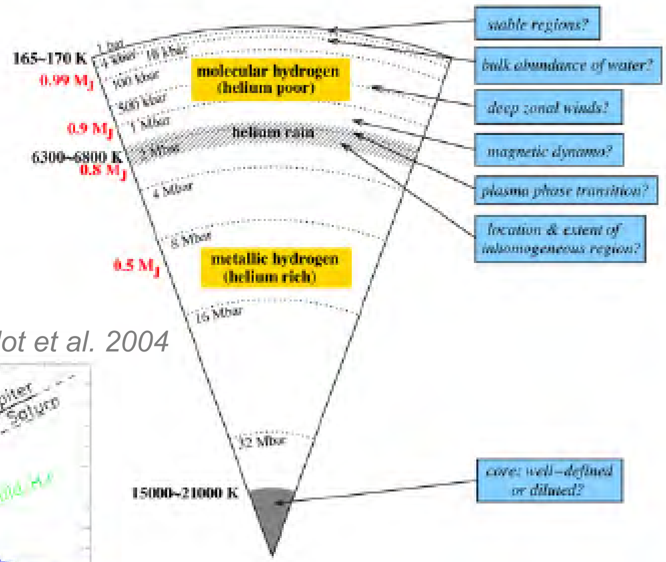
J_2, J_4, J_6 and tides give core mass once water abundance is known

J_8 - J_{30} give deep winds down to $r \sim 0.8\ R_J$

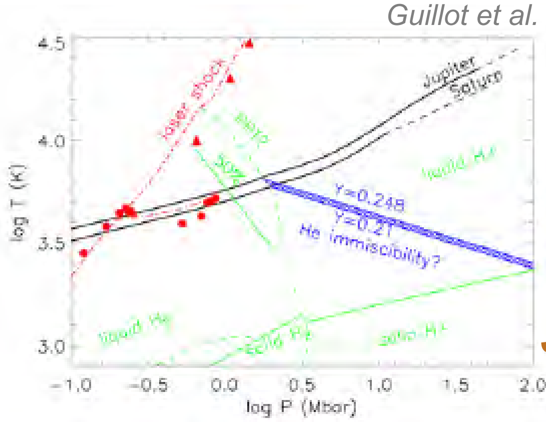
___ model signature of deep winds



Modeling Interior Structure Requires Equation of State + Gravity Data

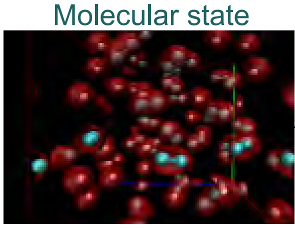


Guillot et al. 2004

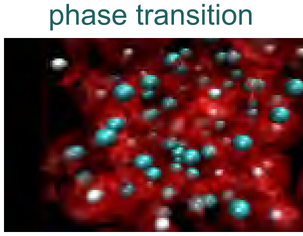


Juno provides Gravity Data

Molecular state

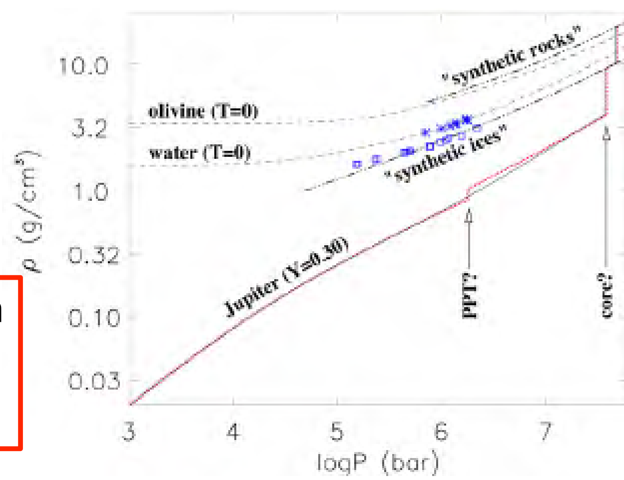


~2.5 Mbar
phase transition



Plasma state

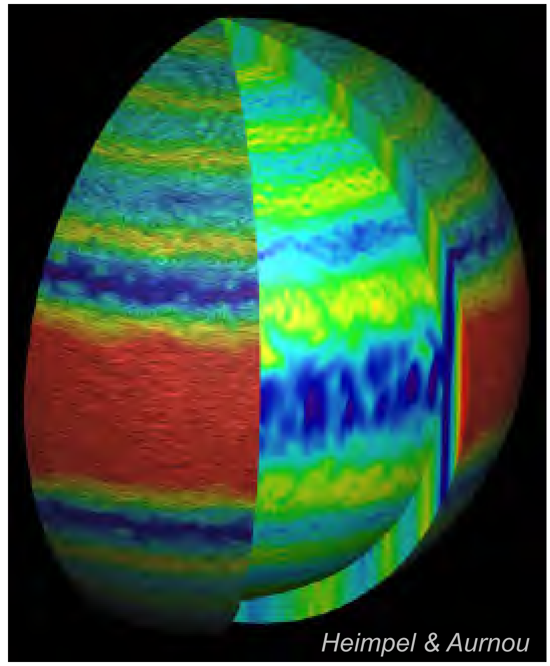
Guillot et al. 2004



At Plasma Phase Transition
Hydrogen conducting
-> magnetic dynamo region

Juno Maps the Jupiter's Magnetic Field

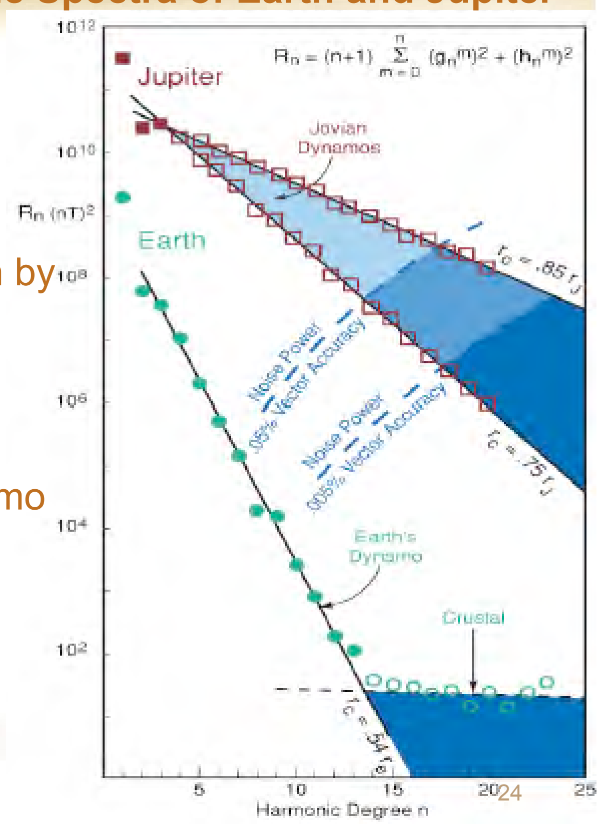
What internal flows drive Jupiter's magnetic dynamo?



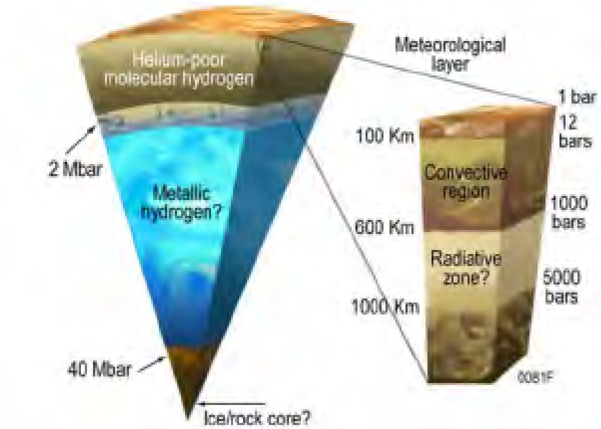
Reveals Jupiter's Dynamo Process

Magnetic Spectra of Earth and Jupiter

- Current knowledge of Jupiter is limited to n < 4
- Earth dynamo at n >14 is hidden by crustal field
- Juno will measure out to n ~ 20
- Determine spectral shape, dynamo radius, and secular variations



Jupiter's Atmosphere



Where's the water?

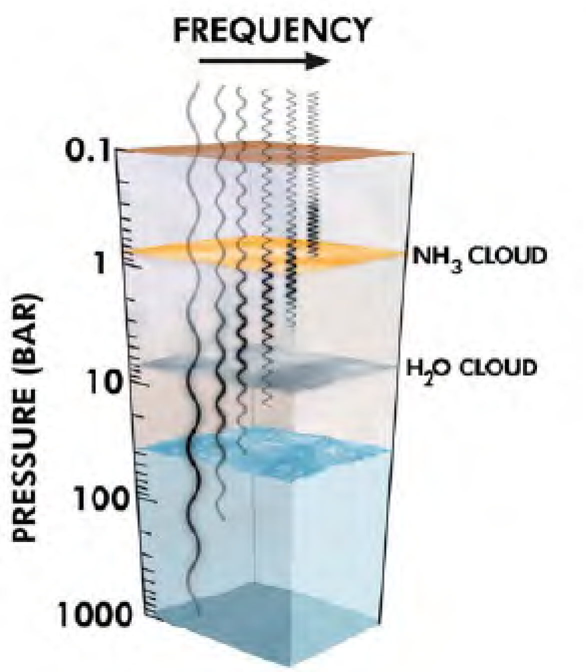
What drives the winds?

Microwave Radiometry

Radiometry sounds atmosphere to 1000 bar depth

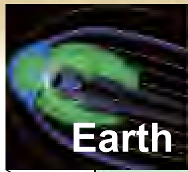
Determines water and ammonia global abundances

6 wavelengths between 1.3 and 50 cm

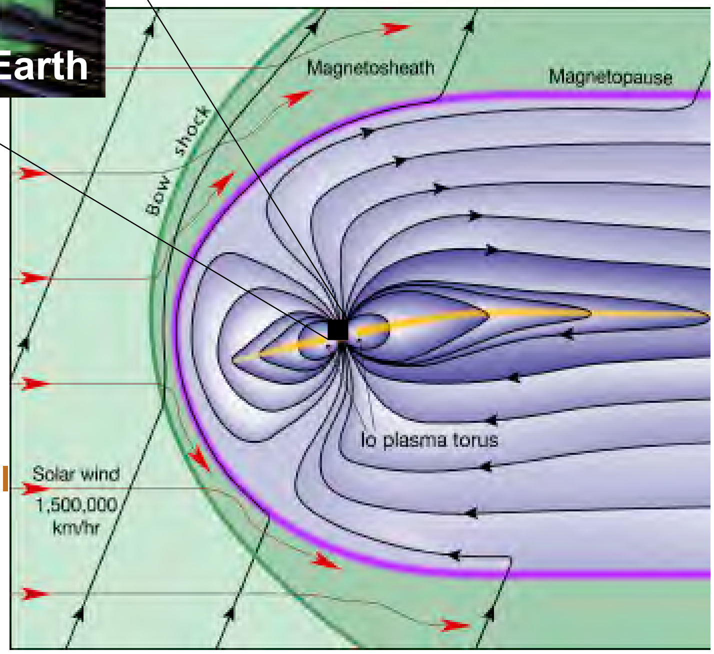


Using the Internal Heat to Map the Water

Jupiter's Magnetosphere



- **Strong Magnetic Field**
- **Large**
  100 x Earth's magnetosphere
- **Rotation-dominated**
  10 hour period
- **Io plasma source**
  ~1 ton/sec S,O ions
- **Equatorial region is well studied**
- **Polar region is completely unexplored**



Jupiter's Polar Magnetosphere is completely unexplored

Jupiter's Aurora

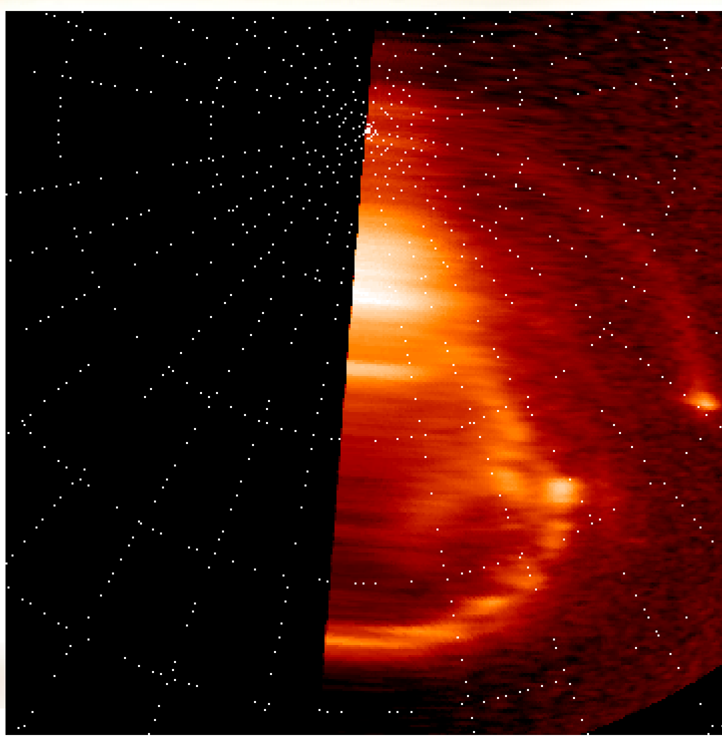
Jupiter's 3 Auroras

1. **Main Aurora**
2. **Polar Aurora**
3. **Io Spot + Wake**

Hubble Space Telescope

Shown in magnetic coordinates

- rotating with Jupiter



Grodent et al.

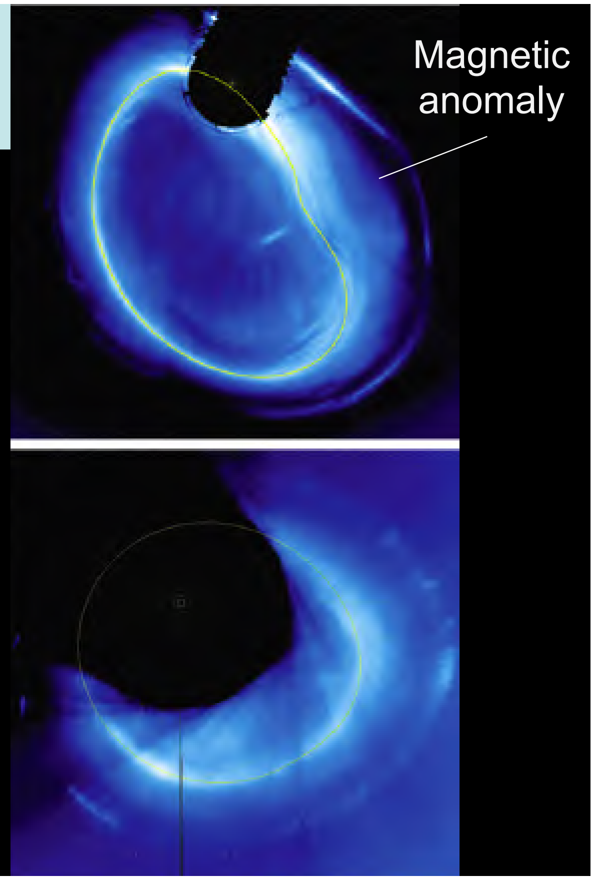
Main Aurora

~1° Narrow

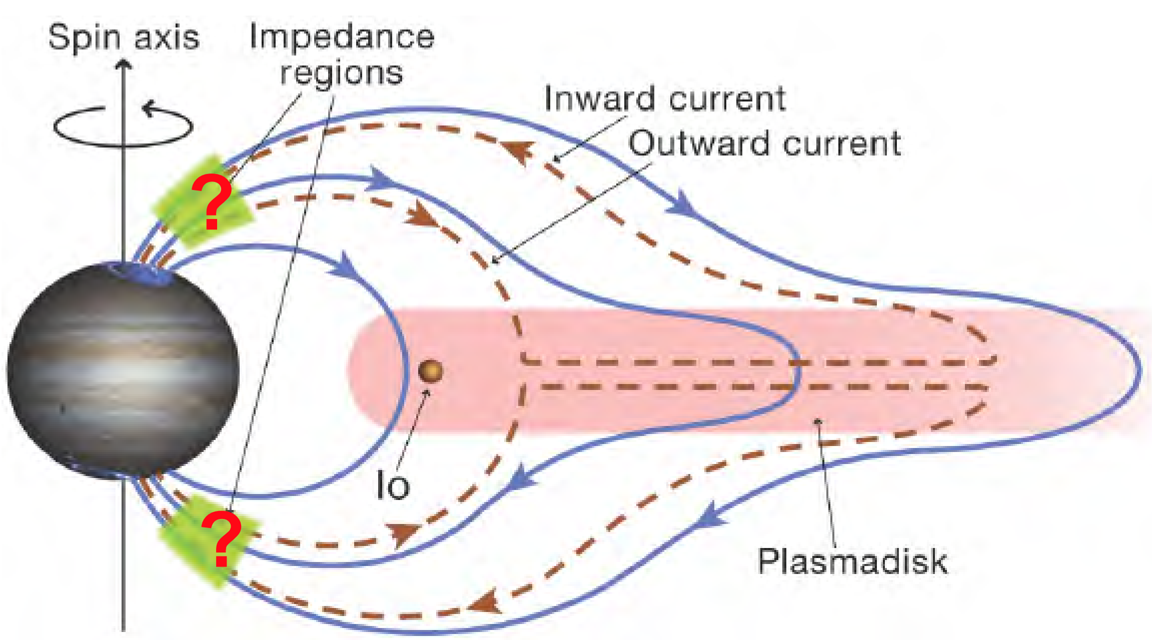
Shape constant, fixed in magnetic co-ordinates

Steady intensity

Clarke et al., *Grodent et al.* HST



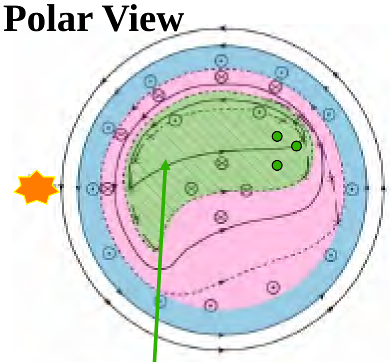
The main aurora is the signature of Jupiter's attempt to spin up its magnetosphere



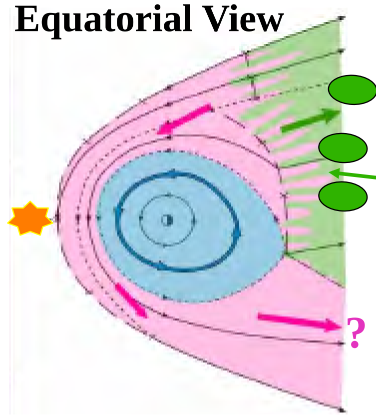
Hill 1979; Cowley & Bunce 2001; Nichols & Cowley 2004; Ray et al. 2010

Polar Aurora: Debate about Dynamics of Outer Magnetosphere

Polar View

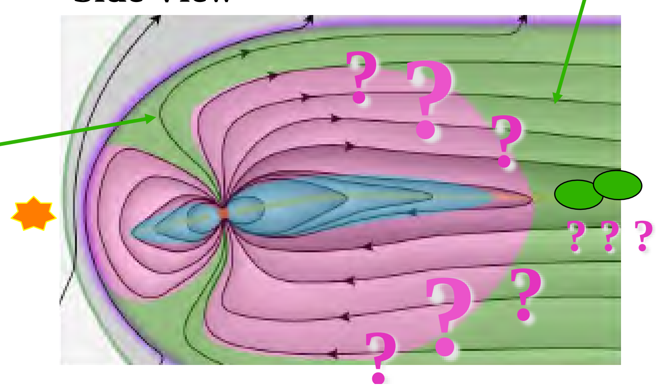


Equatorial View



How much does solar wind drive dynamics?

Side View



How Much of Polar Flux is Open to the solar wind?

Juno

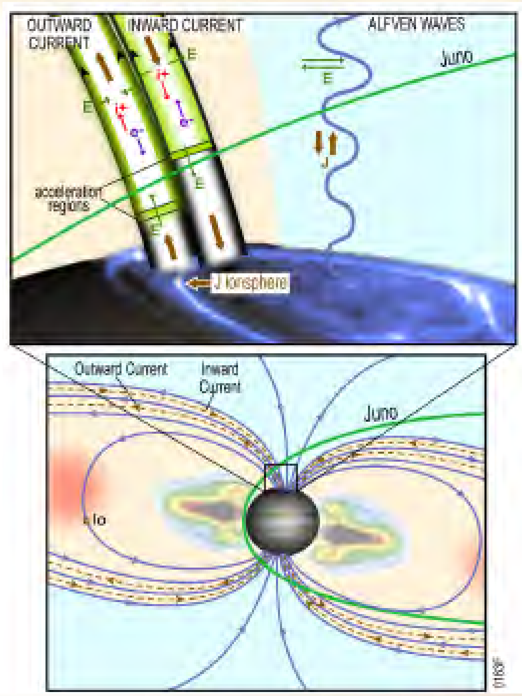
Polar Magnetosphere Exploration

Juno passes directly through auroral field lines

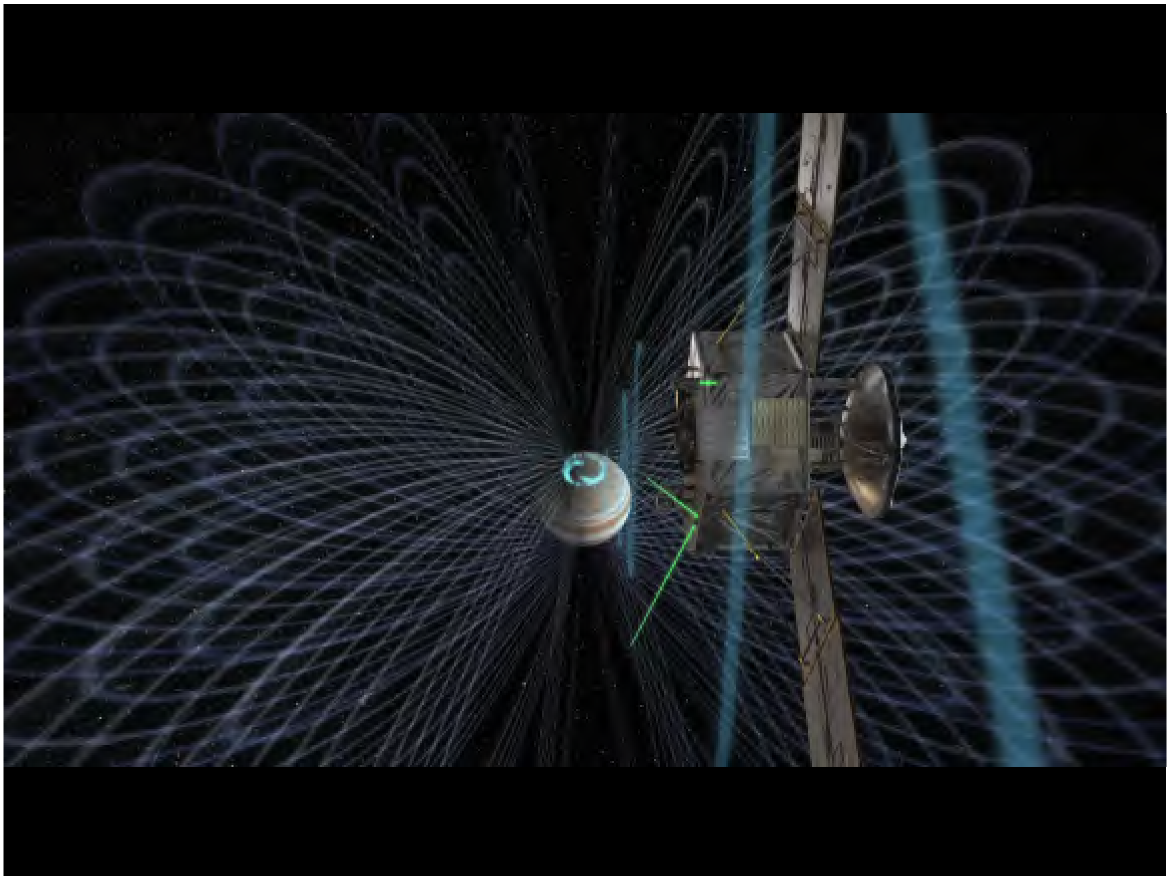
Measures particles precipitating into atmosphere creating aurora

Plasma/radio waves reveal processes responsible for particle acceleration

UV & IR images provides context for *in-situ* observations



Polar orbit is perfect for *in-situ* exploration of polar magnetosphere



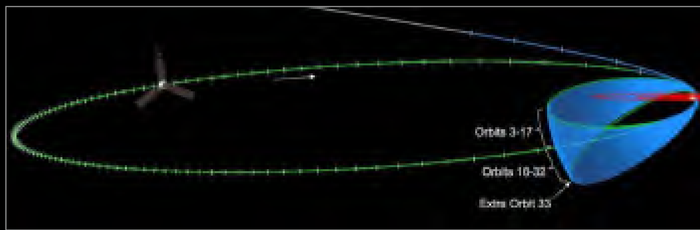
Juno Launch
Aug 5, 2011

[http://www.youtube.com/user/NASAJuno?blend=5&ob=5 - p/f/5/ki_vL-v9WG0](http://www.youtube.com/user/NASAJuno?blend=5&ob=5#p/f/5/ki_vL-v9WG0)

Juno

Can Juno study the moons?

Juno's orbit deliberately avoids the four large Galilean moons.

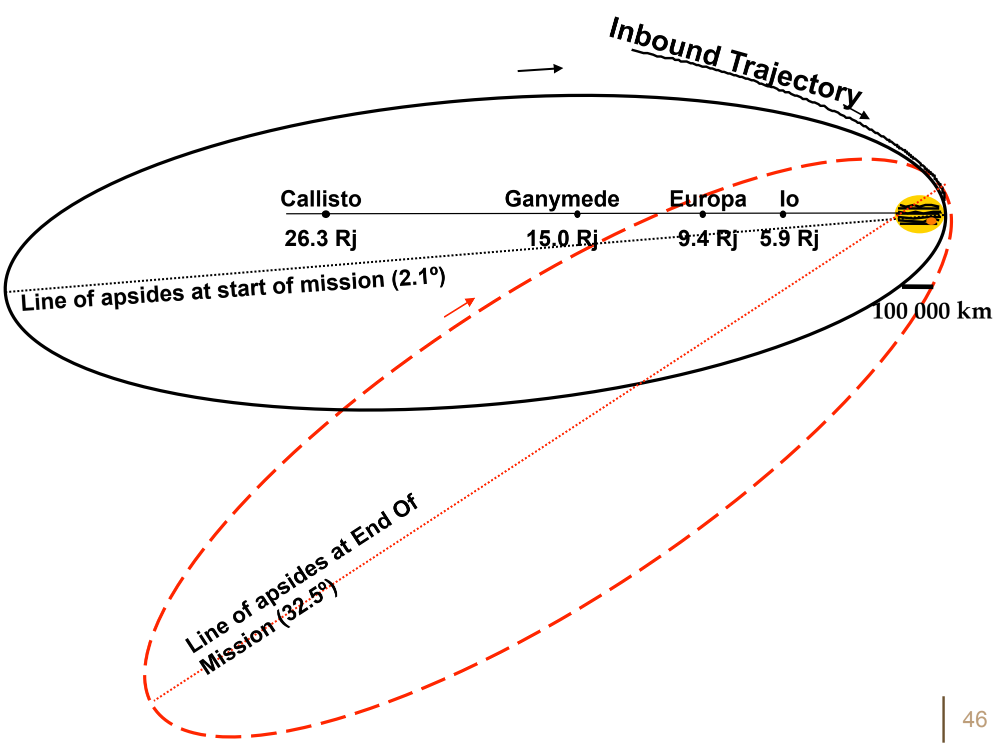


Why go all that way and not visit Europa?

… maybe in the later orbits…..

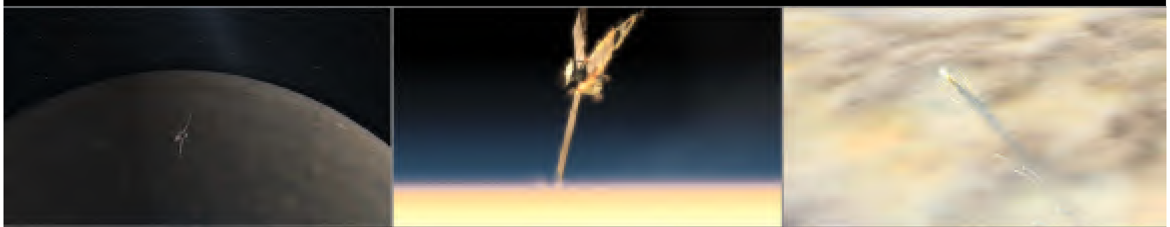
Juno

Jupiter Orbit Geometry



End of mission

Why crash a perfectly good spacecraft into Jupiter?



After 33 orbits and 15 months at Jupiter, Juno will have received a dose of radiation equal to 100 million dental x-rays!

Eventually radiation damage would render Juno uncontrollable, so the spacecraft is sent into Jupiter in a controlled way so there's no possibility it will impact the icy moons.

….. And we run out of $$$......

July 2016 here we come!

Thank you!