National Aeronautics and
Space Administration

Unlocking Jupiter's Secrets

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Mission Overview

FEATURES

- First solar-powered mission to Jupiter
- Eight science instruments, plus a camera for public outreach
- Spinning orbiter spacecraft launched on August 5, 2011
  - 5-year cruise to Jupiter, arriving July 2016
  - About 1 year at Jupiter, ending with de-orbit into Jupiter in February 2018
- Elliptical 14-day polar orbit swings below radiation belts to minimize radiation exposure
- Second mission in NASA’s New Frontiers Program

OBJECTIVE

- Improve our understanding of giant planet formation and evolution by studying Jupiter’s origin, interior structure, atmospheric composition and dynamics, and magnetosphere

PROJECT MANAGEMENT

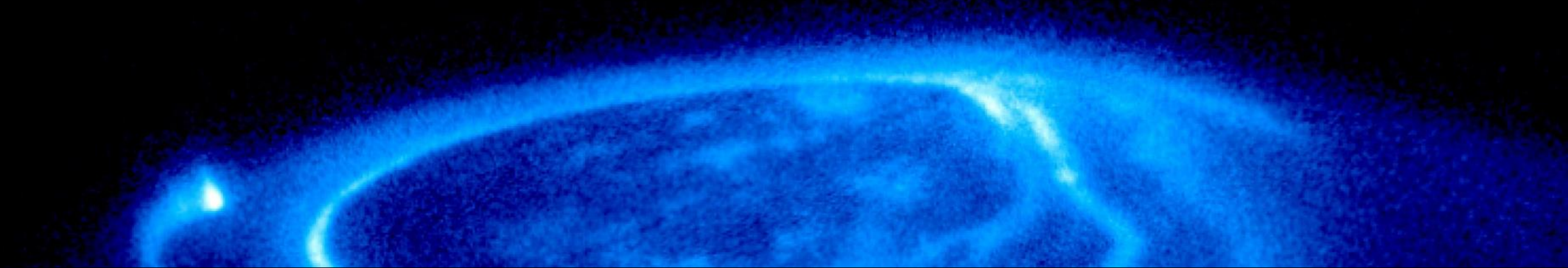
- NASA’s Jet Propulsion Laboratory manages the mission for the Principal Investigator, Scott Bolton, of the Southwest Research Institute

Partners

SwRI	Southwest Research Institute
JPL	NASA Jet Propulsion Laboratory
GSFC	NASA Goddard Space Flight Center
KSC	NASA Kennedy Space Center
UI	University of Iowa
JHU/APL	Johns Hopkins University/Applied Physics Laboratory
MSSS	Malin Space Science Systems
LMSSC	Lockheed Martin Space Systems Company
ULA	United Launch Alliance
DTU	Danish Technical University
ASI	Italian Space Agency
BELSPO	Belgian Science Policy Office
CNES	Centre National d’Études Spatiales

Partners and Roles

SwRI	Southwest Research Institute — Principal Investigator; UVS (Ultraviolet Imaging Spectrograph); JADE (Jovian Auroral Distributions Experiment)
JPL	NASA Jet Propulsion Laboratory — Mission management; MWR (Microwave Radiometer)
GSFC	NASA Goddard Space Flight Center — MAG (Magnetometer)
KSC	NASA Kennedy Space Center — Launch management
UI	University of Iowa — Waves (radio and plasma waves instrument)
JHU/APL	Johns Hopkins University/Applied Physics Laboratory — JEDI (Jupiter Energetic Particle Detector Instrument)
MSSS	Malin Space Science Systems — JunoCam
LMSSC	Lockheed Martin Space Systems Company — Spacecraft
ULA	United Launch Alliance — Atlas V551 launch vehicle
DTU	Danish Technical University — Advanced Stellar Compass for MAG and GS
ASI	Italian Space Agency — JIRAM (Jovian Infrared Auroral Mapper); Ka-band system for GS (Gravity Science) experiment
BELSPO	Belgian Science Policy Office — Scan Mirror Assembly for UVS
CNES	Centre National d’Études Spatiales — Electro-optics for JADE



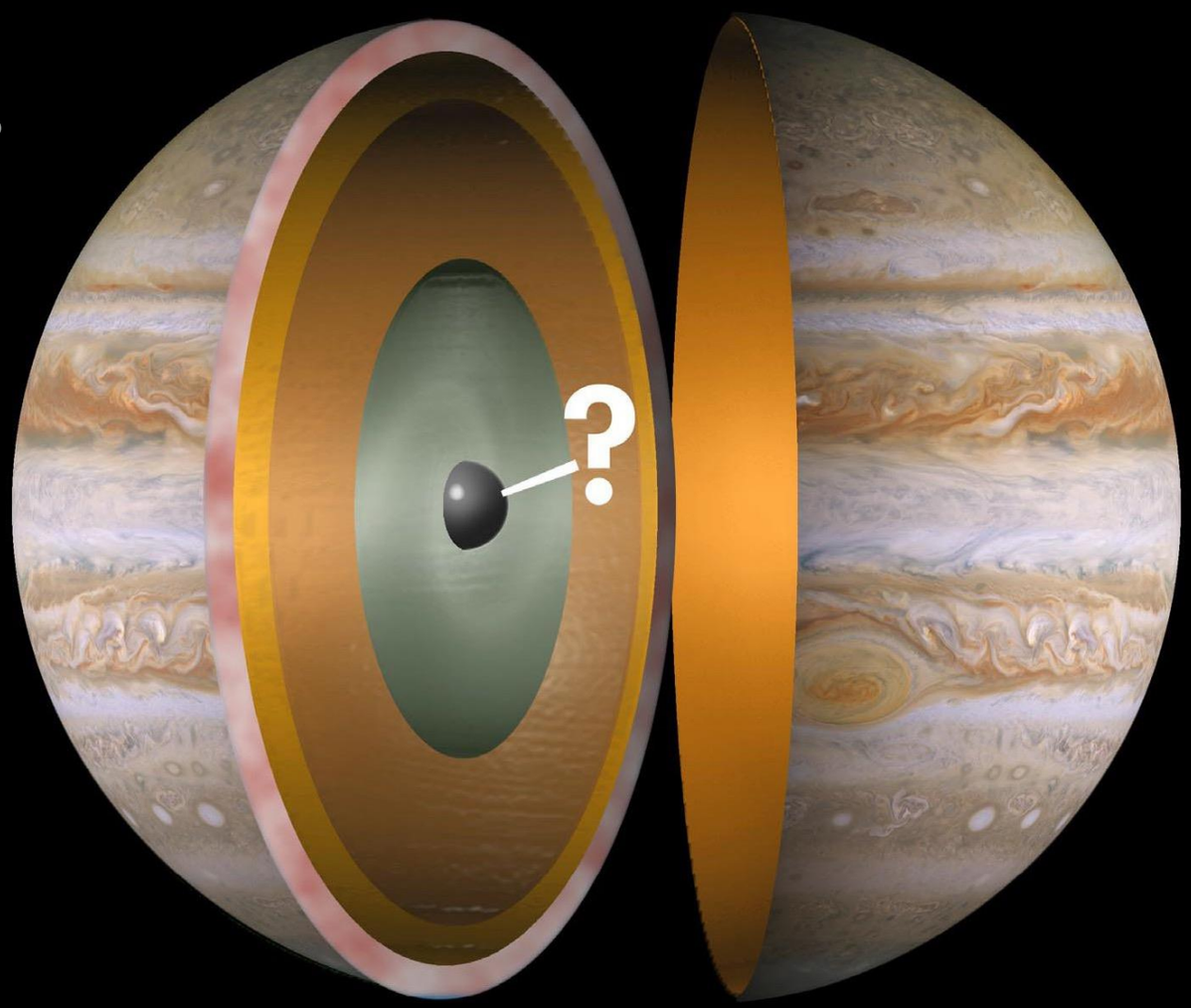
Jupiter Fast Facts

- Fifth planet from the Sun
- Distance from the Sun averages 484 million miles (779 million km) — about 5.2 astronomical units
- Has 53 satellites plus 14 awaiting confirmation
- Has three dark rings, discovered in 1979 by Voyager 1
- Larger than all the other planets and moons combined
- Takes nearly 12 years to complete one solar orbit
- Spins so fast that a Jovian day is a little less than 10 hours

Why Juno?

Major unanswered questions about Jupiter:

- How did Jupiter form?
- How is the planet arranged on the inside?
- Is there a solid core, and if so, how large is it?
- How is its vast magnetic field generated?
- How are atmospheric features related to the movement of the deep interior?
- What are the physical processes that power the auroras?
- What do the poles look like?

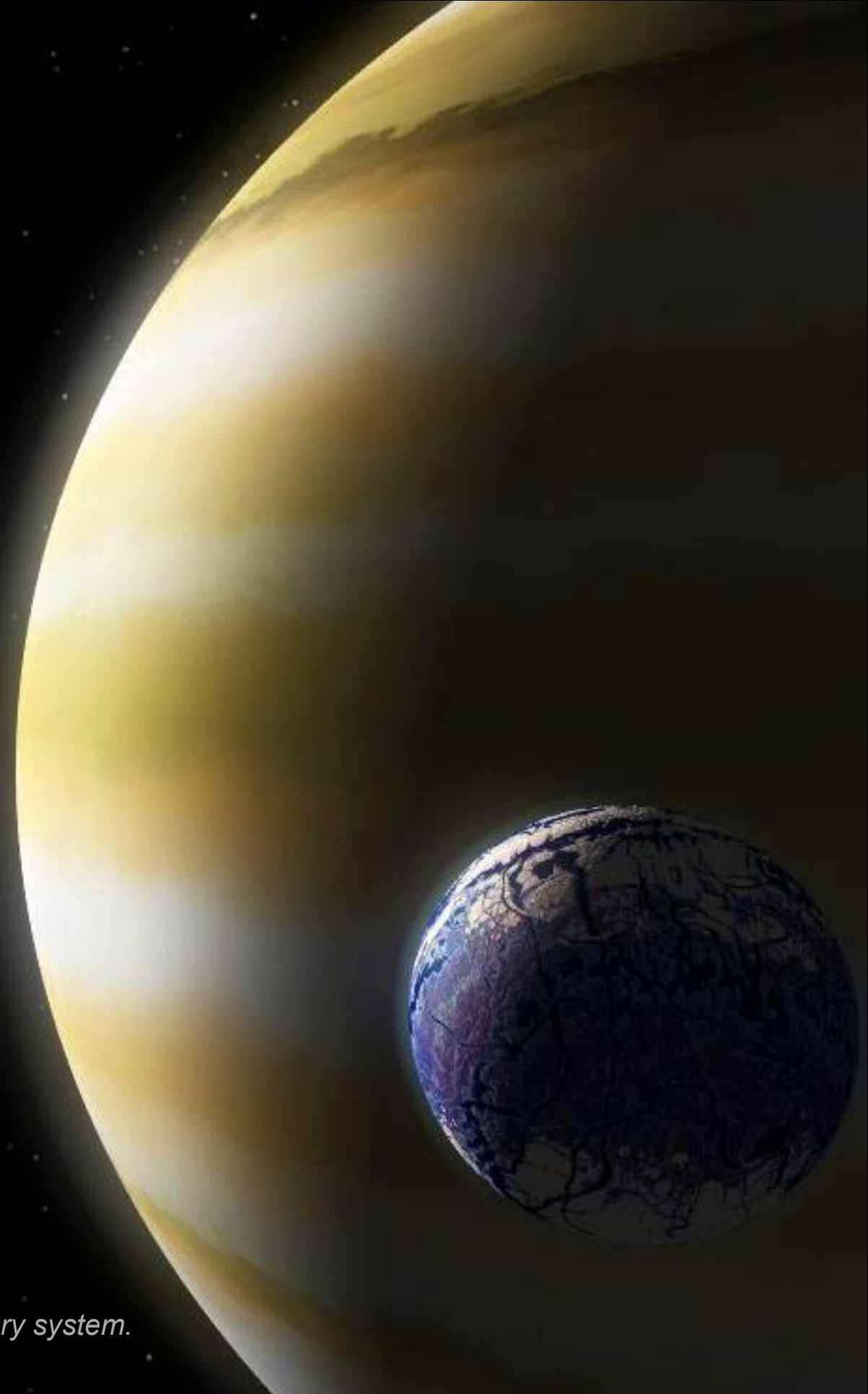


The deep interior of Jupiter is still an unknown.

Giant Planet Mysteries

We also have unanswered questions relevant to the giant planets:

- Over what period in the early solar system did the gas giants form?
- How did the birth of Jupiter and its gas-giant sibling, Saturn, differ from the ice giants Uranus and Neptune?
- What is the history of water and other volatile components across our solar system?
- How do processes that shape the present character of planetary bodies operate and interact?
- What does our solar system tell us about development and evolution of extrasolar planetary systems, and vice versa?



Artist's concept of an extrasolar planetary system.

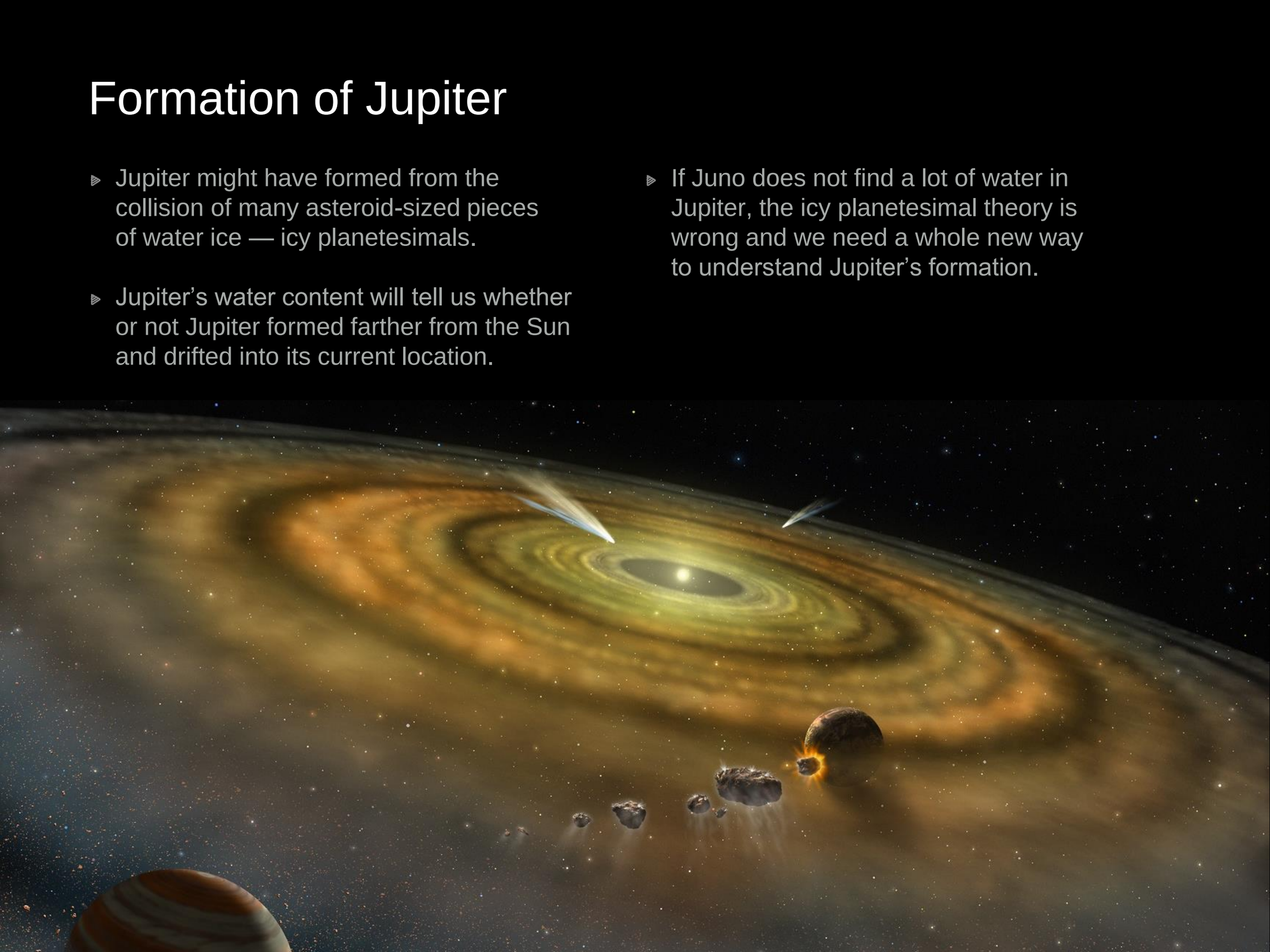
Why Go Back to Jupiter?

The Galileo mission's probe into Jupiter's atmosphere challenged our planetary formation theories.

- The probe was released on July 13, 1995
- Parachuted into the atmosphere on December 7, 1995
- What is the history of water and other volatile components across our solar system?
- Fell into a "hot spot" (cloud-free) entry site
- Carried six instruments
- Transmitted data for 58 minutes
- Detected unexpected dryness

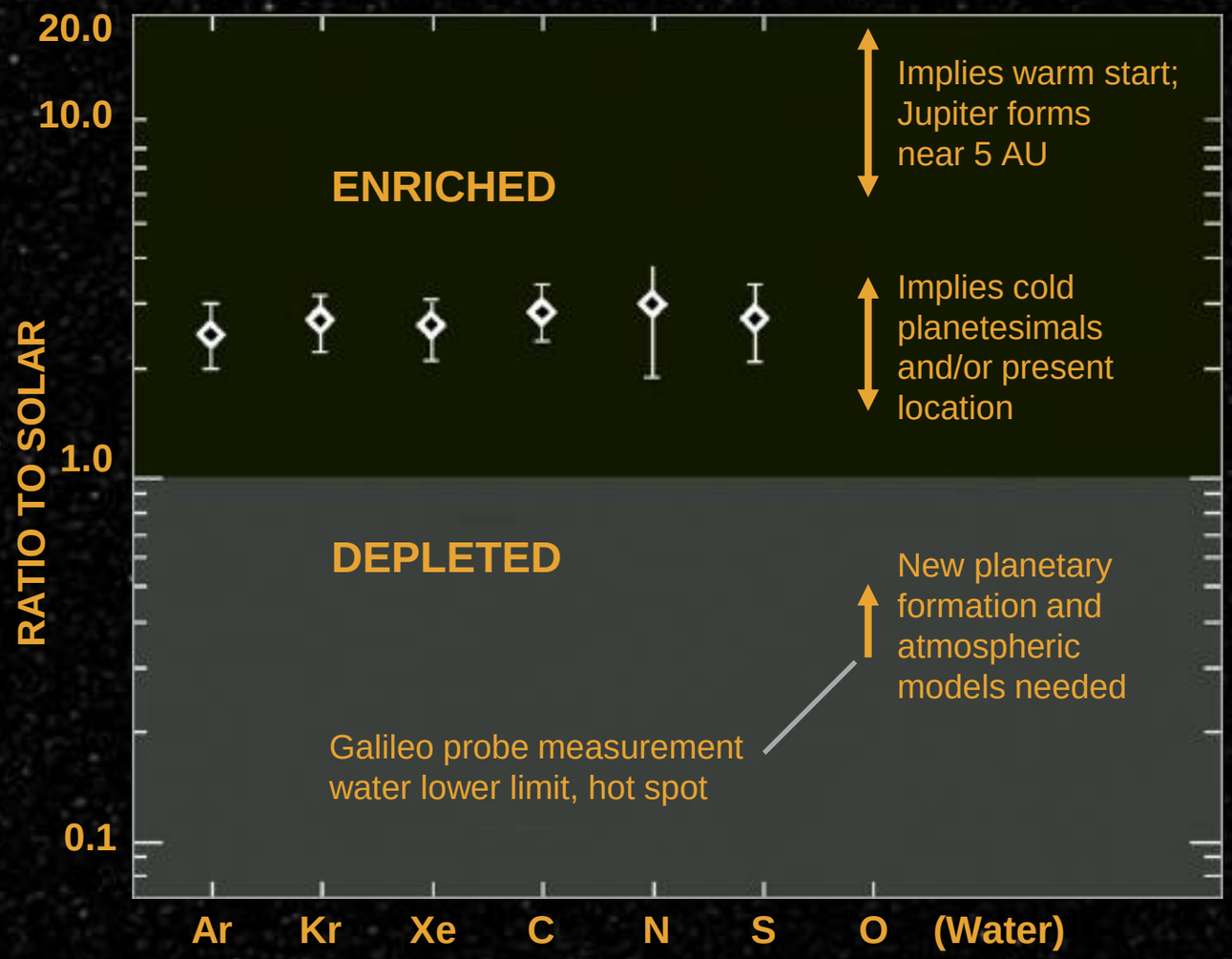
Formation of Jupiter

- Jupiter might have formed from the collision of many asteroid-sized pieces of water ice — icy planetesimals.
- Jupiter’s water content will tell us whether or not Jupiter formed farther from the Sun and drifted into its current location.
- If Juno does not find a lot of water in Jupiter, the icy planetesimal theory is wrong and we need a whole new way to understand Jupiter’s formation.



Formation of Jupiter

- Jupiter is mostly hydrogen and helium, so it must have formed early.
- Juno will determine the oxygen/hydrogen ratio (water abundance) to help decide among alternative theories of origin.



Juno’s Science Objectives

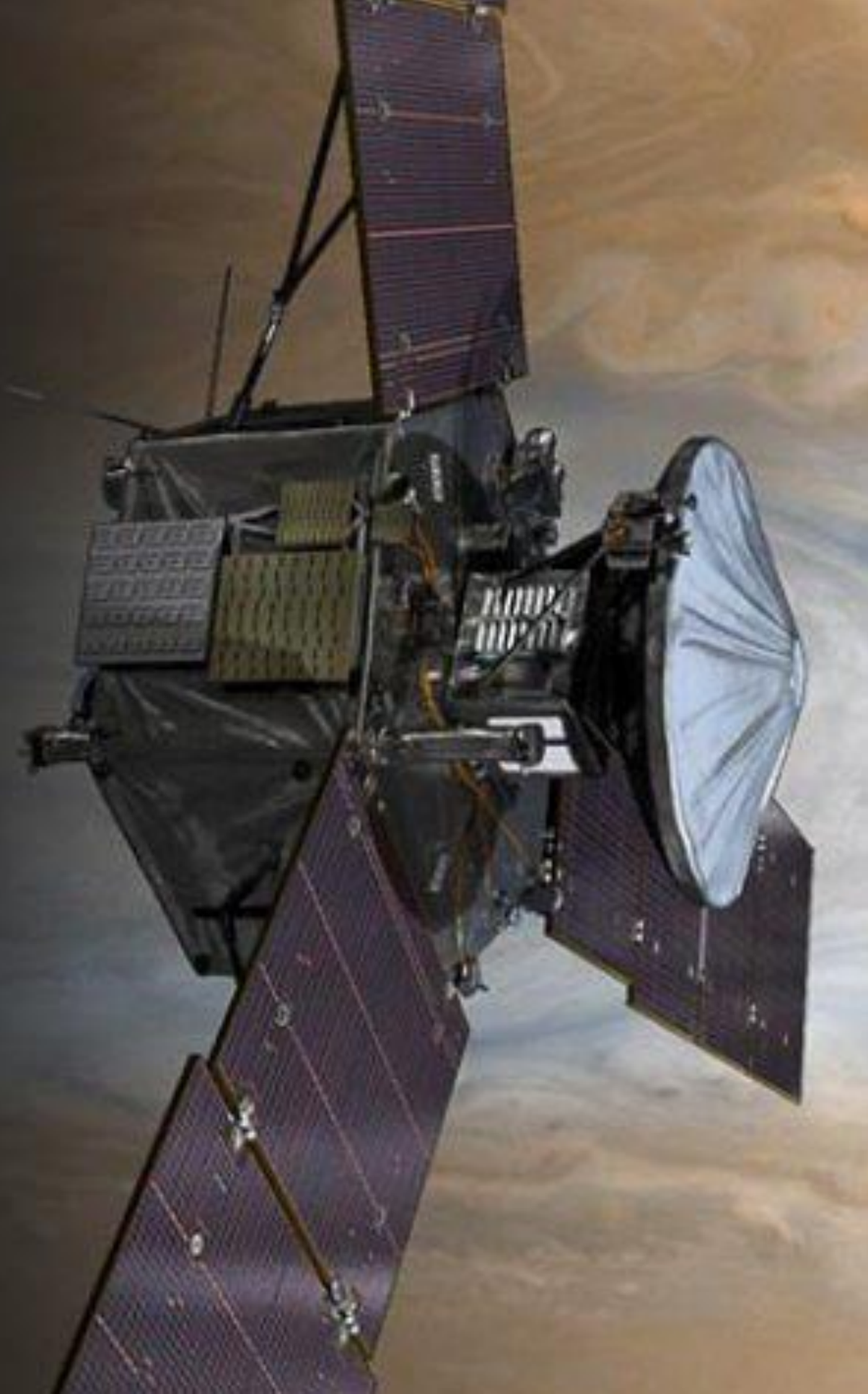
Juno’s 9 science investigations are organized around four themes.

Origin
Determine the abundances of water and place an upper limit on the mass of Jupiter’s dense core to decide which theory of the planet’s origin is correct.

Interior
Understand how Jupiter’s interior structure and how material moves deep within the planet by mapping its gravitational and magnetic fields.

Atmosphere
Map variations in atmospheric composition, temperature, cloud opacity, and dynamics to depths greater than 100 bars at all latitudes.

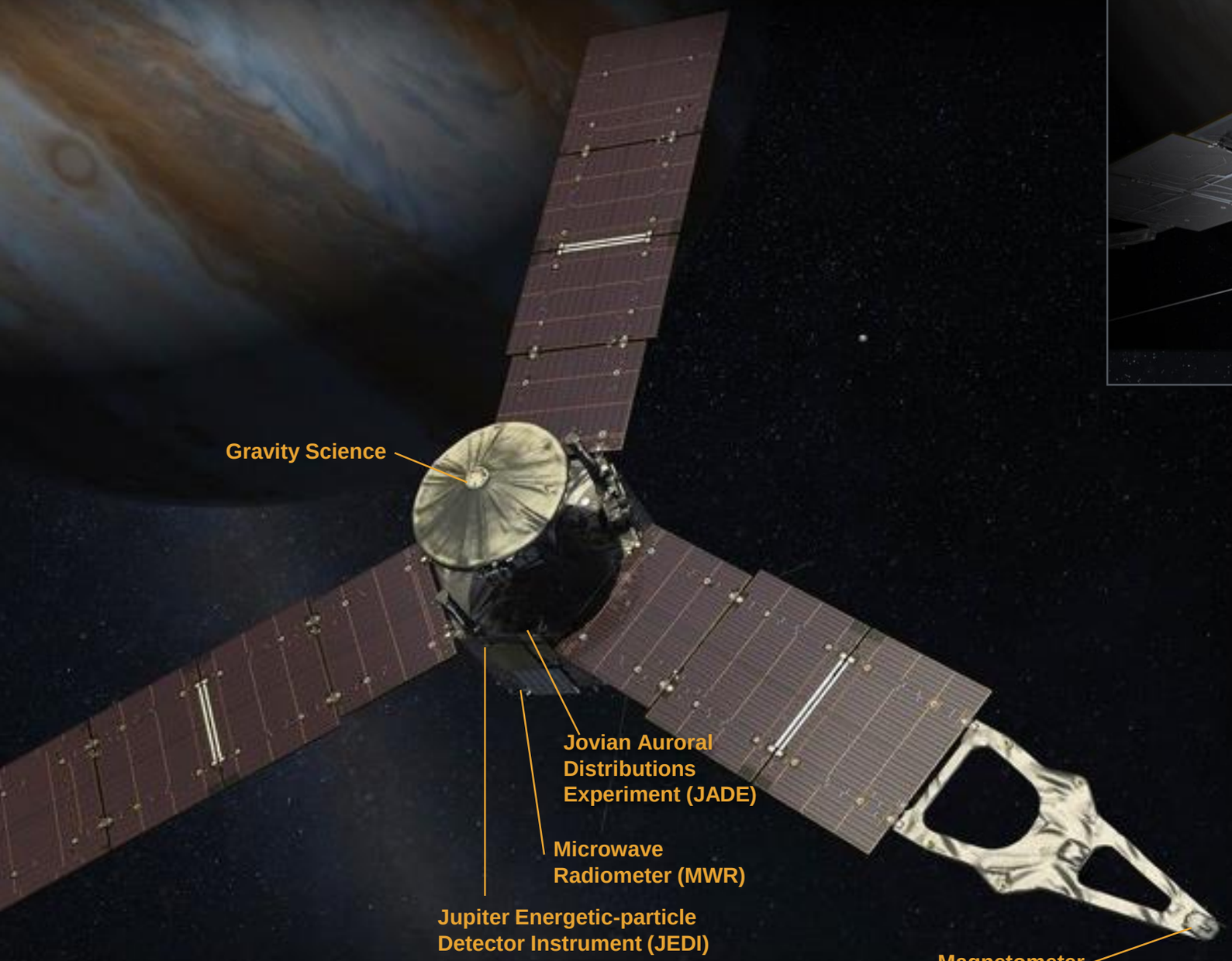
Magnetosphere
Characterize and explore the three-dimensional structure of Jupiter’s polar magnetosphere and auroras.

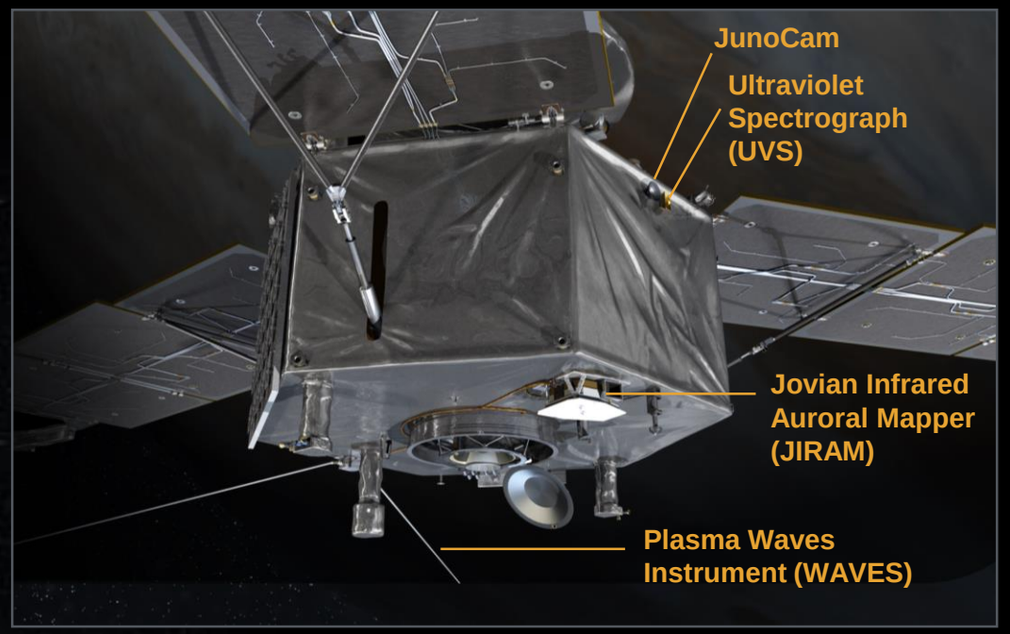


Studying Jupiter

Investigation/ Instrument	Origin	Interior	Atmosphere	Magnetosphere
Gravity Science (GS)	●	●	●	
Magnetometer (MAG)	●	●		●
Microwave Radiometer (MWR)	●	●	●	●
Jupiter Energetic Particle Detector (JEDI)				●
Jovian Auroral Distributions Experiment (JADE)				●
Plasma Waves Instrument (Waves)				●
Ultraviolet Spectrograph (UVS)				●
Jovian Infrared Auroral Mapper (JIRAM)			●	●
Visible Camera (JunoCam)			●	

Spacecraft and Payload





Spacecraft Dimensions:
Diameter: 20 meters (66 feet)
Height: 4.5 meters (15 feet)

Juno's Science Instruments

Gravity Science and Magnetometers
Study Jupiter's deep structure by mapping the planet's gravity field and magnetic field

Microwave Radiometer
Probe Jupiter's deep atmosphere and measure how much water (and hence oxygen) is there

JEDI, JADE AND Waves
Sample electric fields, plasma waves and particles around Jupiter to determine how the magnetic field is connected to the atmosphere and especially the auroras (northern and southern lights)

UVS and JIRAM
Using ultraviolet and infrared cameras, take images of the atmosphere and auroras, including chemical fingerprints of the gases present

JunoCam
Take spectacular close-up, color images

Launch

Juno ready to be enclosed in the payload fairing

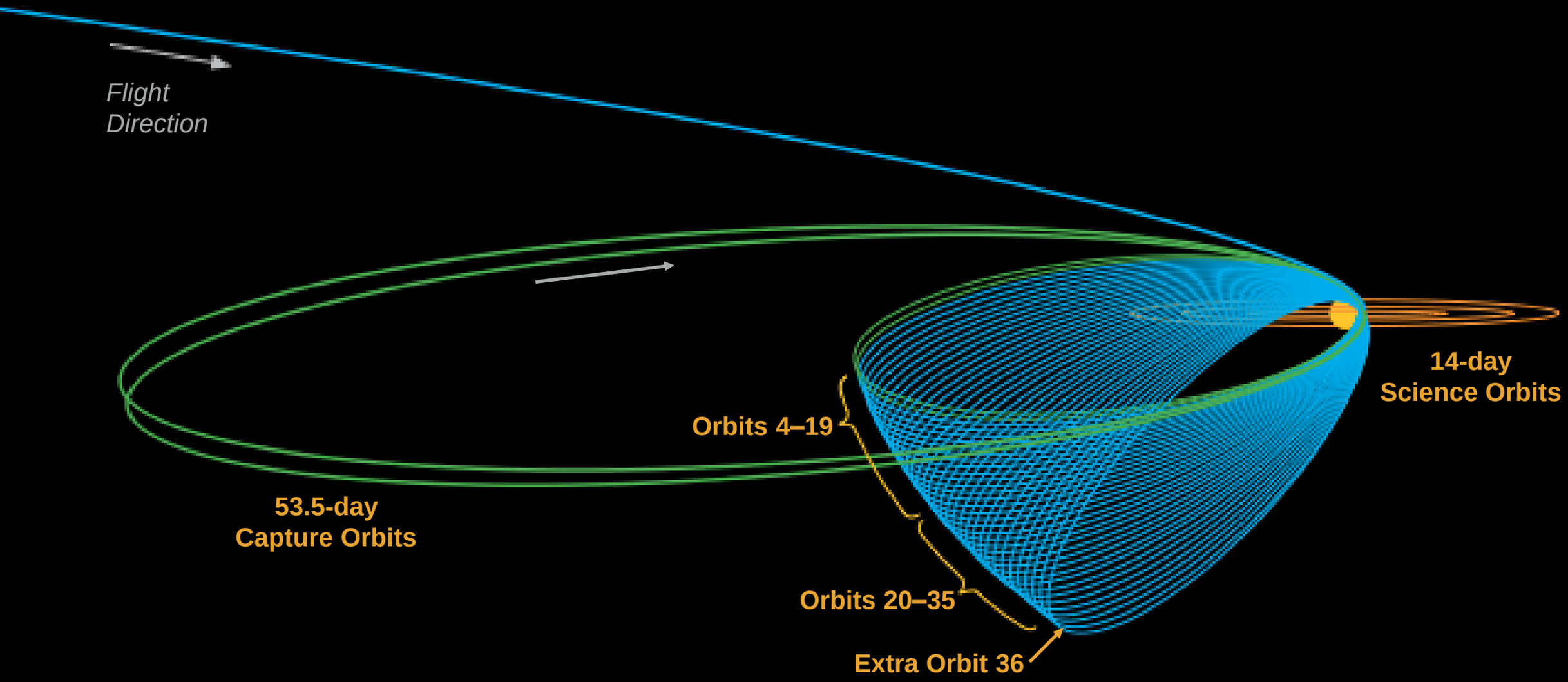
Launched on Atlas V 551, Cape Canaveral Air Force Station, August 5, 2011

Juno’s Trajectory

- Looped once around the inner solar system before heading for Jupiter.
- Direct path would have required a much more powerful launch vehicle.
- Using Earth’s gravity for a boost makes the trip longer, but saves a lot of rocket cost.
- From launch to Jupiter orbit insertion is a trip of 1.76 billion miles.

The Orbit: Key to the Mission

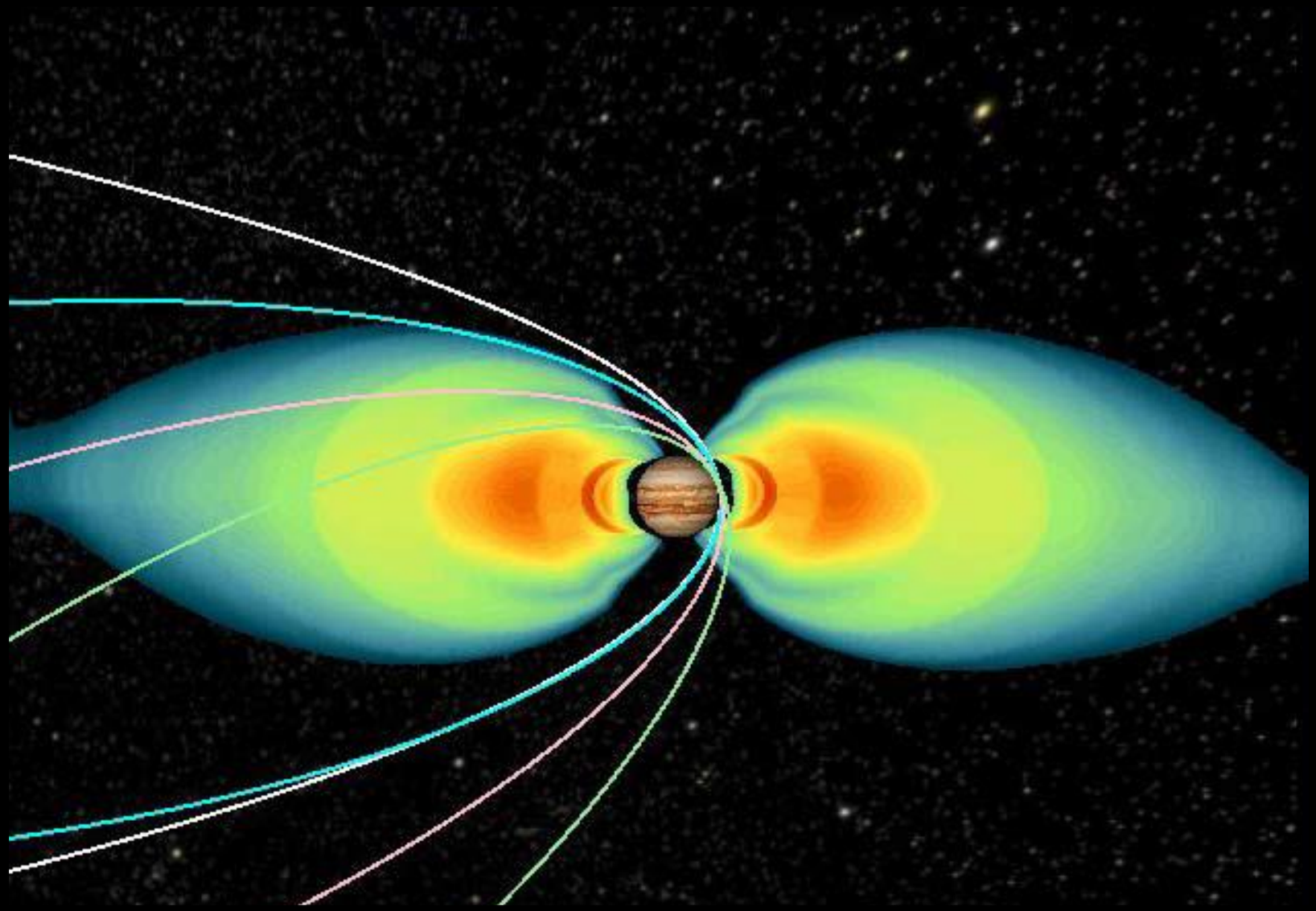
- Juno makes 37 total orbits, including 33 science orbits
- Juno will cover every part of Jupiter as the planet rotates beneath the spacecraft



Mission Phases: Jupiter Orbit Insertion, Capture Orbits, Perijove Raise Maneuver, Orbits 2–3, Science Orbits,Deorbit

Jupiter’s Killer Radiation

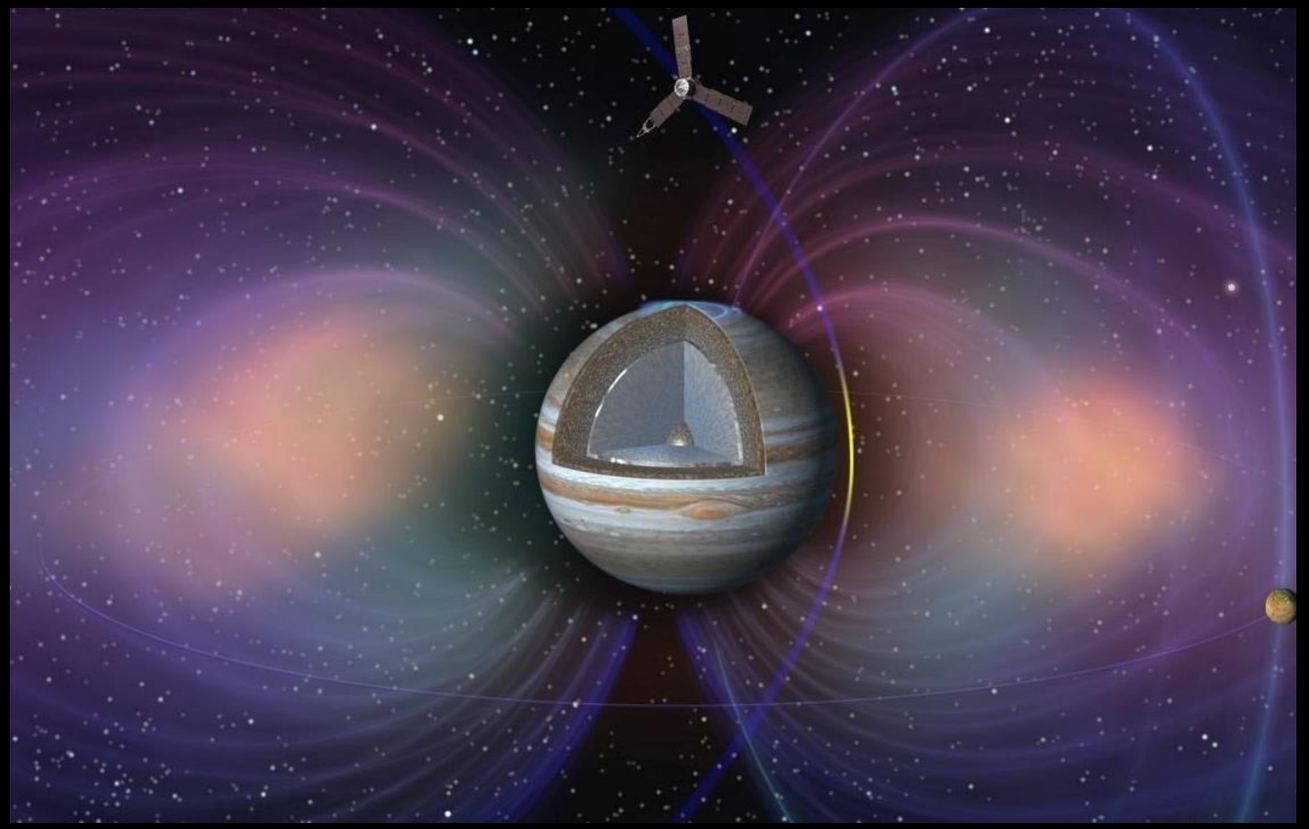
- Jupiter is surrounded by a torus-shaped region of high intensity radiation
- Juno employs a highly elliptical polar orbit to minimize radiation exposure



Why Did Juno Arrive on the 4th of July?

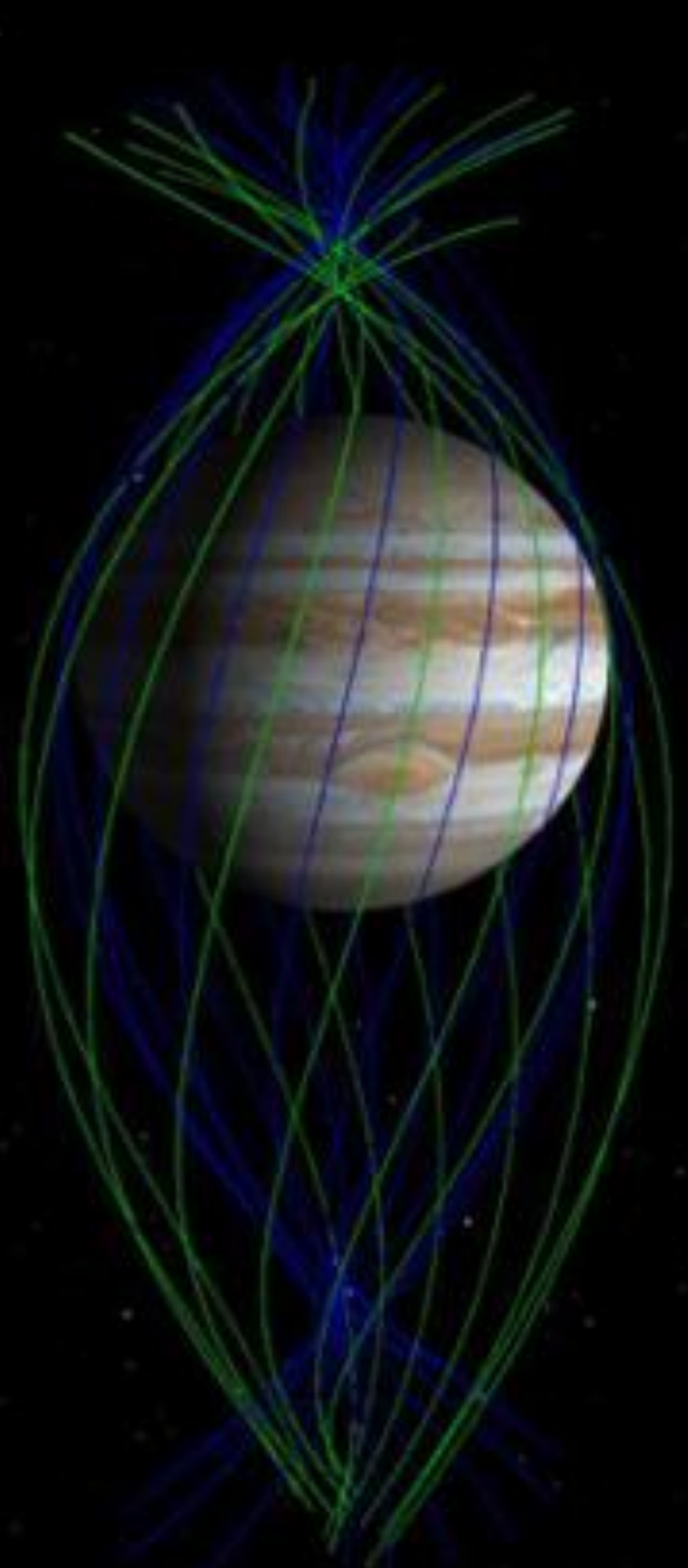
Selecting the Jupiter arrival date required consideration of

- ΔV – *Minimize ΔV to minimize the required propellant*
- Magnetic field – *Jupiter's magnetic field isn't uniform and rotates with the planet*
- Radiation – *The arrival date dictates the orbital geometry*
- Communication – *Precise orbit insertion timing and geometry required*



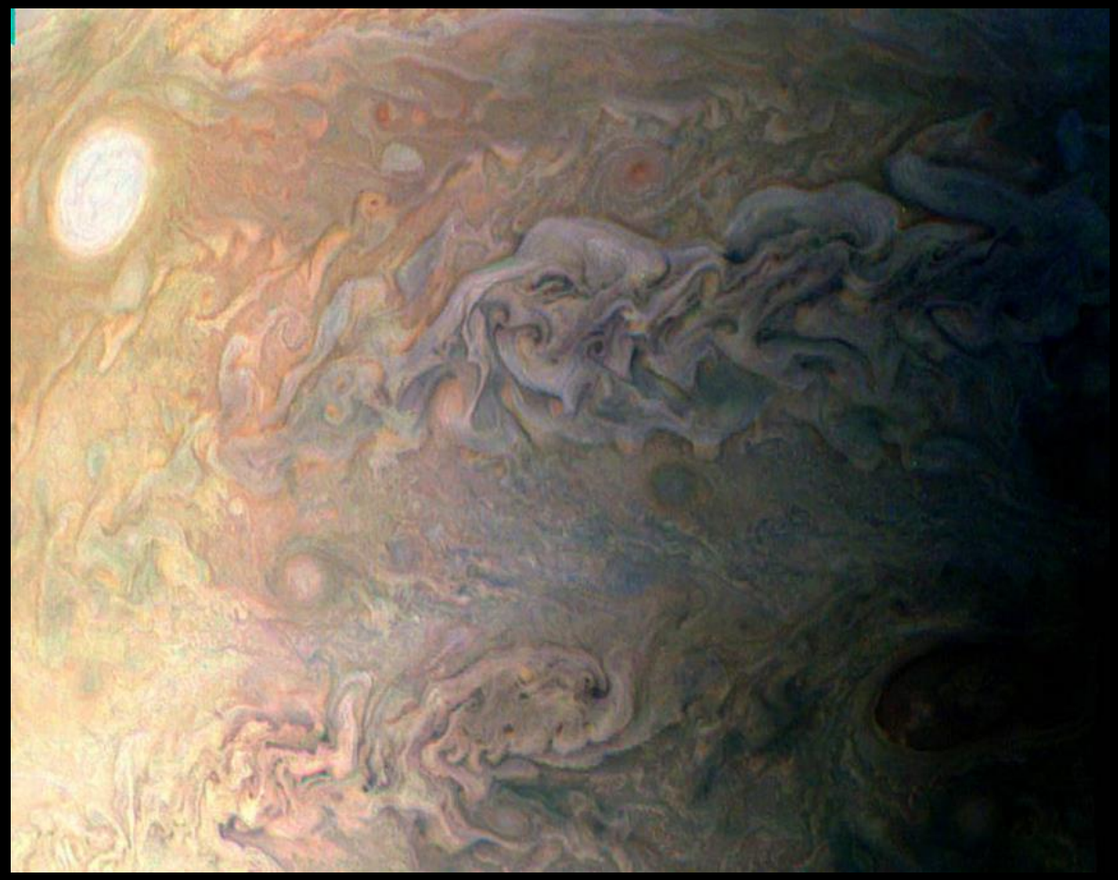
Juno’s Orbit at Jupiter

- To make the most accurate measurements of the gravitational and magnetic fields, Juno must get very close to Jupiter.
- On each orbit, Juno comes within 3,100 miles of the cloud tops.
- Though avoiding the most intense region of radiation, the orbits carry the spacecraft repeatedly through the radiation belts.
- Each orbit is 14 days long.



Current Orbit

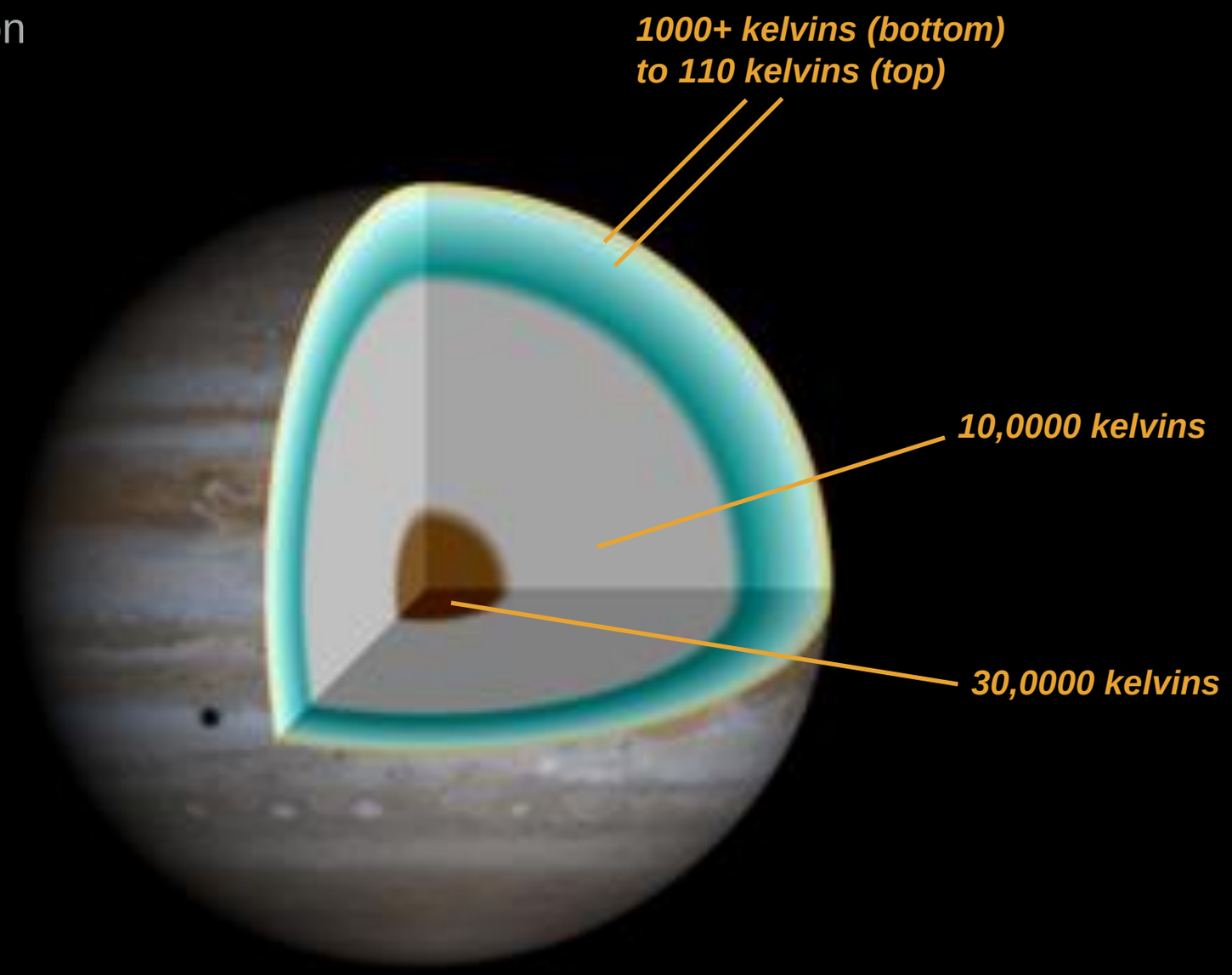
- The Period Reduction Maneuver (PRM) scheduled for Oct. 19, 2017 was postponed to allow more time to study the performance of a set of valves that are part of the spacecraft's fuel pressurization system.
- PRM would have reduced the orbital period from 53.5 days to 14 days.
- The Juno Team is currently studying multiple options for potential changes to the orbit period.



Credits: NASA/JPL-Caltech/SwRI/MSSS/Eric Jorgensen

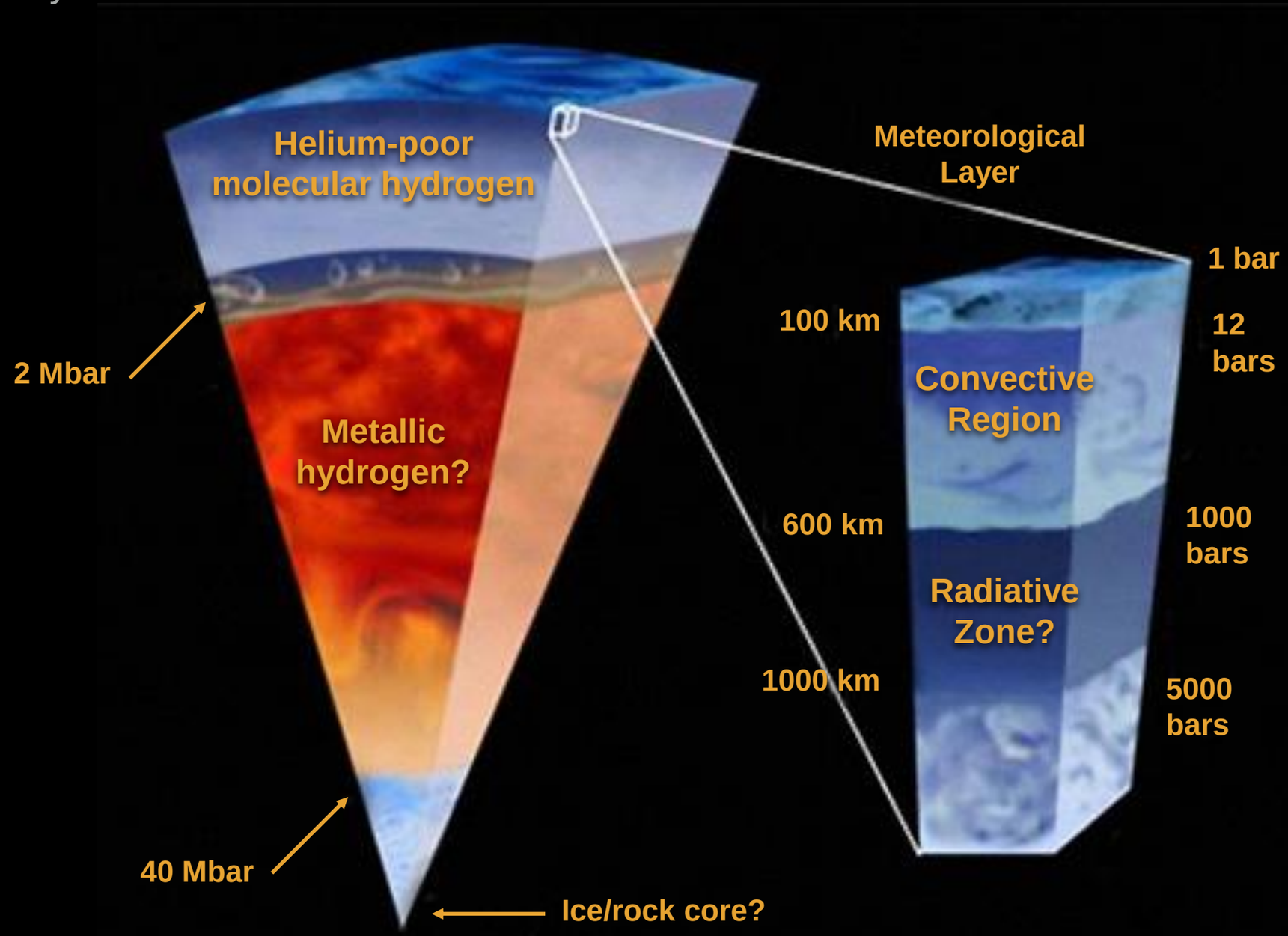
Jupiter’s Temperature

- Juno will discern a temperature profile of the planet’s atmosphere.
- Jupiter retains heat from its formation 4.5 billion years ago.
- The planet is slowly cooling as heat is transported outwards.
- The atmosphere cools predictably with altitude (like Earth).



Probing Deep and Globally

- Juno’s microwave radiometer experiment will map from the deepest interior to the atmosphere using microwaves, magnetic fields, and gravity fields.



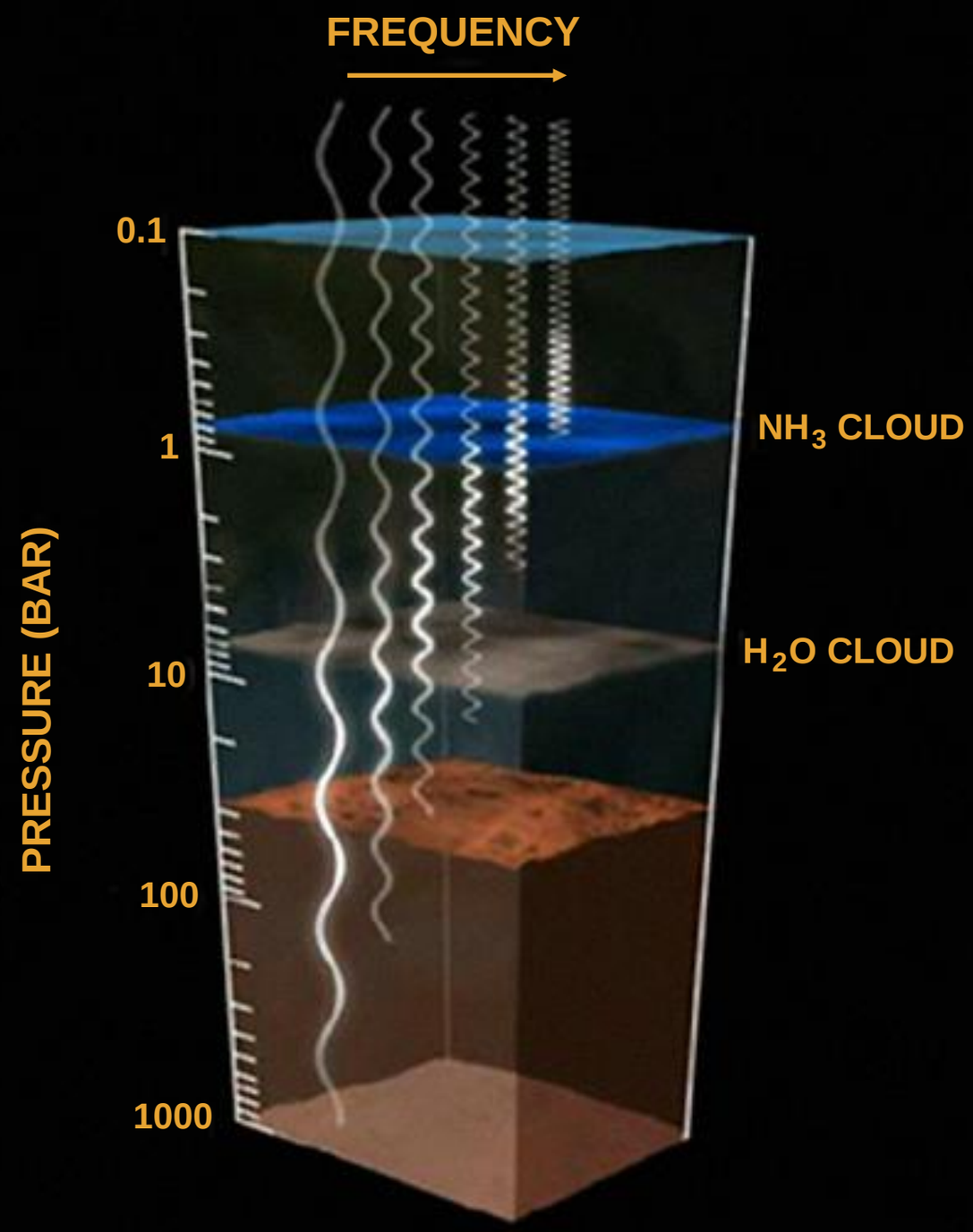
Sensing the Deep Atmosphere

- Juno measures thermal radiation from the atmosphere to as deep as 1000 atmospheres pressure (~500 to 600 km below the visible cloud tops).

- Determines water and ammonia abundances in the atmosphere all over the planet.

- Six microwave radiometer antennas measure Jupiter’s brightness at six different wavelengths.

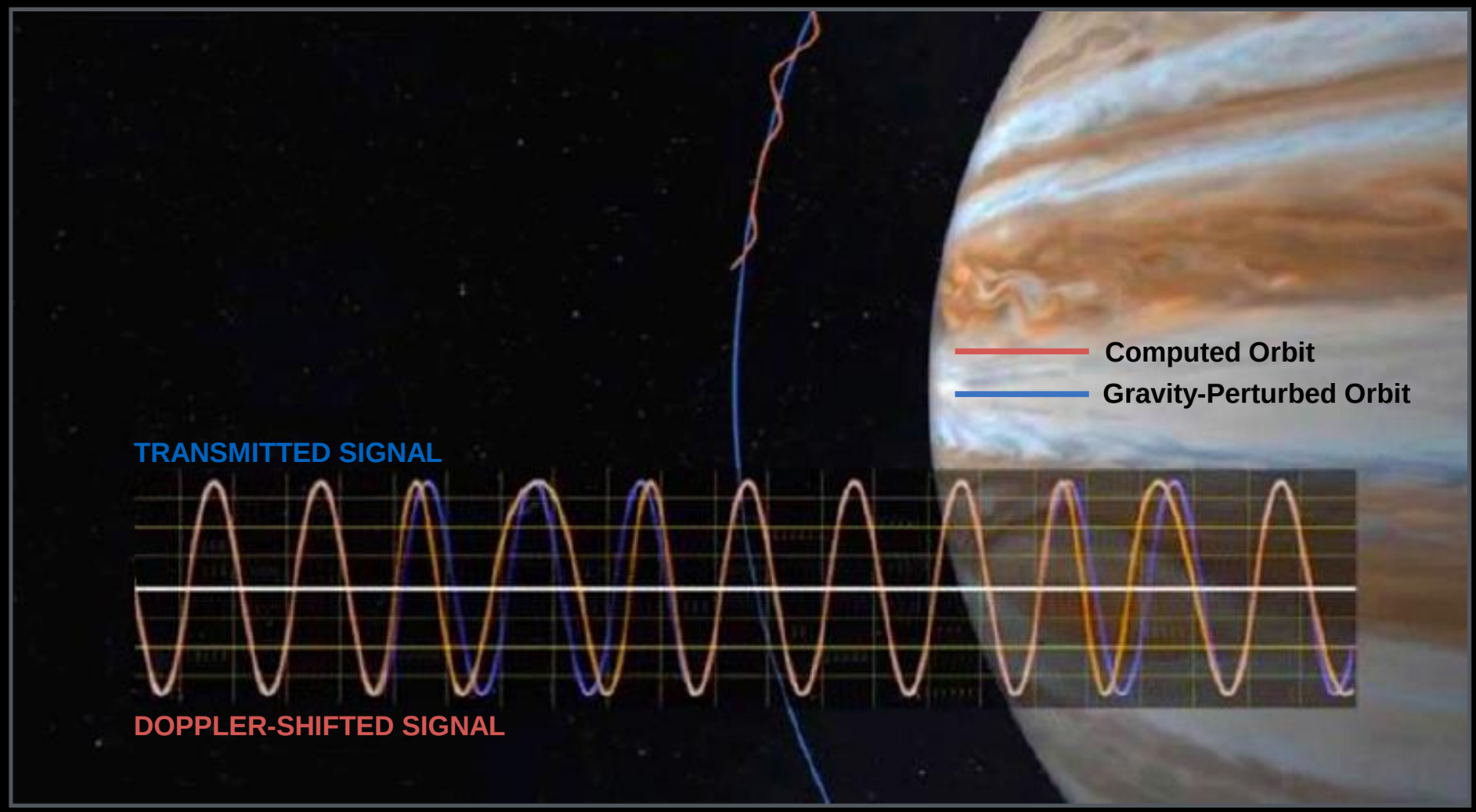
- Each antenna sees a different depth or range of depths.



Longer wavelengths of microwaves come from deeper down.

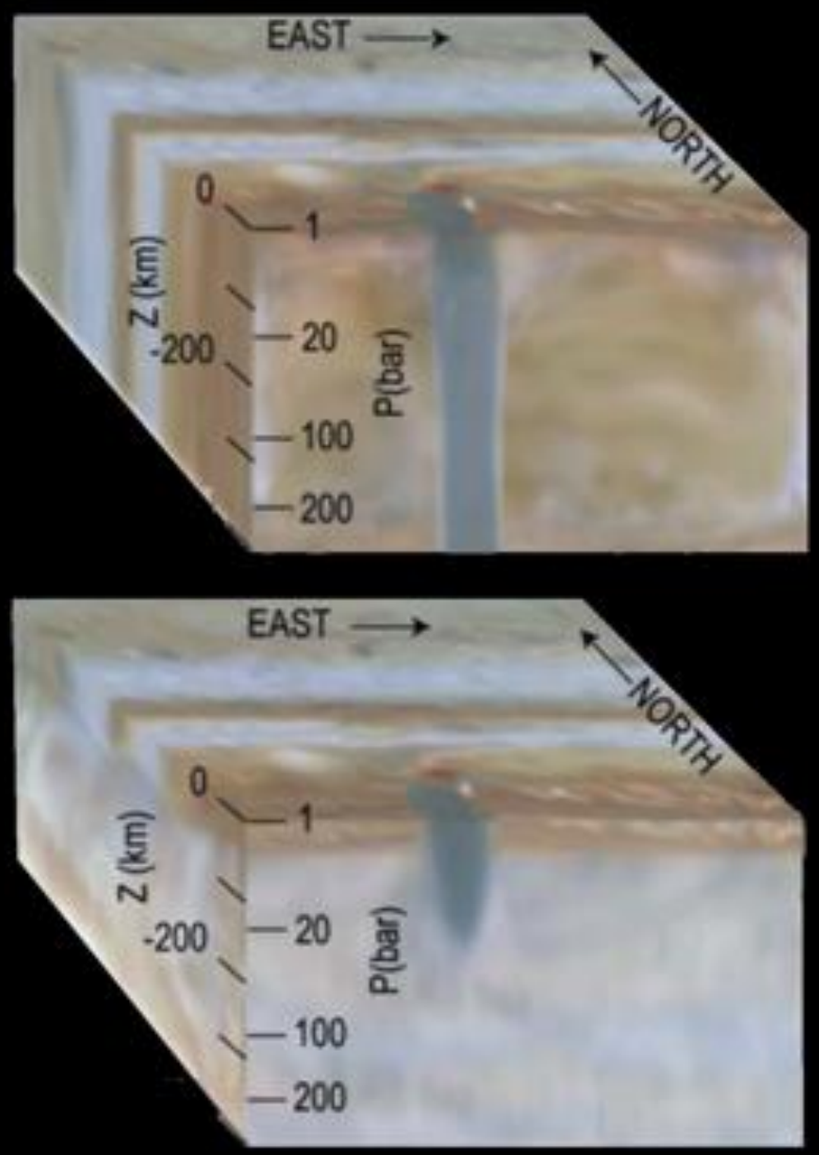
Mapping Jupiter’s Gravity

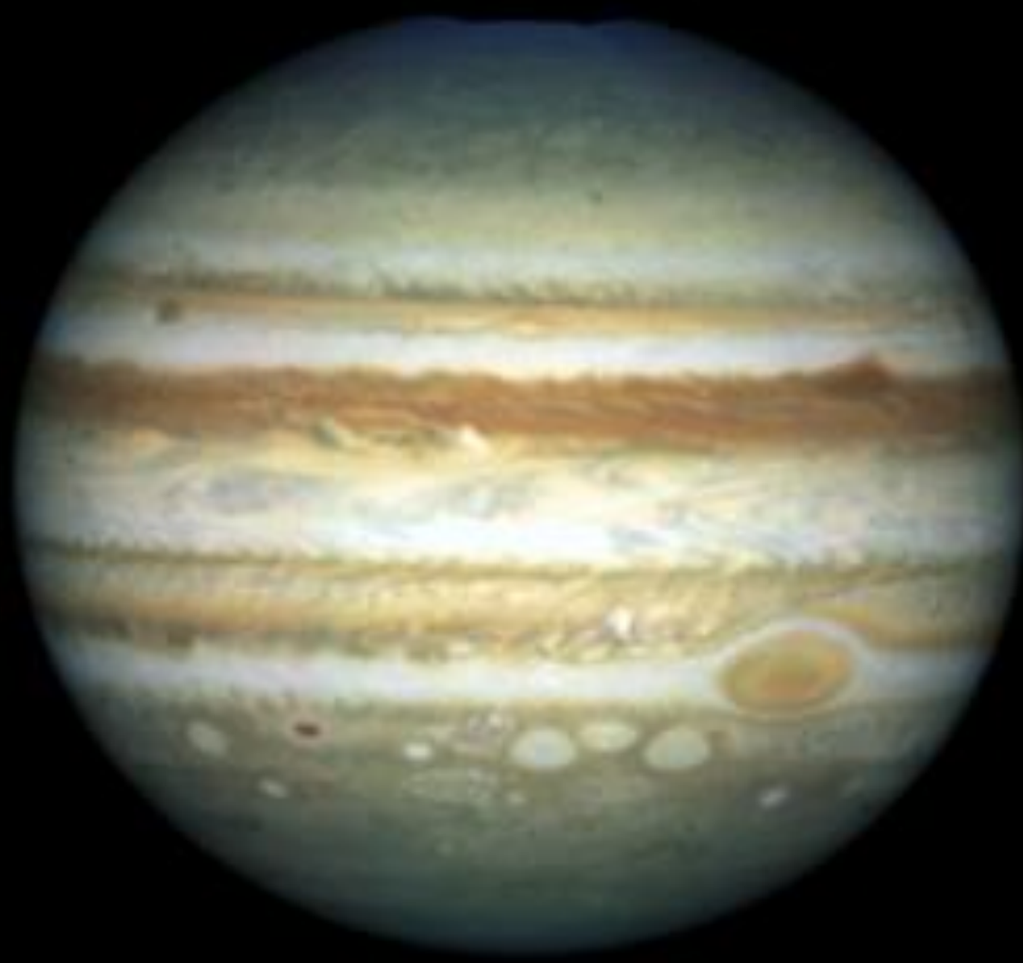
- Tracking changes in Juno’s velocity reveals Jupiter’s gravity and how the planet is arranged on the inside.
- Precise Doppler measurements of spacecraft motion reveal the gravity field.
- Tides in Jupiter caused by the moons may be detected and provide further clues.



Studying Atmospheric Dynamics

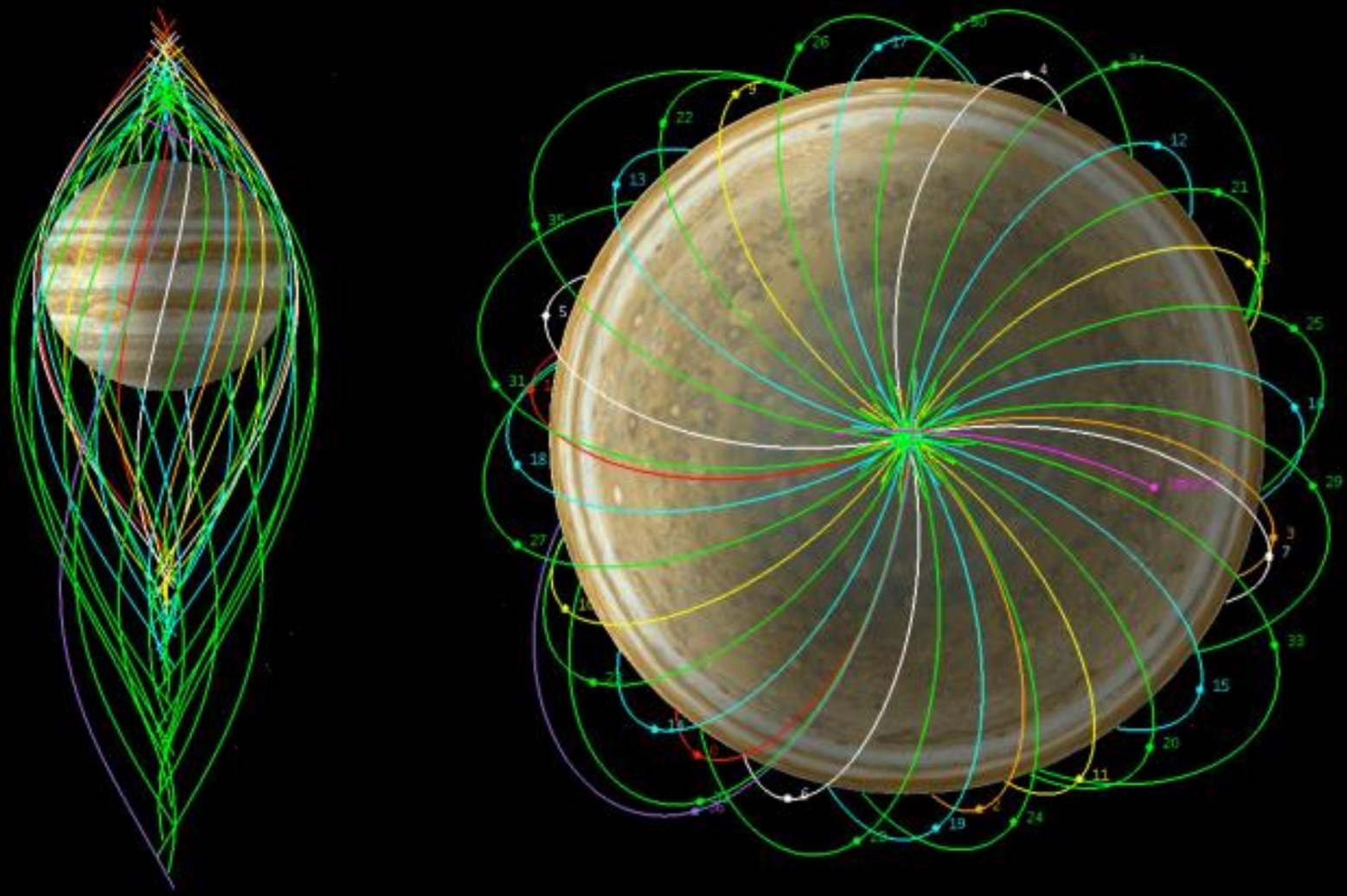
- Radiometry investigates atmospheric structure.
- Gravity investigates differential rotation.



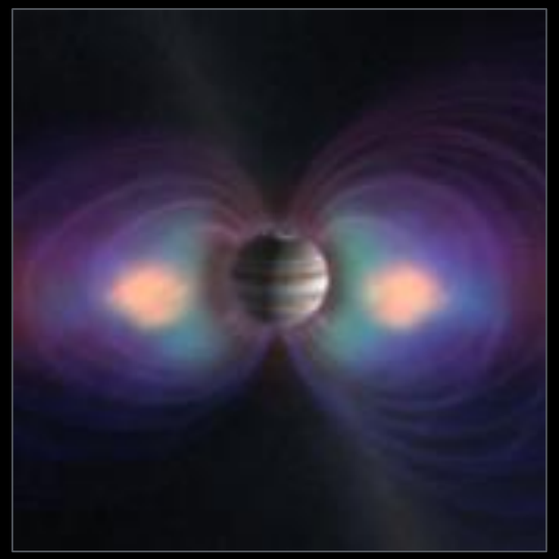


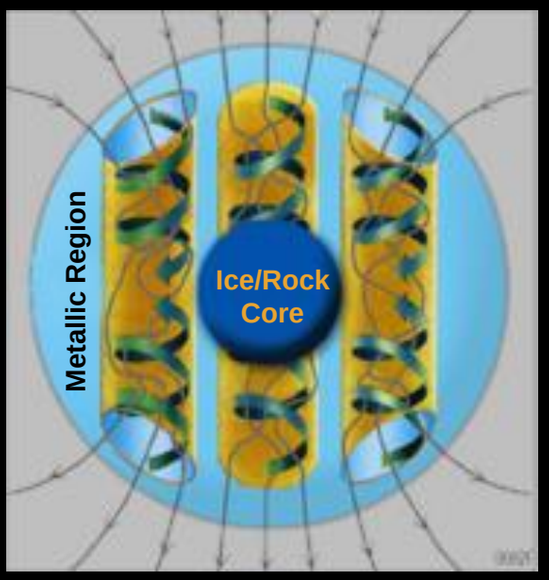
Mapping Jupiter’s Magnetic Field

- Jupiter’s magnetic field, generated by a liquid metallic hydrogen ocean, lets us probe deep inside the planet.
- Juno’s polar orbit provides complete mapping of the powerful magnetic field.



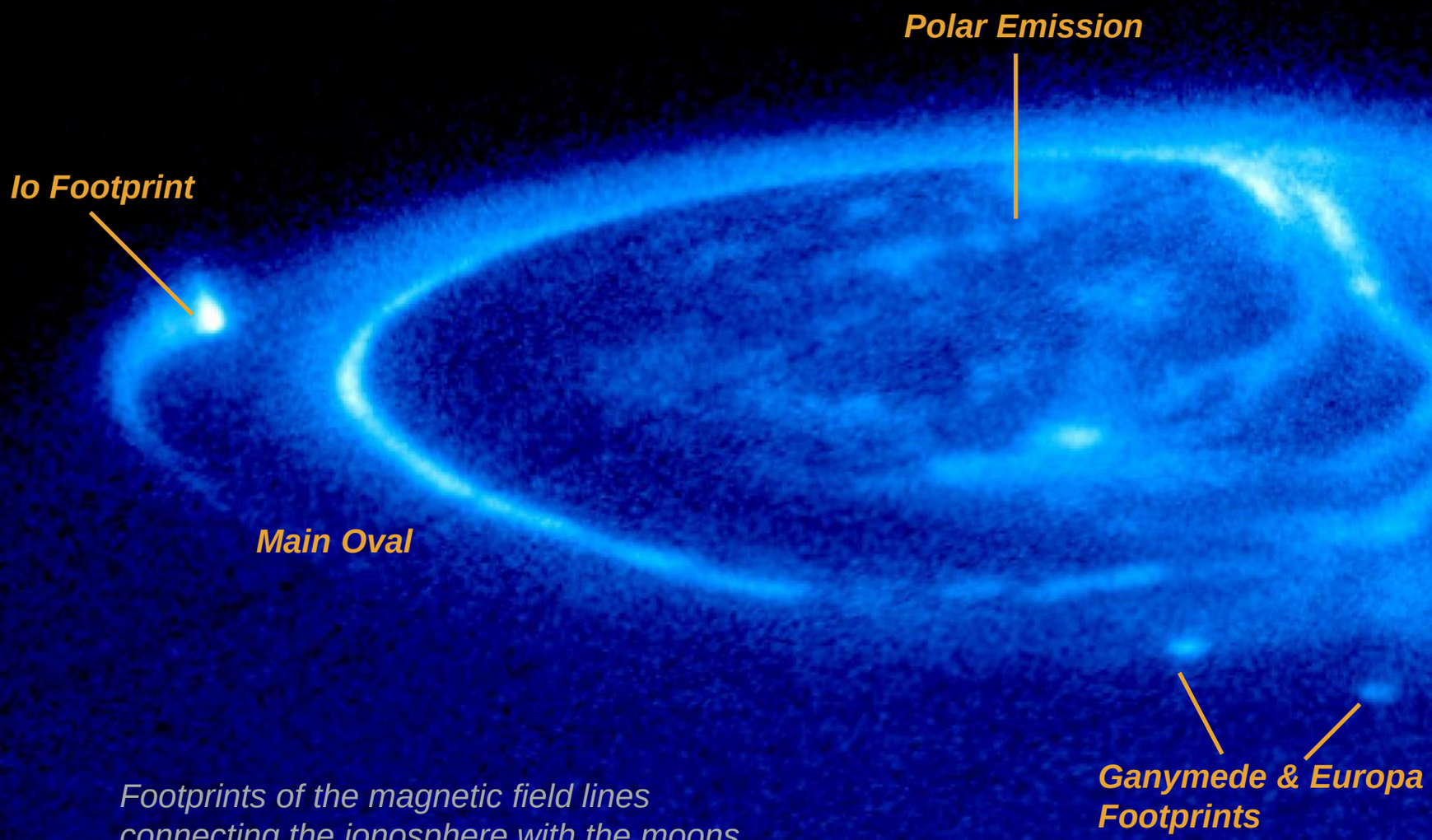
Juno orbits Jupiter every 2 weeks





Exploring the Polar Magnetosphere

- Jupiter’s magnetosphere near the planet’s poles is a completely unexplored region.
- Juno’s investigation will provide new insights about how the planet’s enormous magnetic force field generates the aurora.



Footprints of the magnetic field lines connecting the ionosphere with the moons.

End of Mission

- After 20 months at Jupiter and 37 orbits, 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 will be deorbited into Jupiter.
- The deorbit trajectory in February 2018 will ensure that Juno will not impact any of the icy moons.

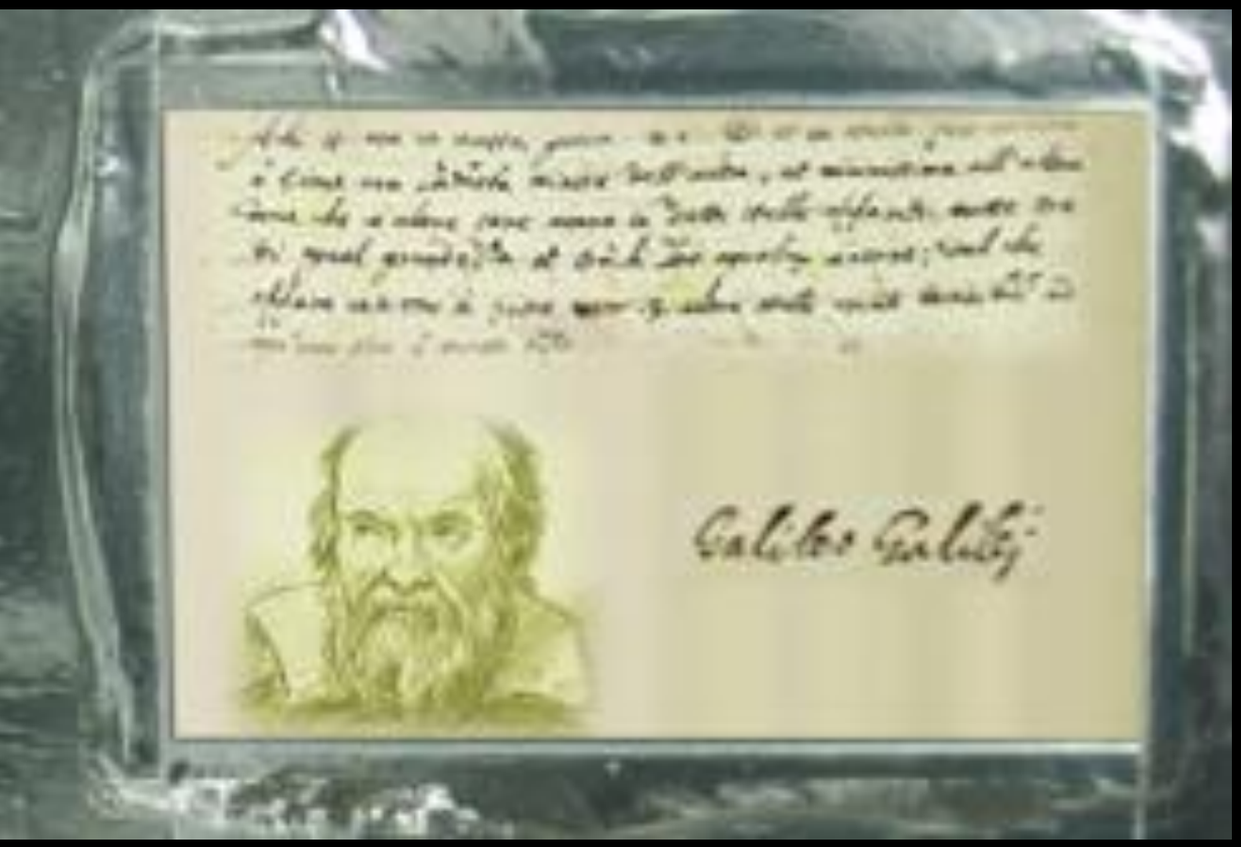
Public Participation

“Science in a Fishbowl”

http://missionjuno.swri.edu — click on “Junocam”

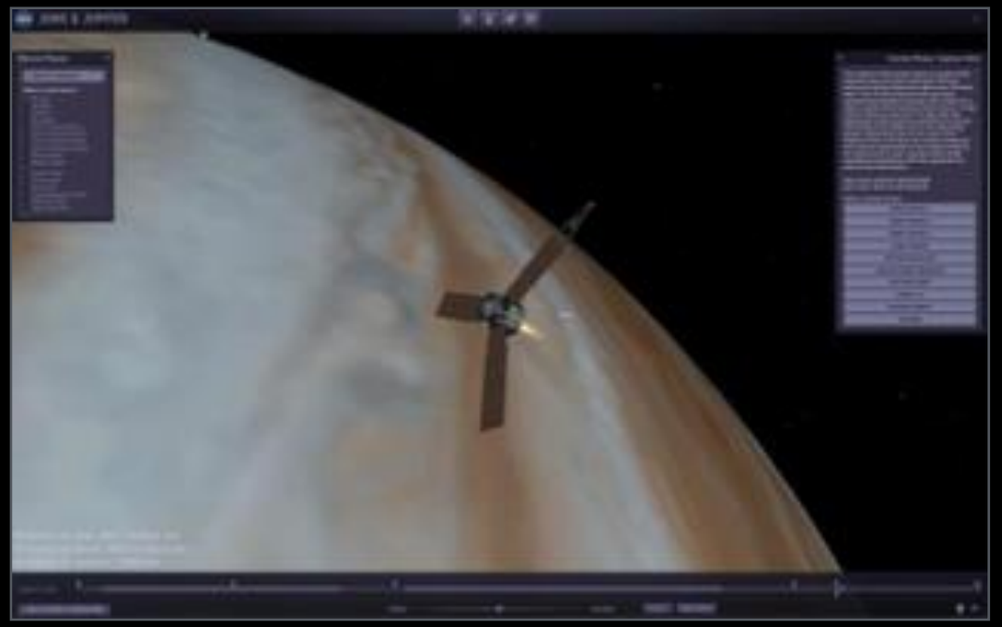
Juno’s Special Passengers

- A plaque honoring Galileo Galilei features a self-portrait and a description of Jupiter and its four largest moons he wrote in 1610.
- Three LEGO figures representing Galileo and the Roman god Jupiter and his wife Juno rode along, too.



Fly Along with Juno

Juno is part of NASA's 3D interactive, *Eyes on the Solar System*



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