

Planetary exploration



Jonathan Nichols

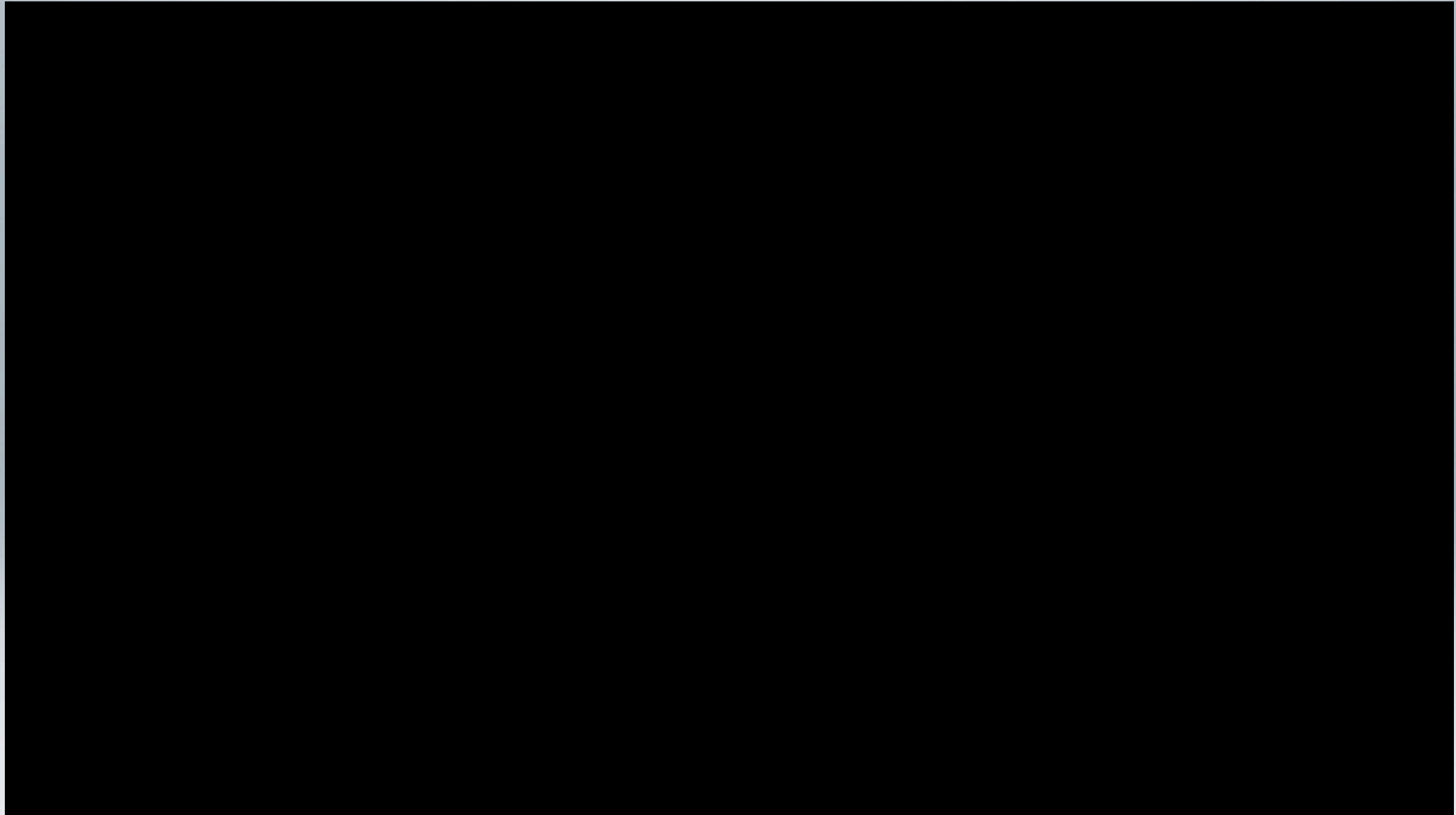
STFC Introductory Astronomy Course

University of Sussex, 6 Sept 2012



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Leicester**

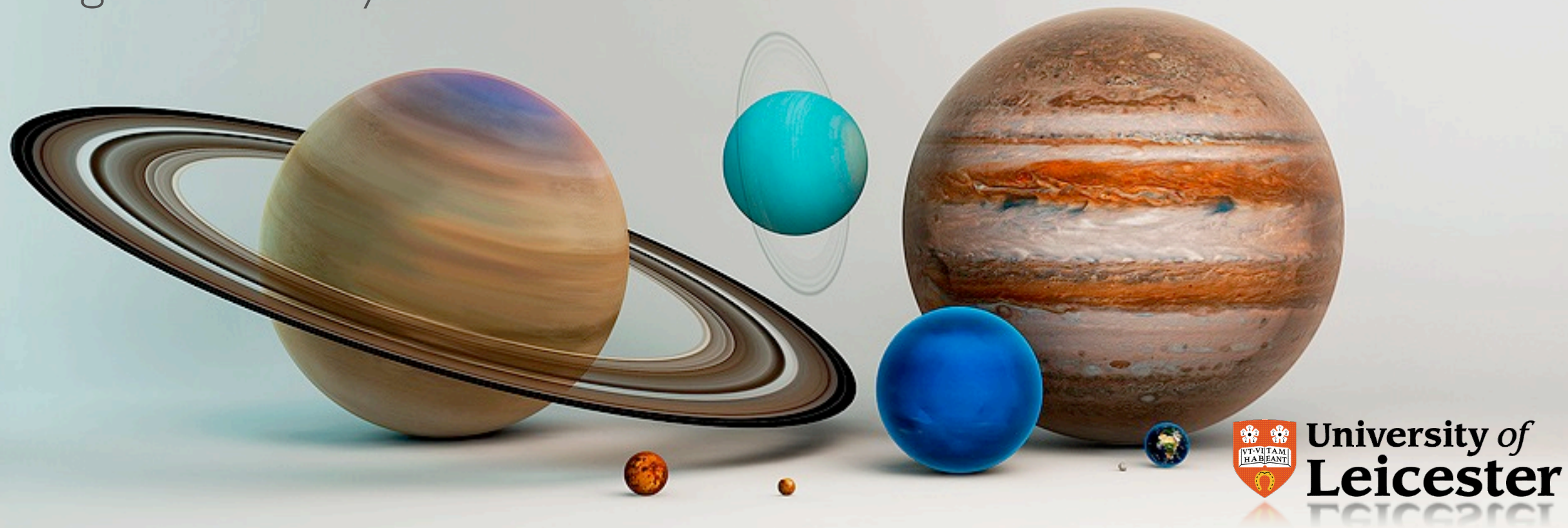
Earth is a planet...



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Why explore the solar system?

1. What controls the properties and evolution of stars including the Sun?
2. How do the Sun and other stars affect their environments?
3. How are stars born and how do planetary systems, including our own Solar System, form and evolve?
4. What is the extent of habitable environments and life in the Universe?
5. What fundamental processes operate in astrophysical sources, including the Solar System?



How can we explore the planets?

How can we explore the planets?

Earth-based
remote sensing



How can we explore the planets?

Earth-based
remote sensing



Spacecraft
flyby or
orbiter



How can we explore the planets?

Earth-based
remote sensing



Spacecraft
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orbiter



Atmospheric
probe

How can we explore the planets?

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Spacecraft
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Atmospheric
probe



Robotic
lander

How can we explore the planets?

Earth-based
remote sensing



Spacecraft
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Atmospheric
probe



Robotic
lander



Manned
exploration

How can we explore the planets?

Earth-based
remote sensing



Spacecraft
flyby or
orbiter



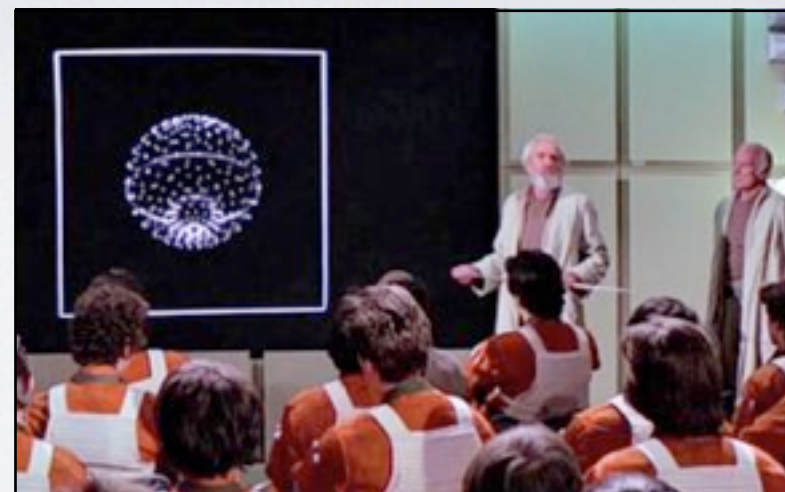
Atmospheric
probe



Robotic
lander

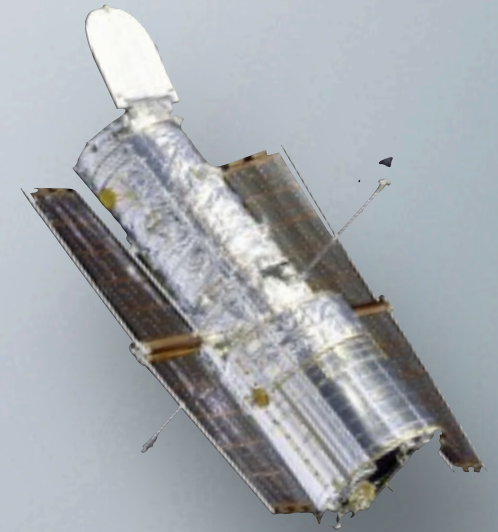


Manned
exploration



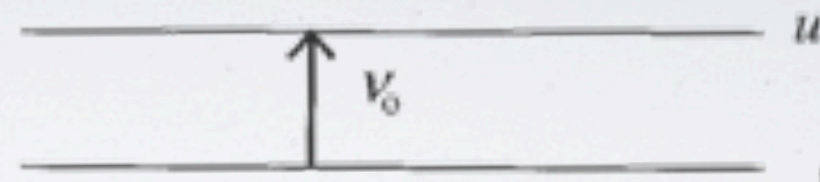
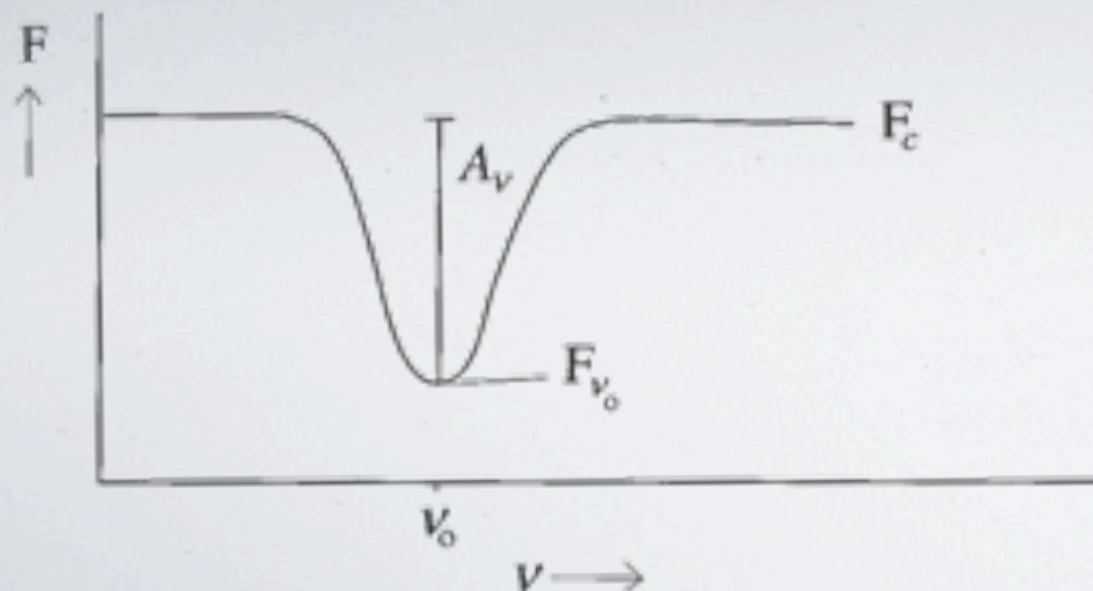
Theoretical
modelling

Remote sensing - spectra



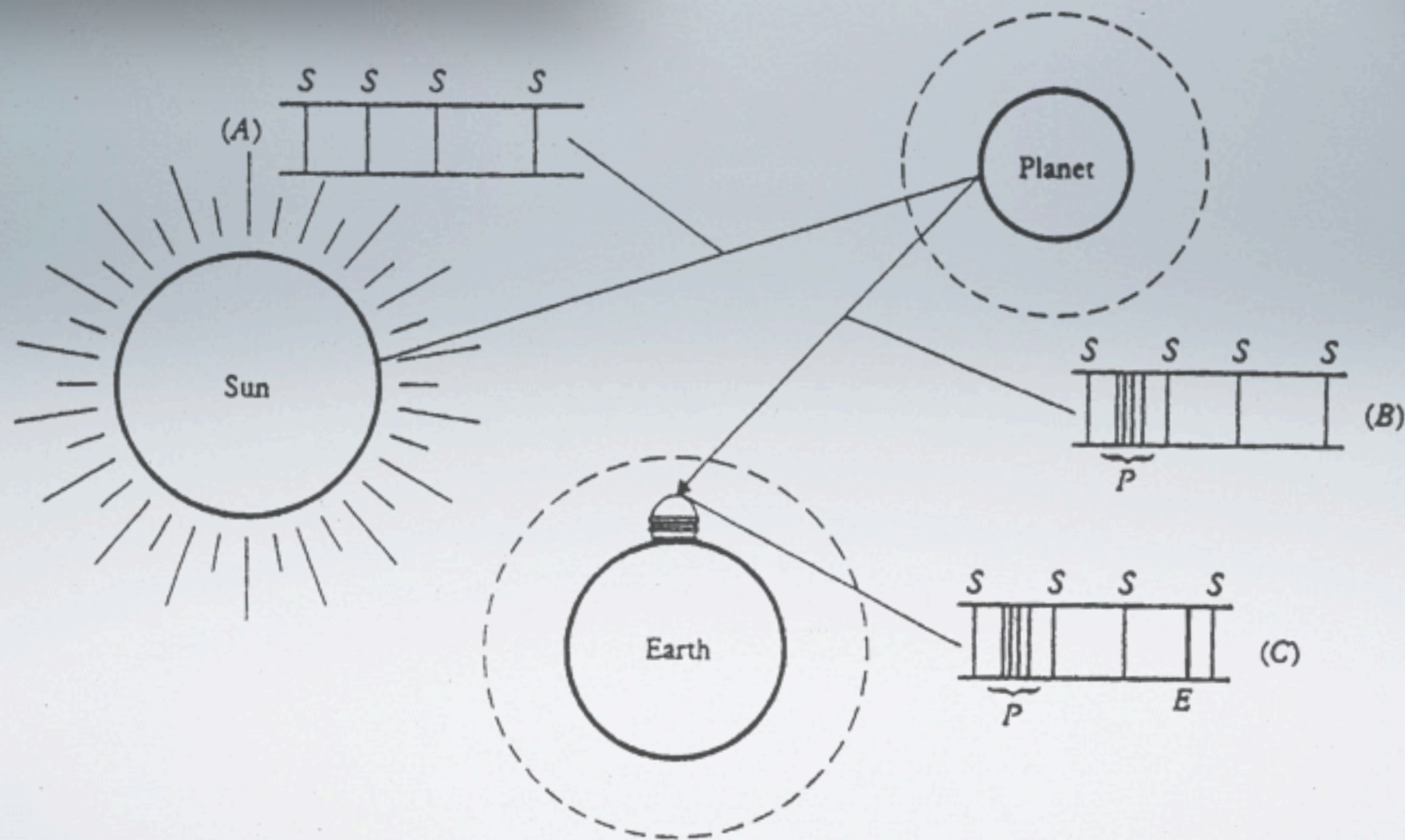
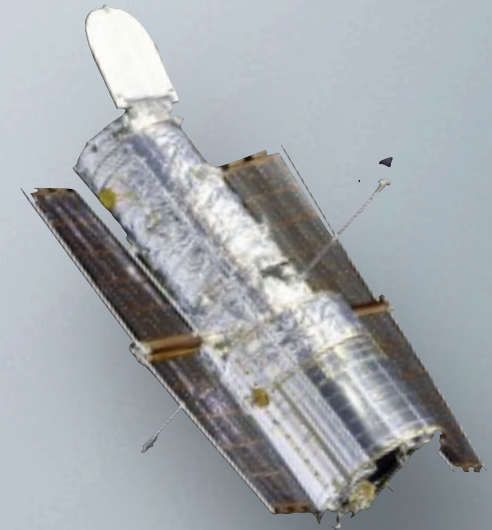
Each line is associated with an atomic or molecular transition between energy levels

Shape of line depends on abundance, pressure, temperature

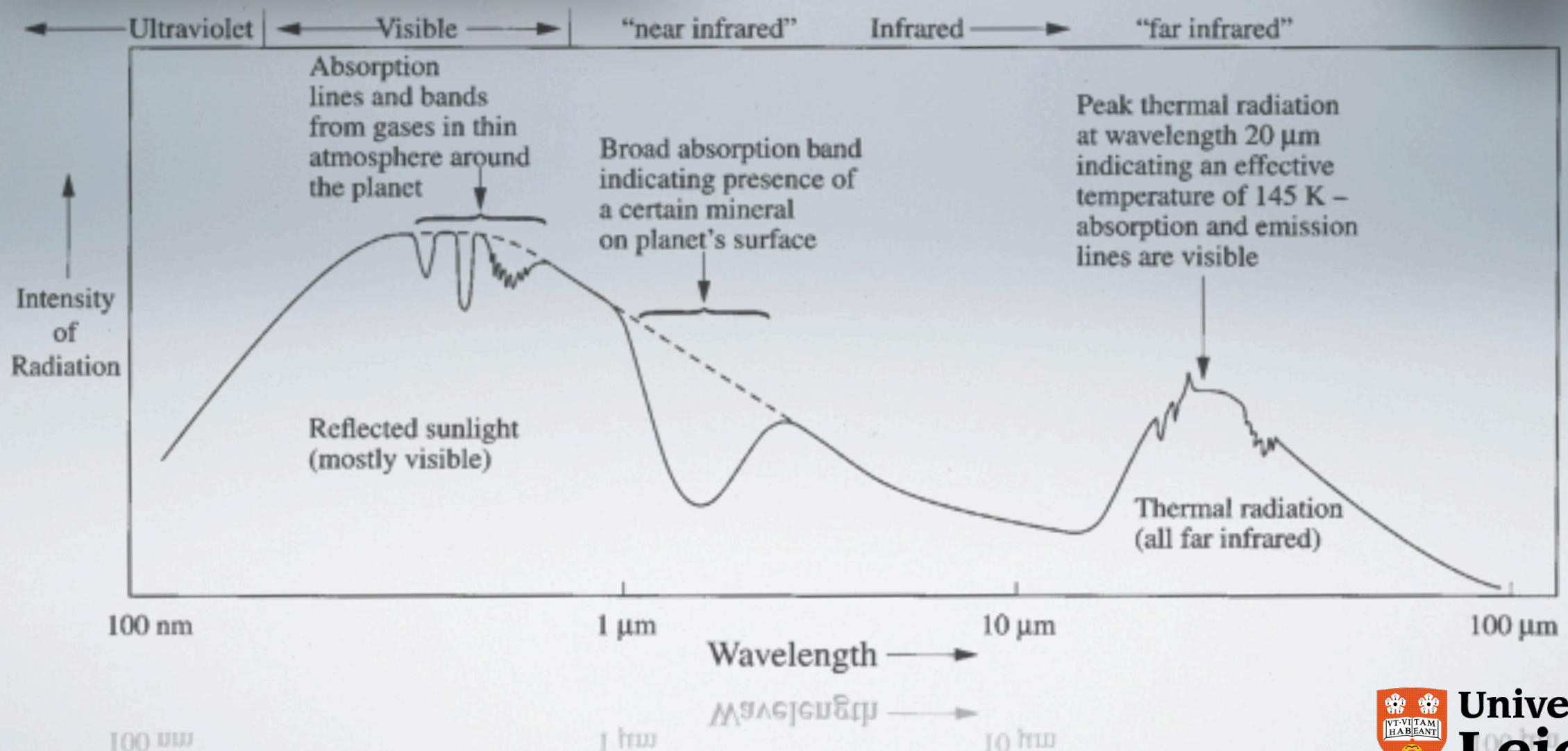
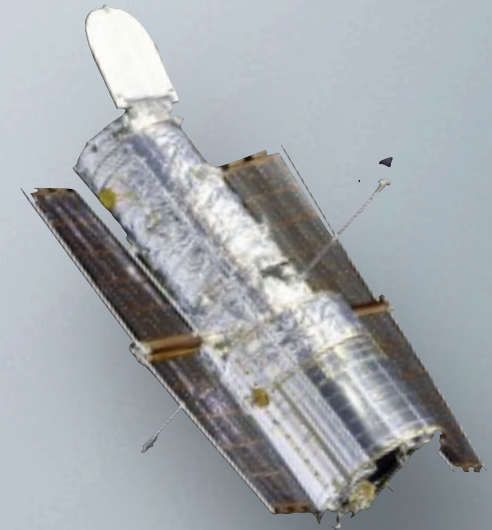


Absorbing atom,
energy levels u, l

Remote sensing - spectra

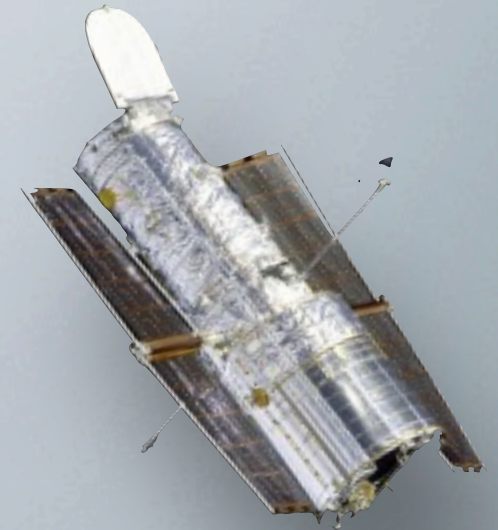


Remote sensing - spectra



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Remote sensing - spectra



Electronic excitation of atoms/molecules

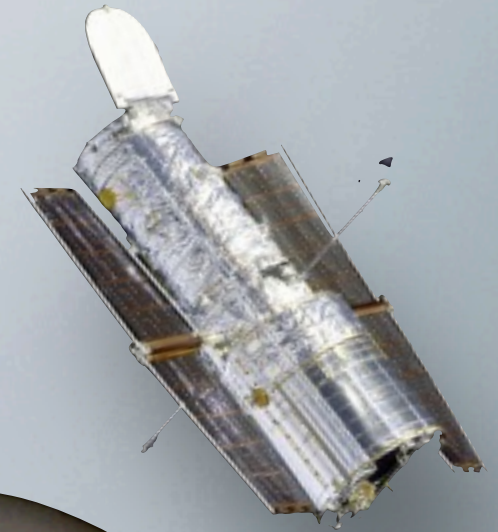
→ primarily visible and UV

Atomic vibration → IR and sub-millimetre

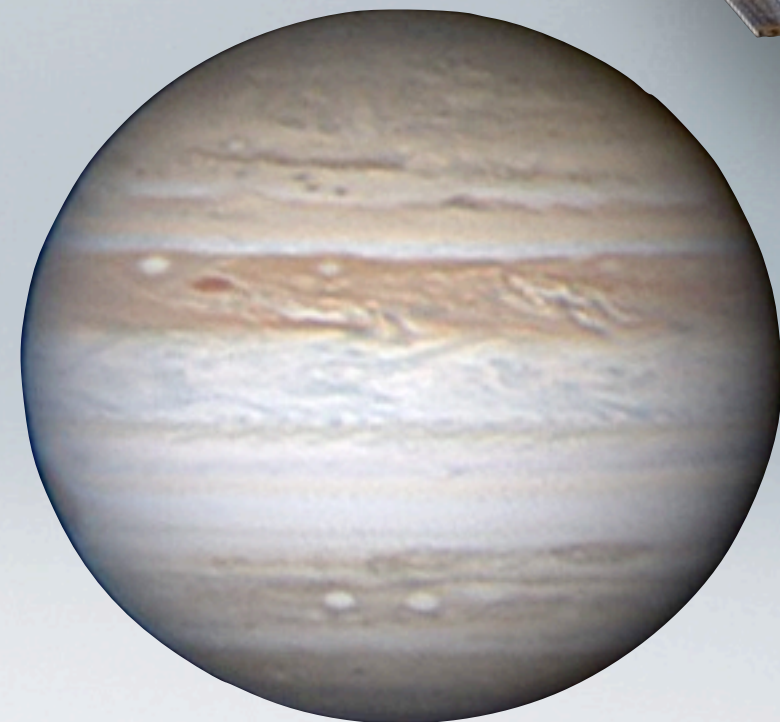
Rotation of molecules → radio

In general, the longer the wavelength the deeper the layer observed

Remote sensing - images

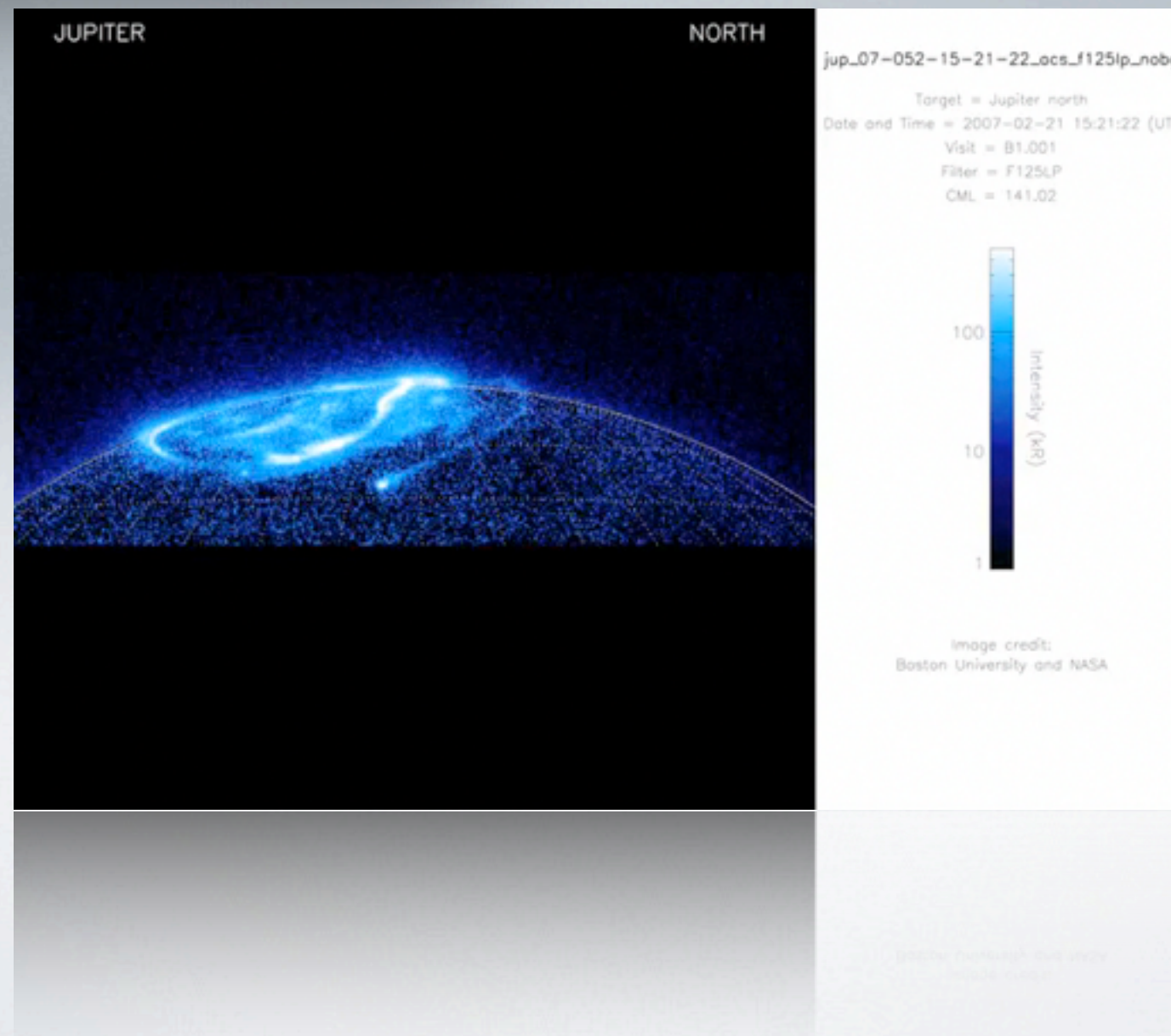
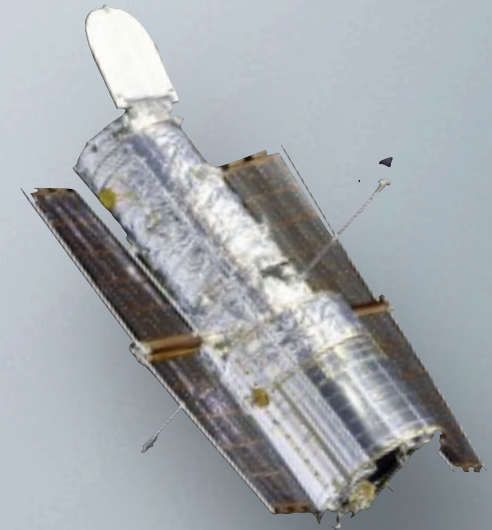


BEFORE: Aug 4 2009

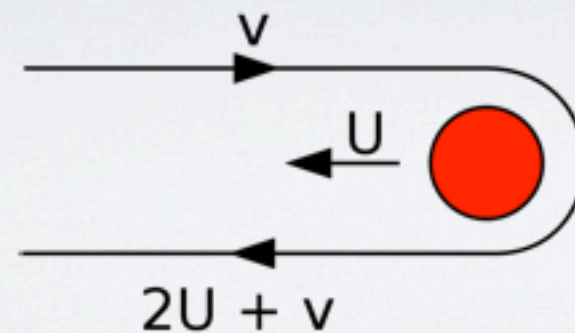
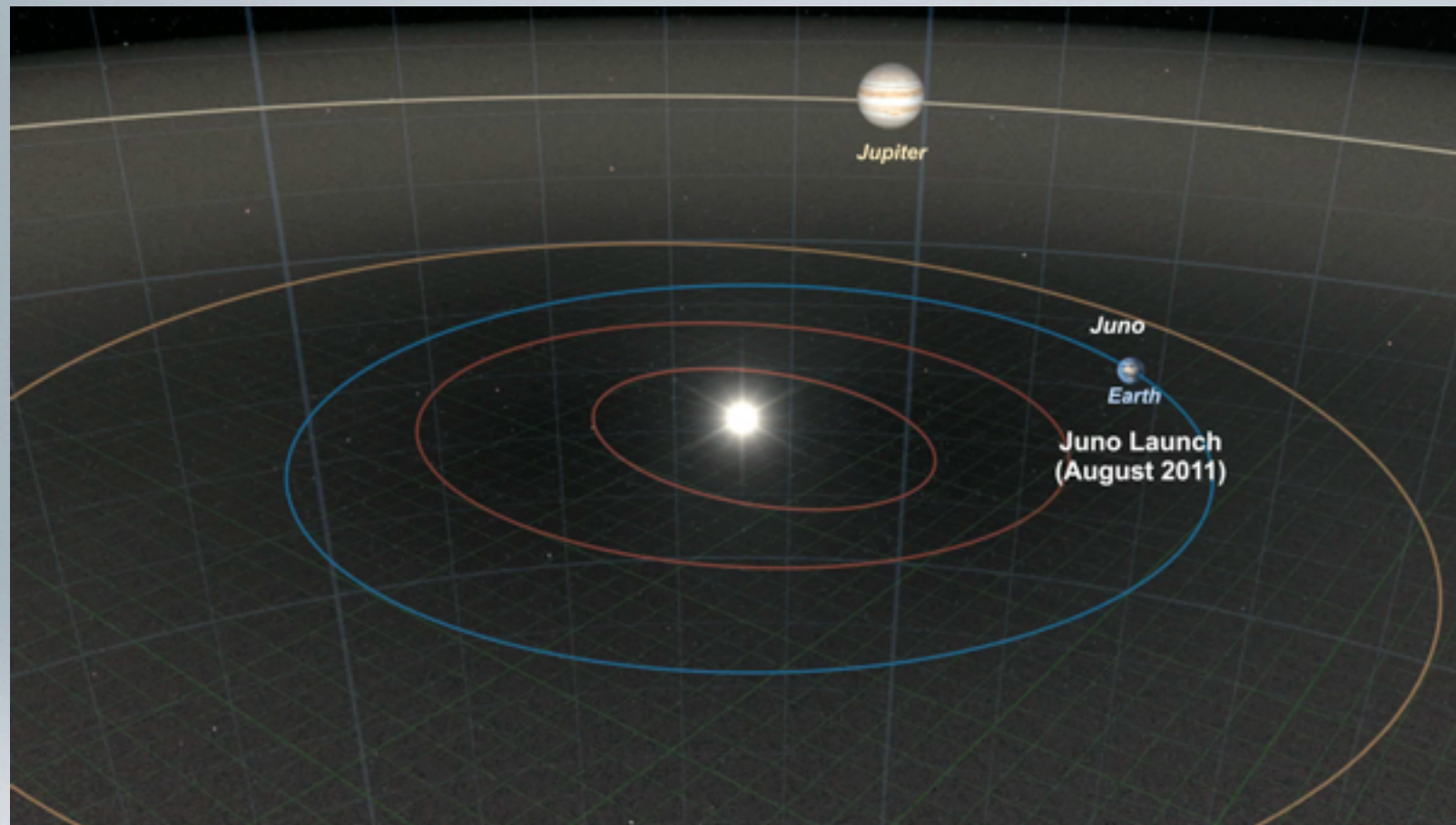


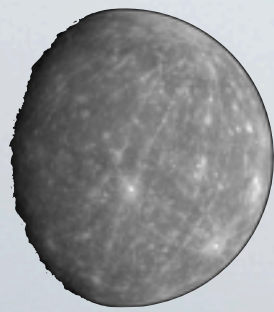
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Remote sensing - images

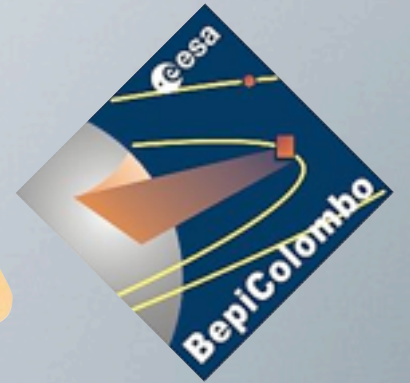


Gravity assists

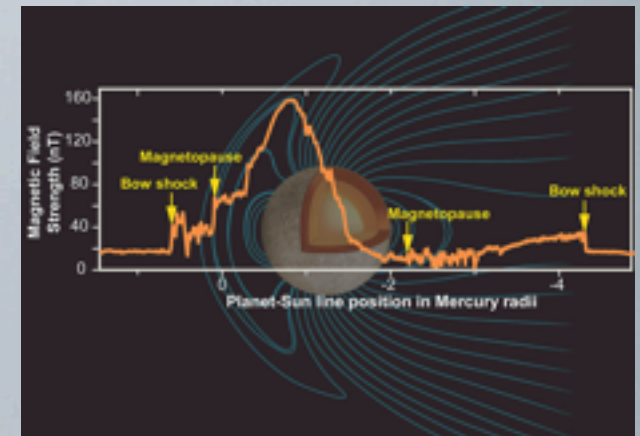




Mercury

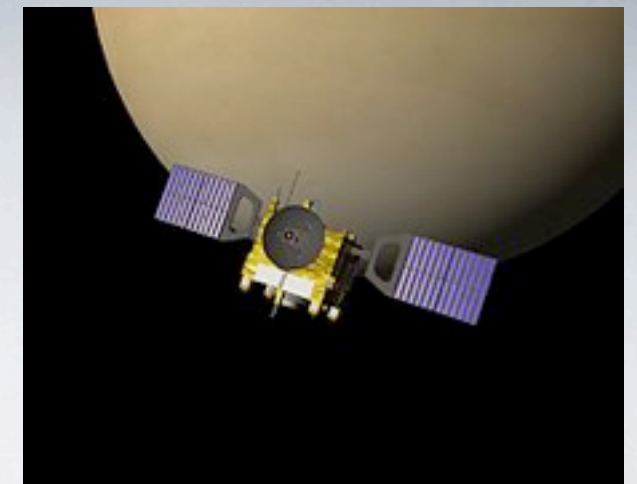


MESSENGER (NASA)
BepiColombo (ESA/JAXA)



Venus

Venus Express (ESA)





Mars

Mars Odyssey (NASA)

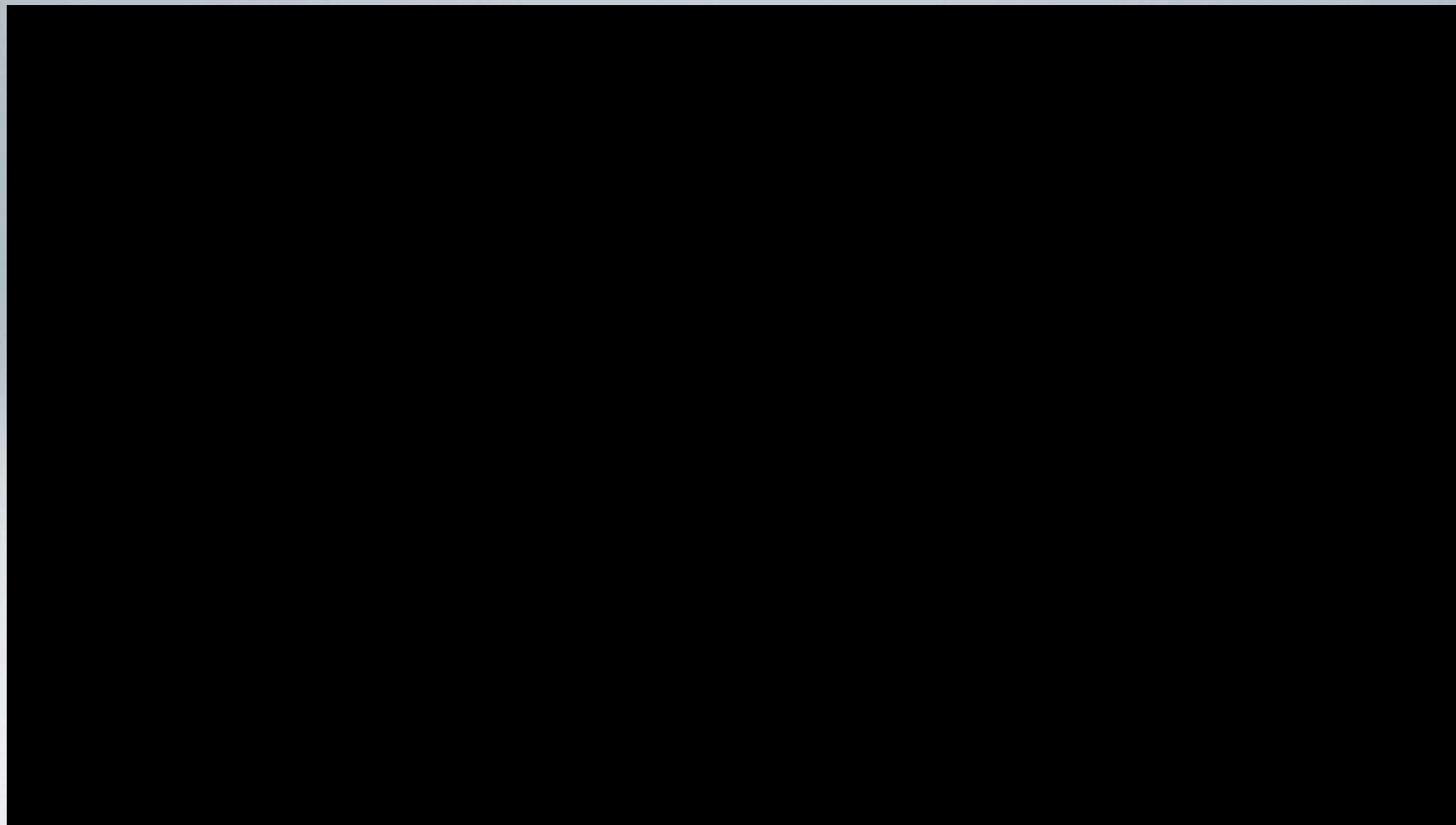
Mars Express (ESA)

Mars Reconnaissance Orbiter (NASA)

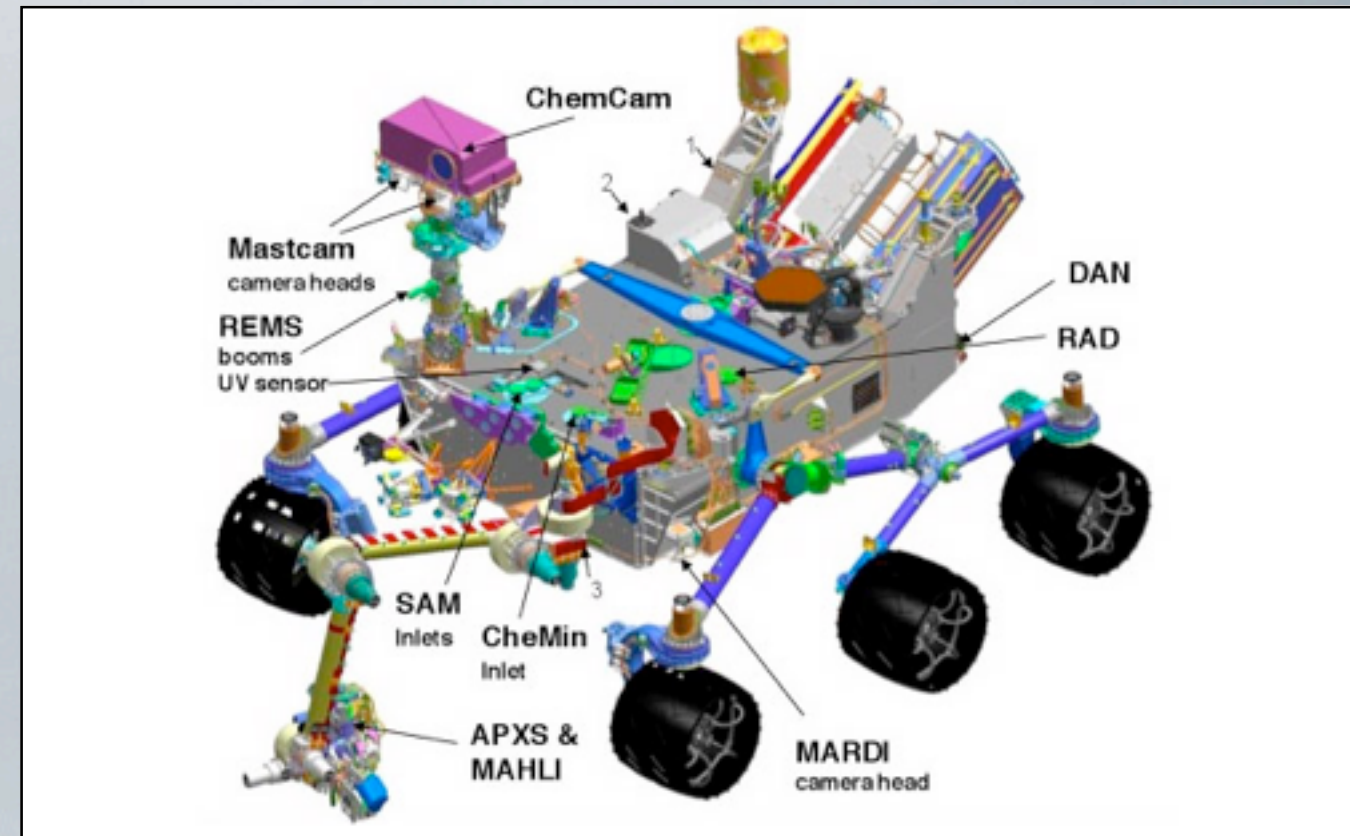
Mars Exploration Rover / Opportunity (NASA)

Mars Science Laboratory / Curiosity (NASA)

Curiosity lander payload



Curiosity lander payload



Mast Camera (Mastcam)

Mars Hand Lens Imager (MAHLI)

Mars Descent Imager (MARDI)

Alpha Particle X-Ray Spectrometer (APXS)

Chemistry & Camera (ChemCam)

Chemistry & Mineralogy X-Ray Diffraction/X-Ray Fluorescence Instrument (CheMin)

Sample Analysis at Mars (SAM) Instrument Suite

Radiation Assessment Detector (RAD)

Dynamic Albedo of Neutrons (DAN)

Rover Environmental Monitoring Station (REMS)

Mars Science Laboratory Entry Descent and Landing Instrument (MEDLI)



Jupiter

Juno (NASA)

JUICE (hopefully to be renamed to e.g. Laplace) (ESA)



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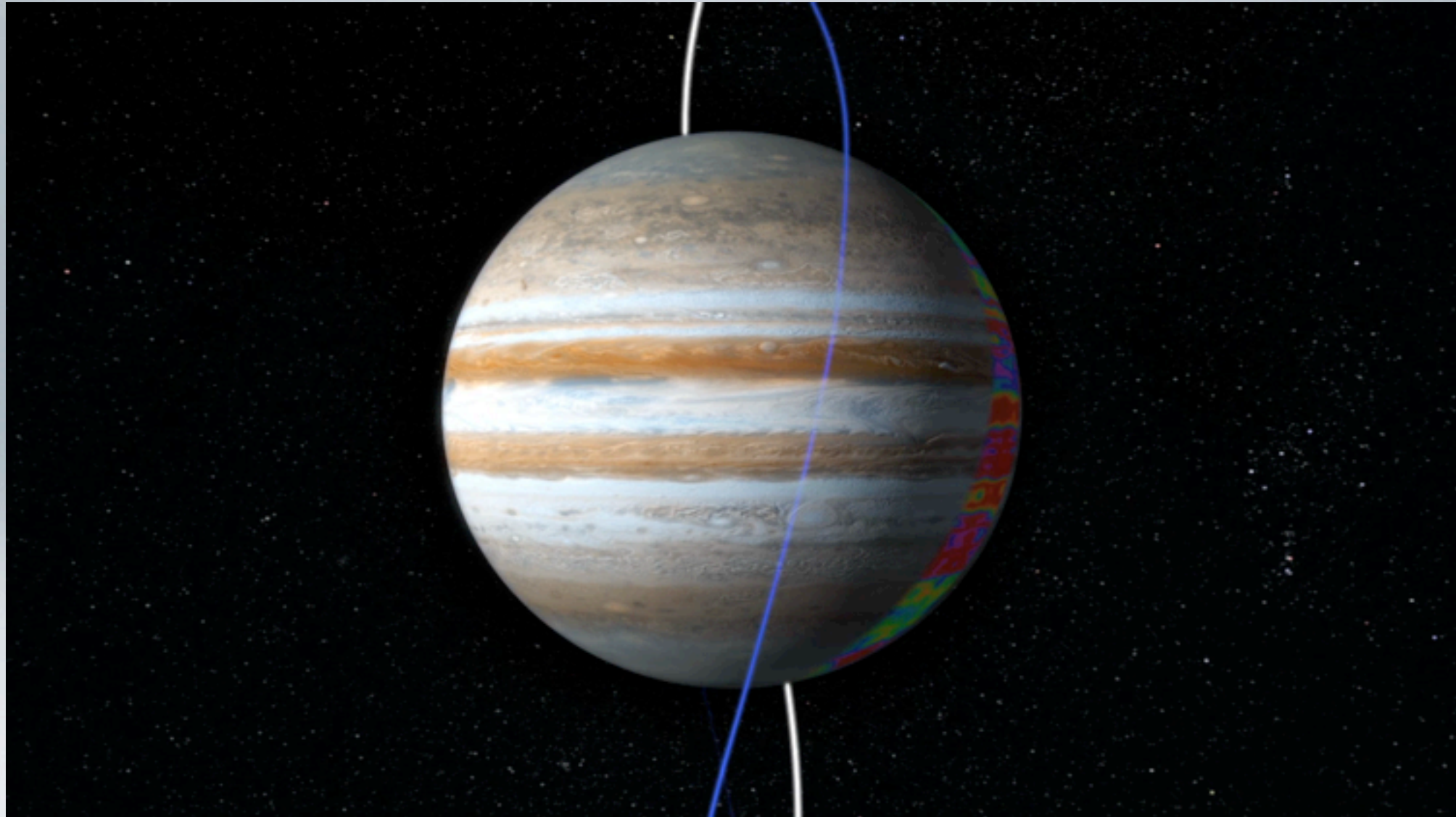


Jupiter





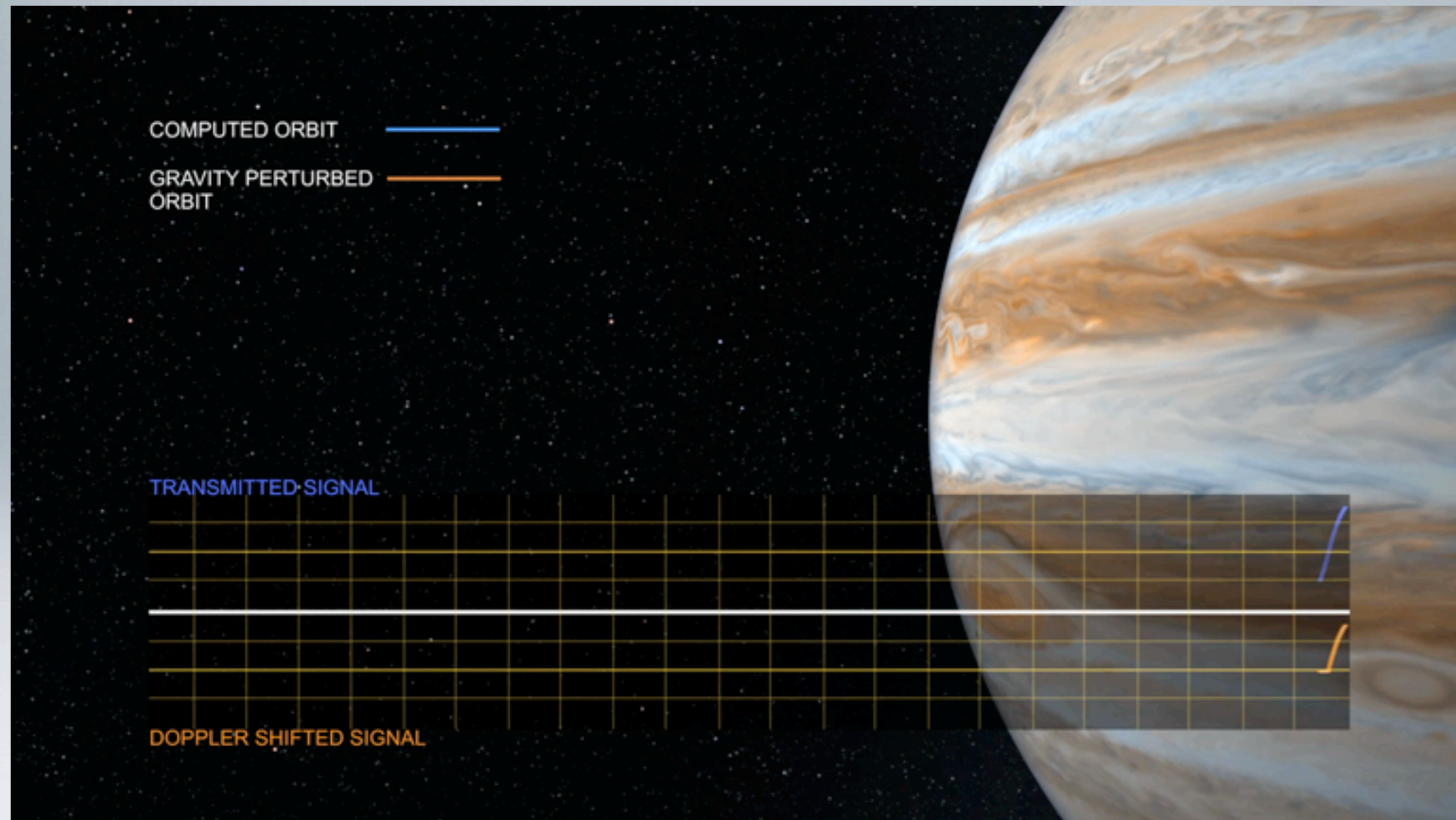
Jupiter



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Jupiter





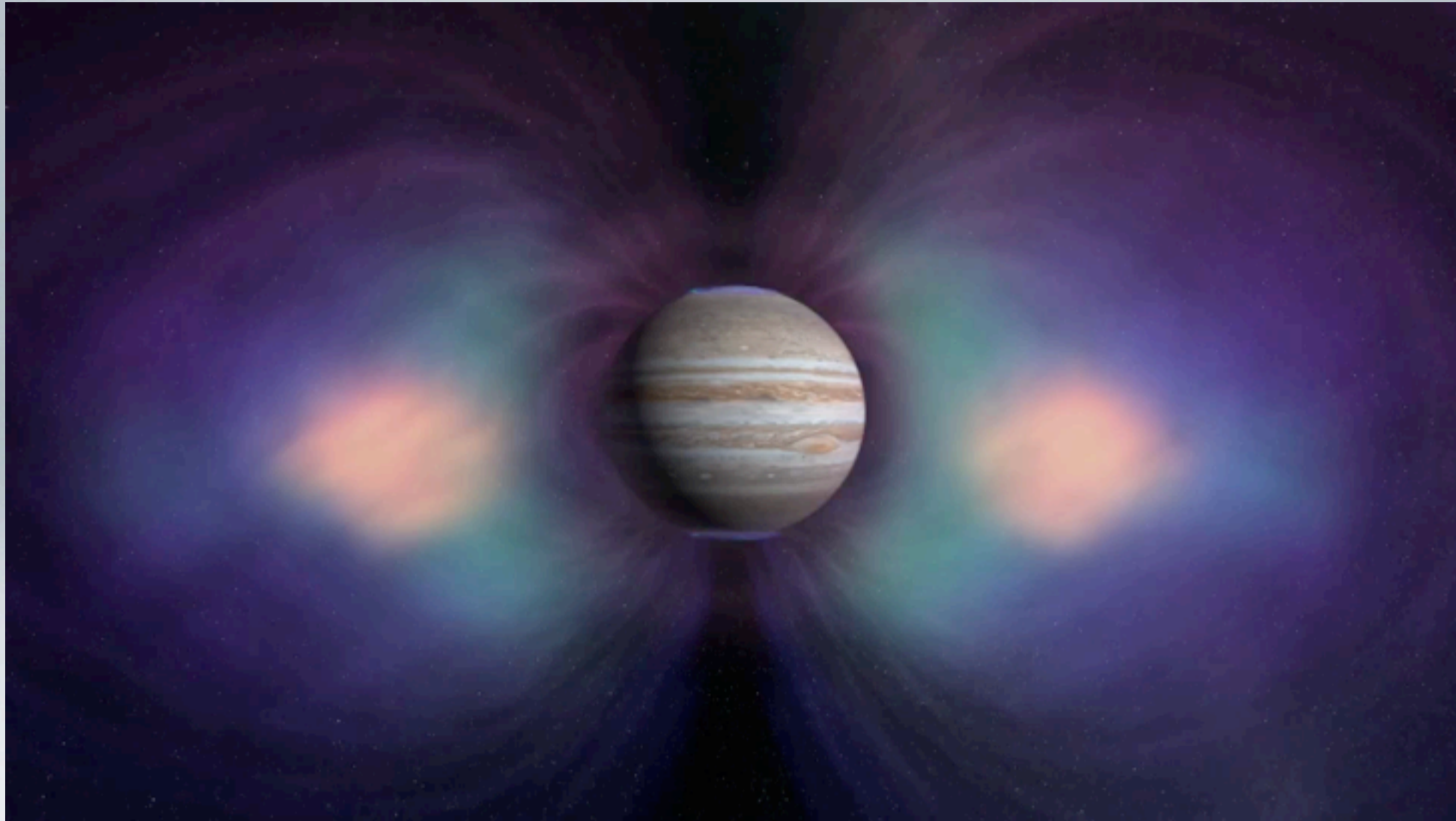
Jupiter



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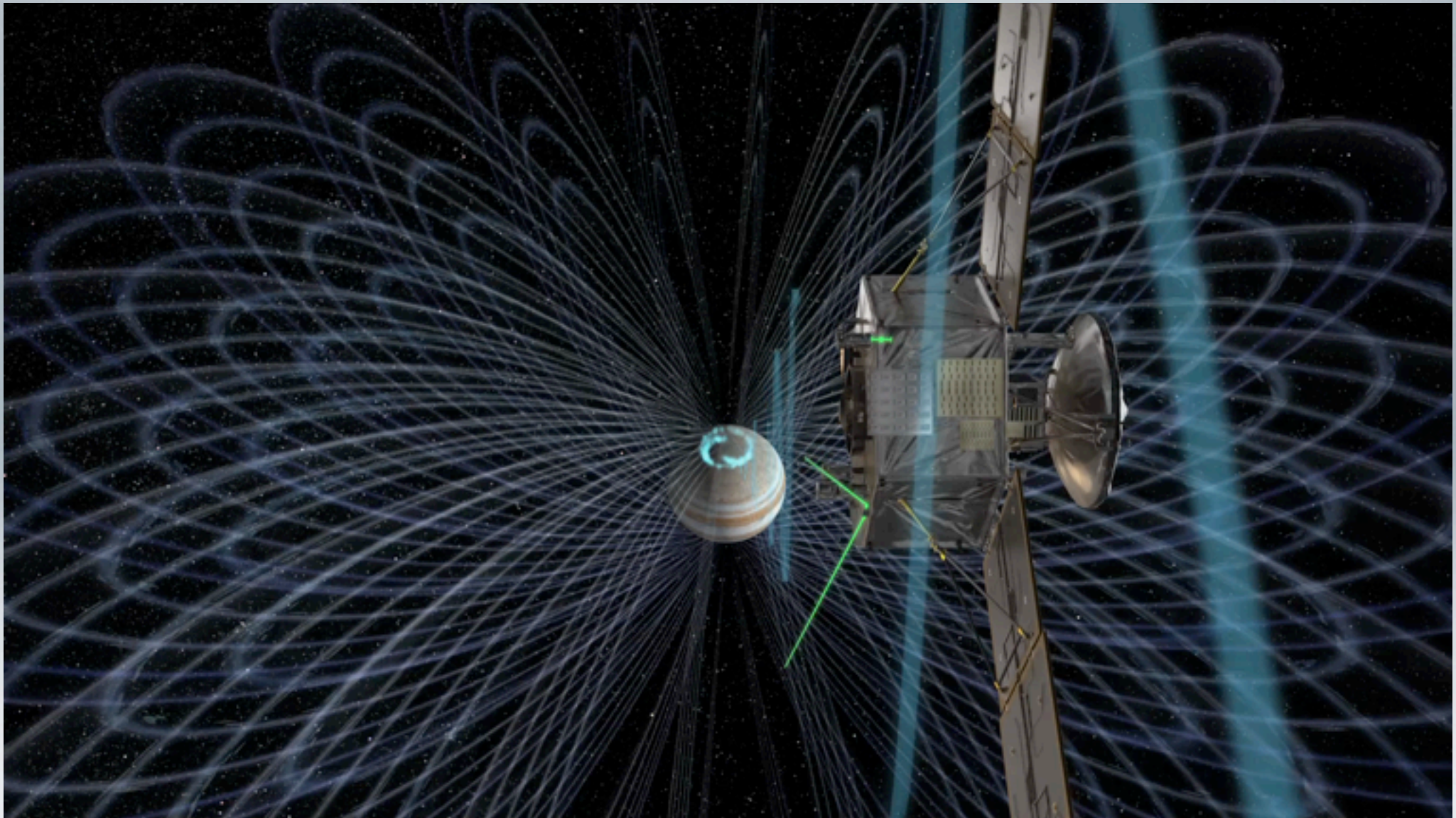
Jupiter



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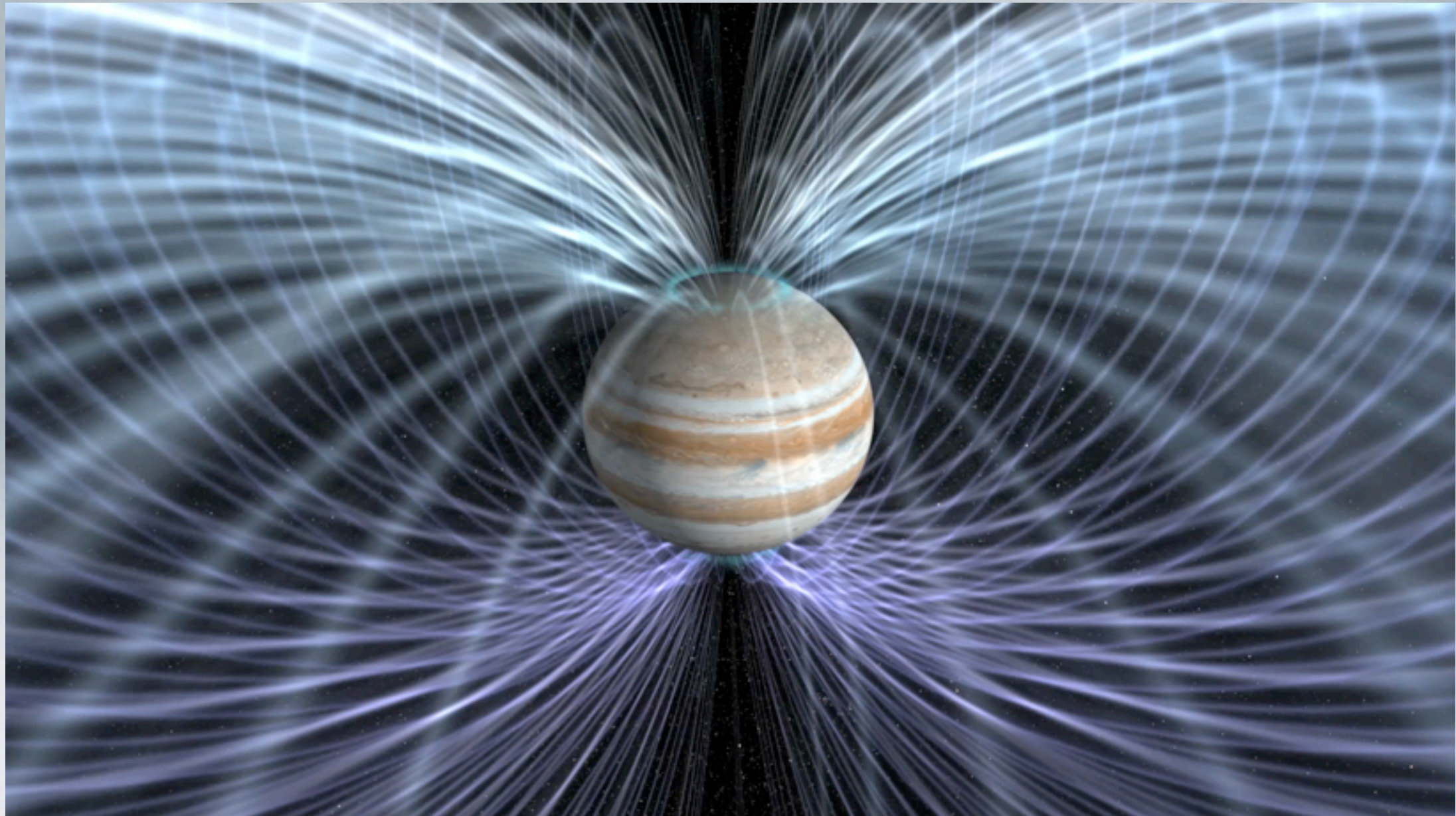
Jupiter



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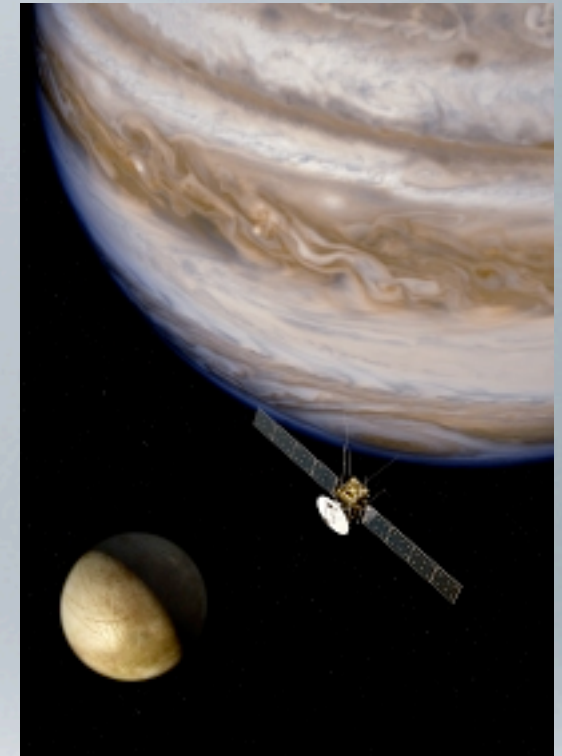


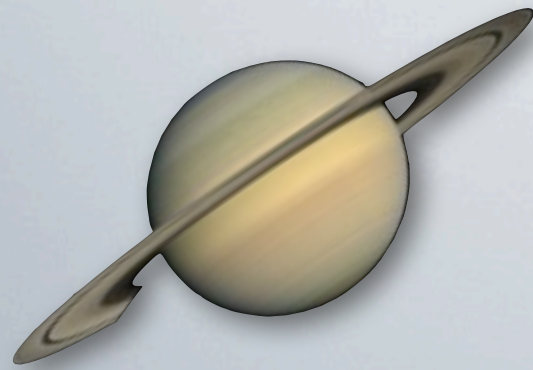
Jupiter



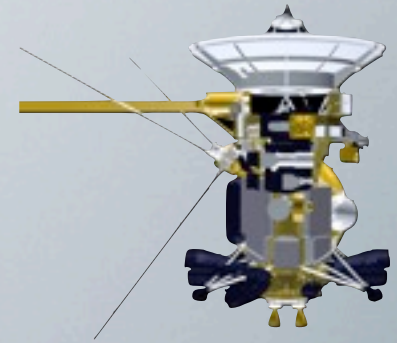
JUICE orbiter payload

Laser Altimeter
Radio Science Experiment
Ice Penetrating Radar
Visible-IR Imaging Spectrometer
Ultraviolet Imaging Spectrometer
Narrow Angle Camera
Wide Angle Camera
Magnetometer
Plasma Analyser
Energetic Particle Analyser
Neutral Ion Mass Spectrometer
Submillimetre Wave Instrument
Radio and Plasma Wave Instrument

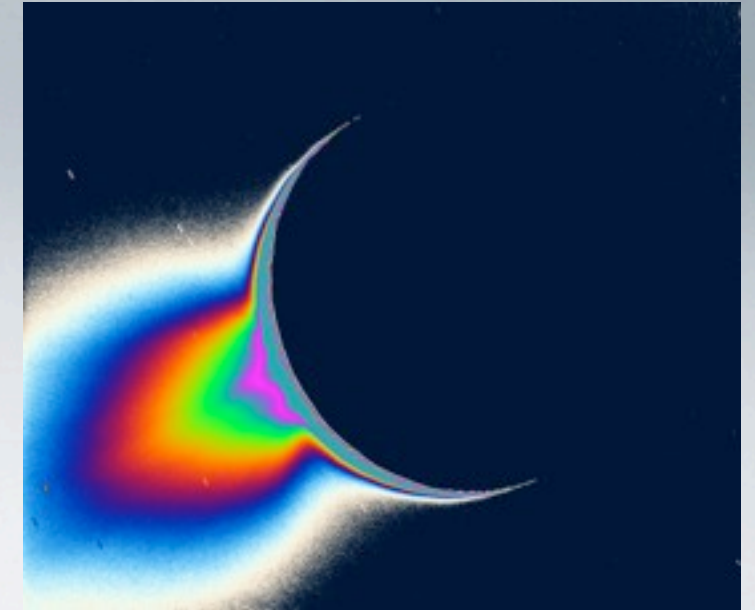
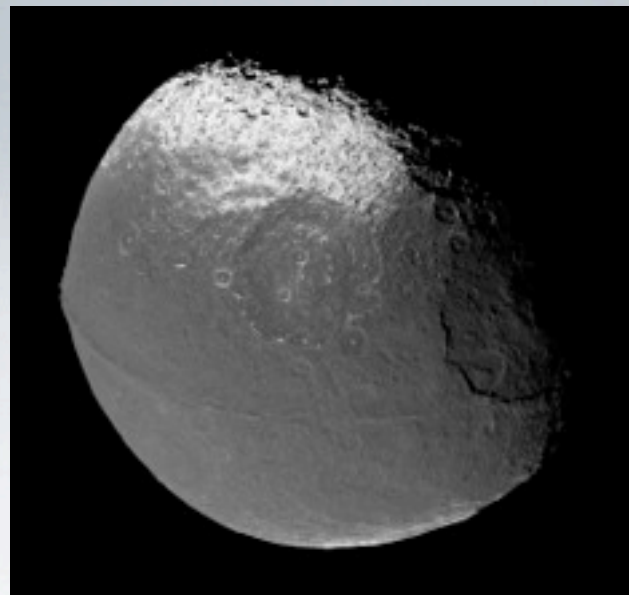
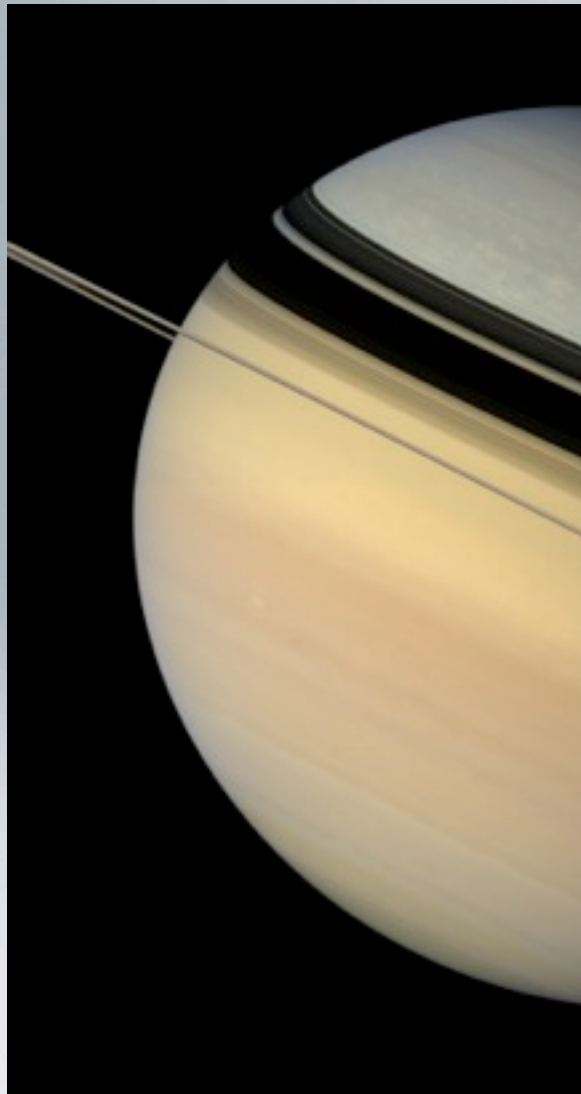


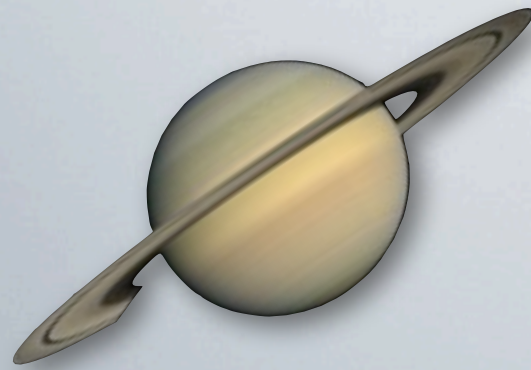


Saturn

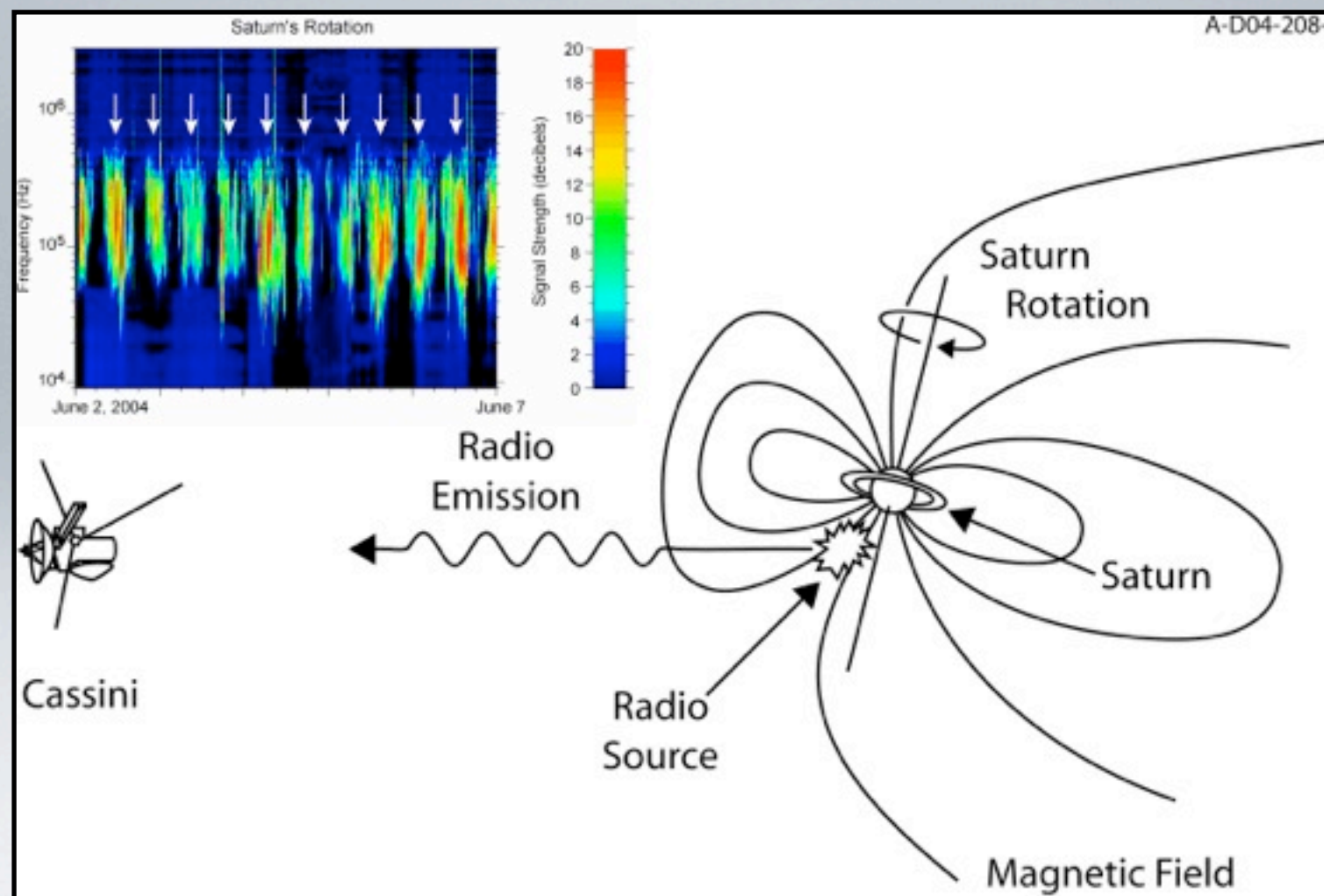
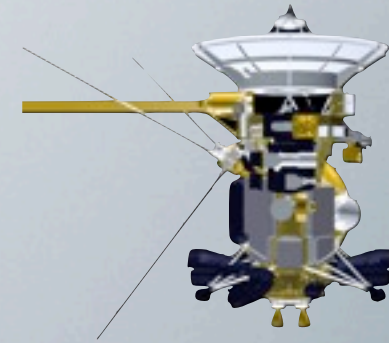


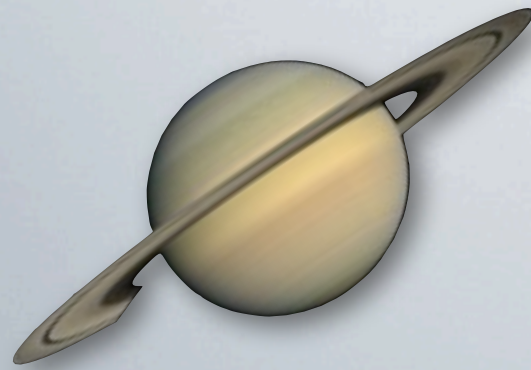
Cassini (NASA/ESA)



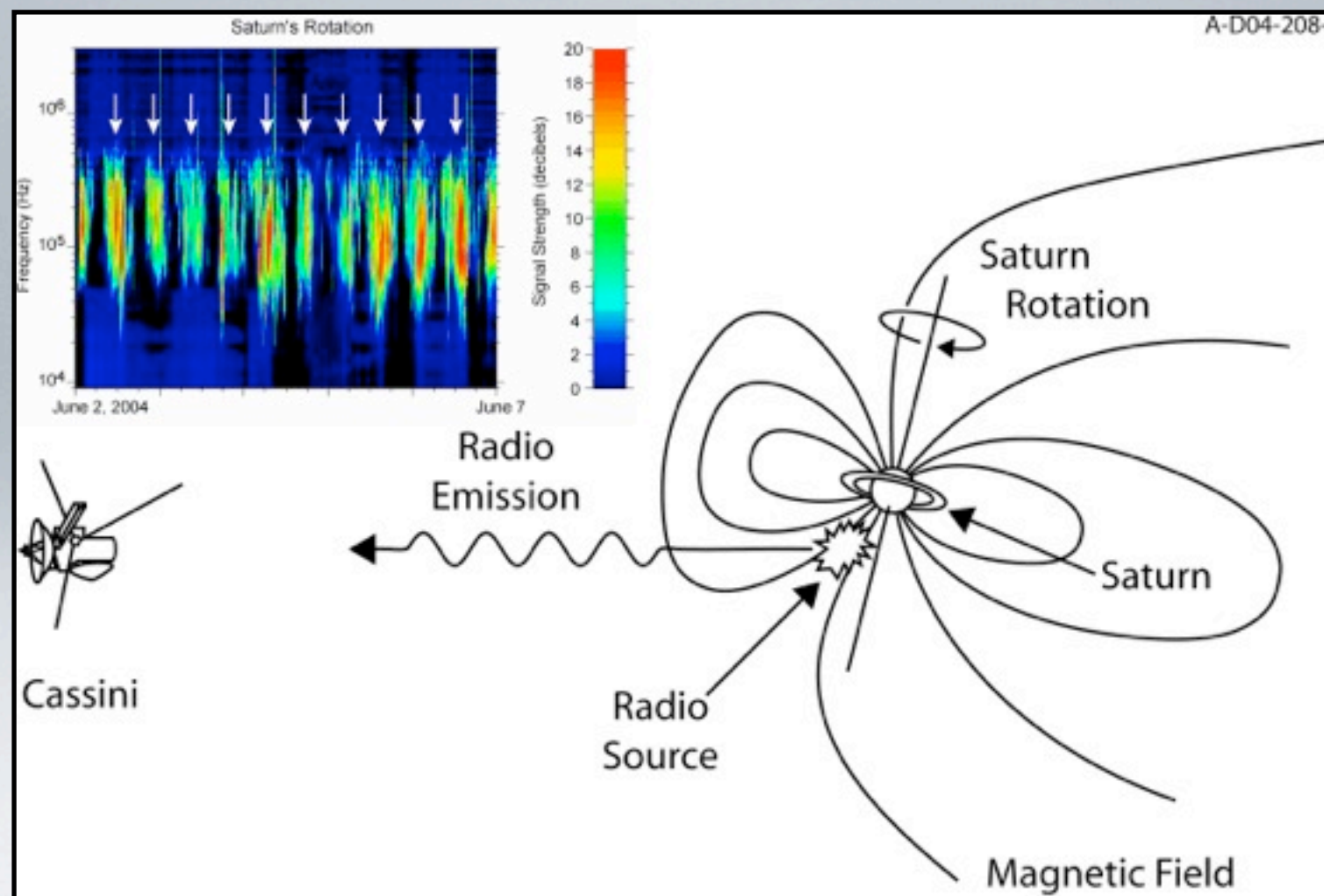
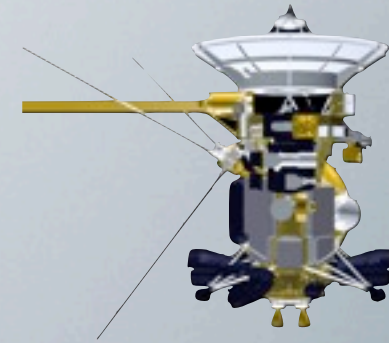


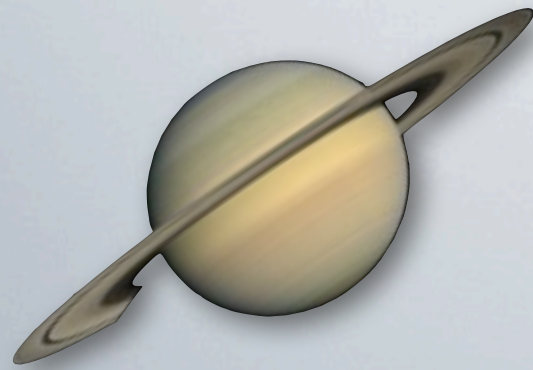
Saturn



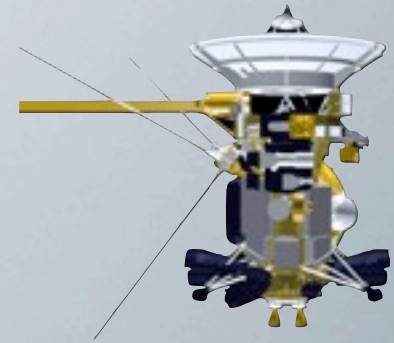


Saturn

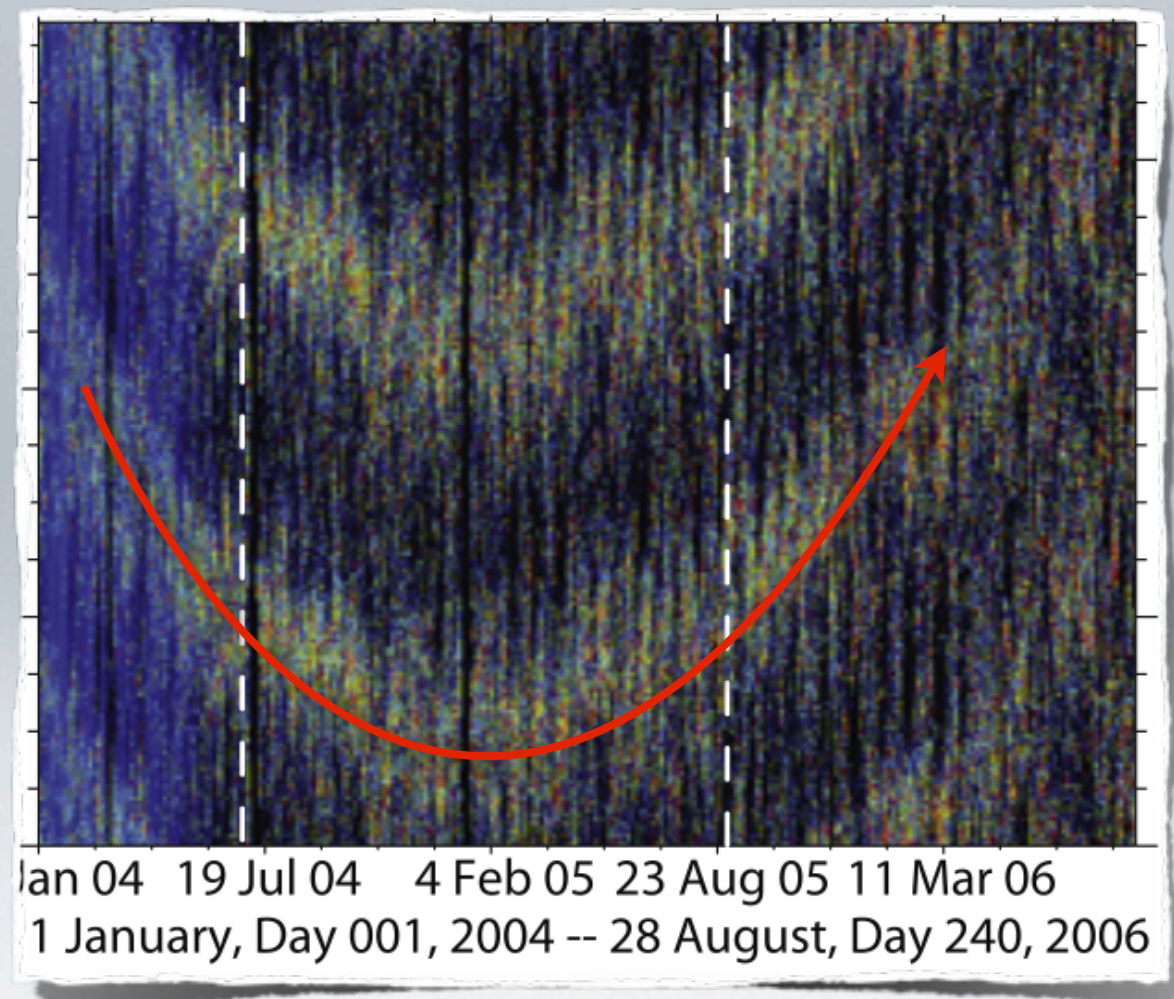




Saturn

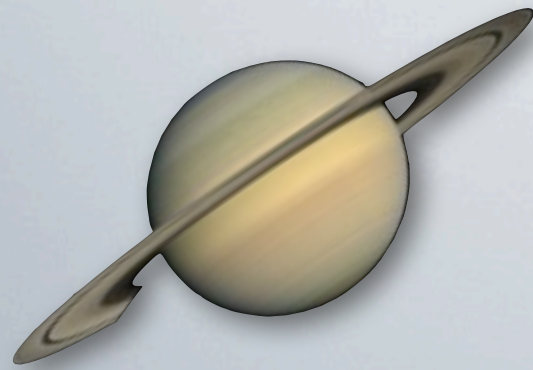


Saturn's Day
length

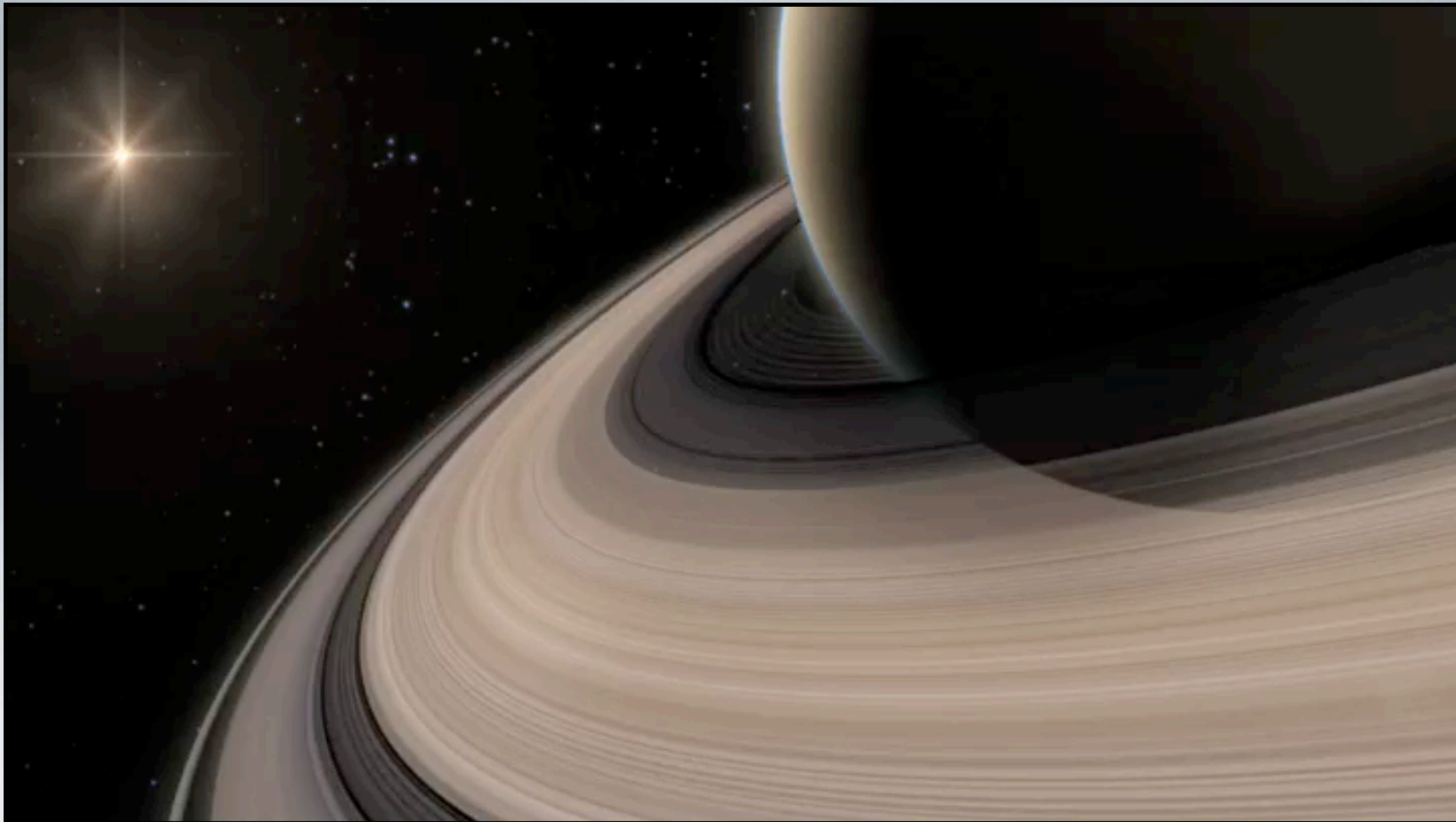
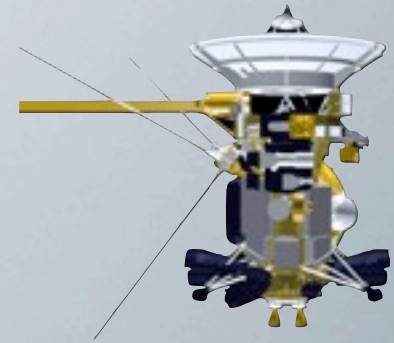


The culprit is
unknown

time



Saturn

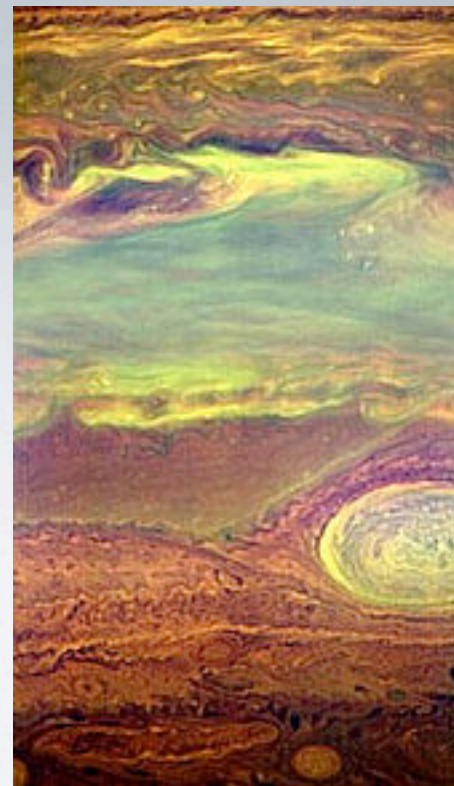
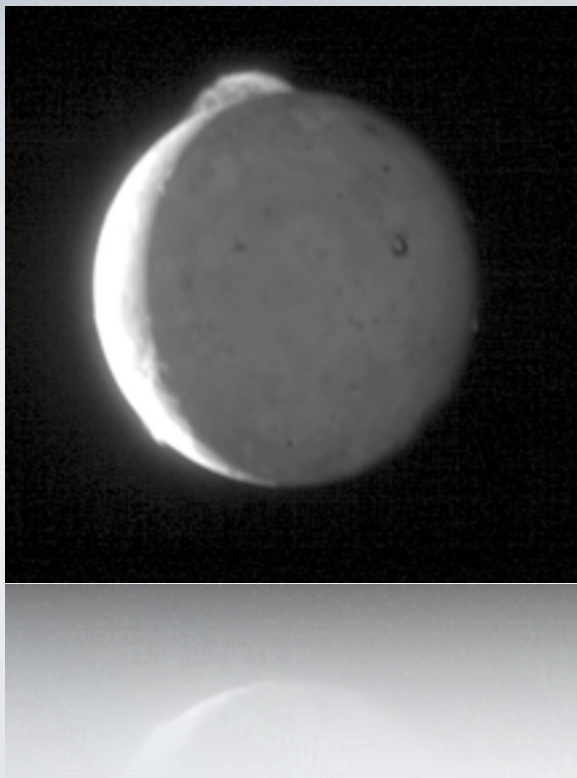


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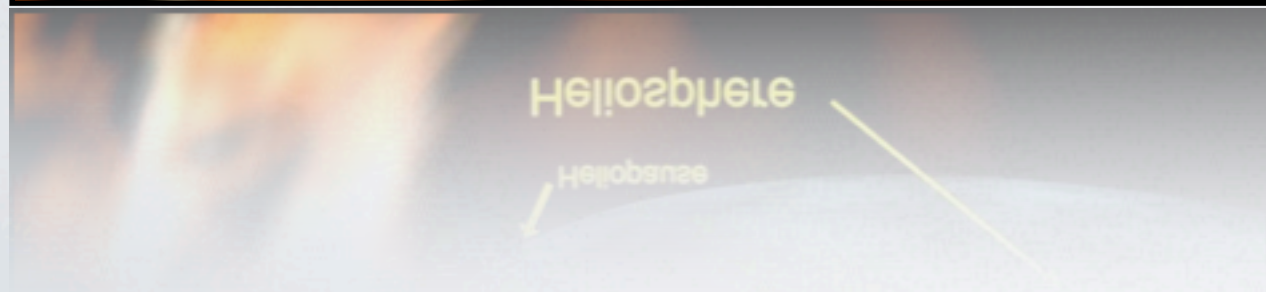
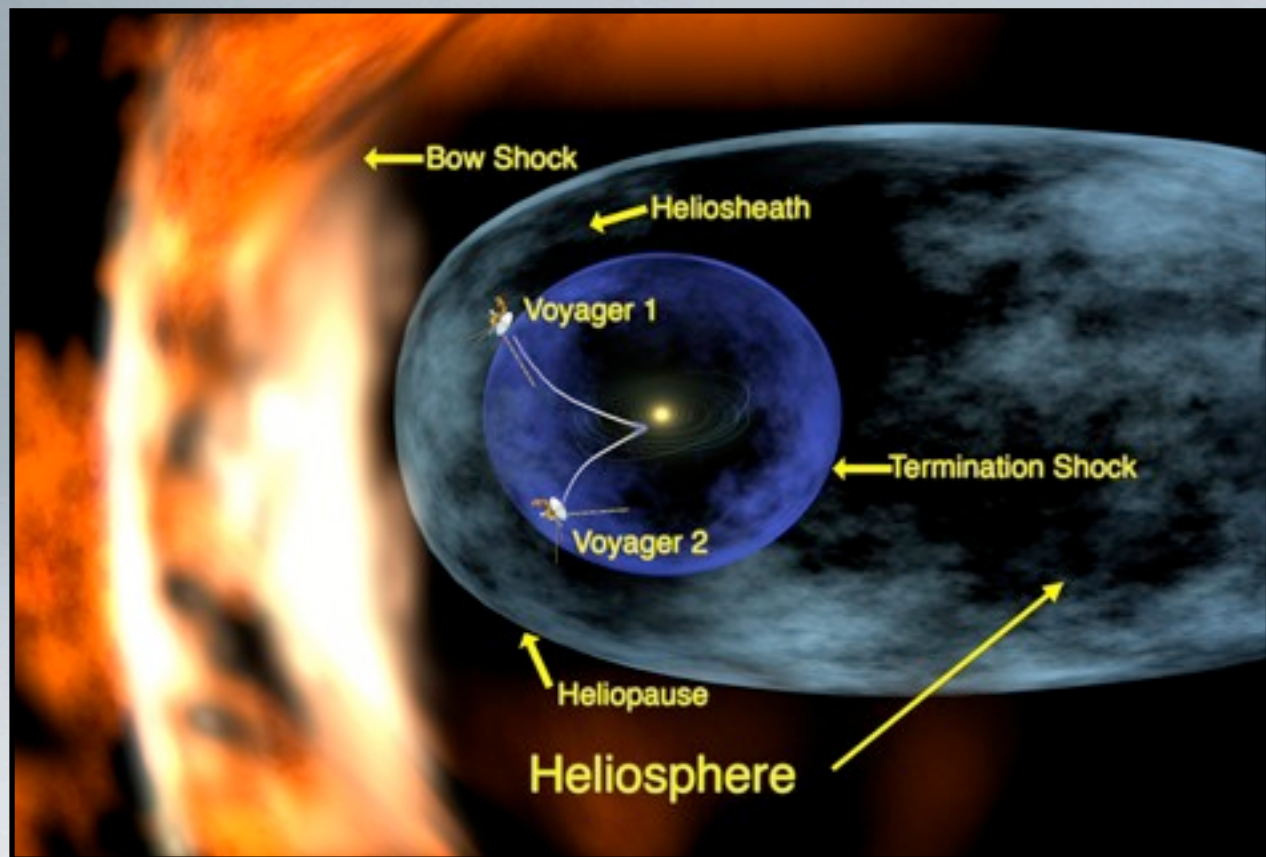


Pluto

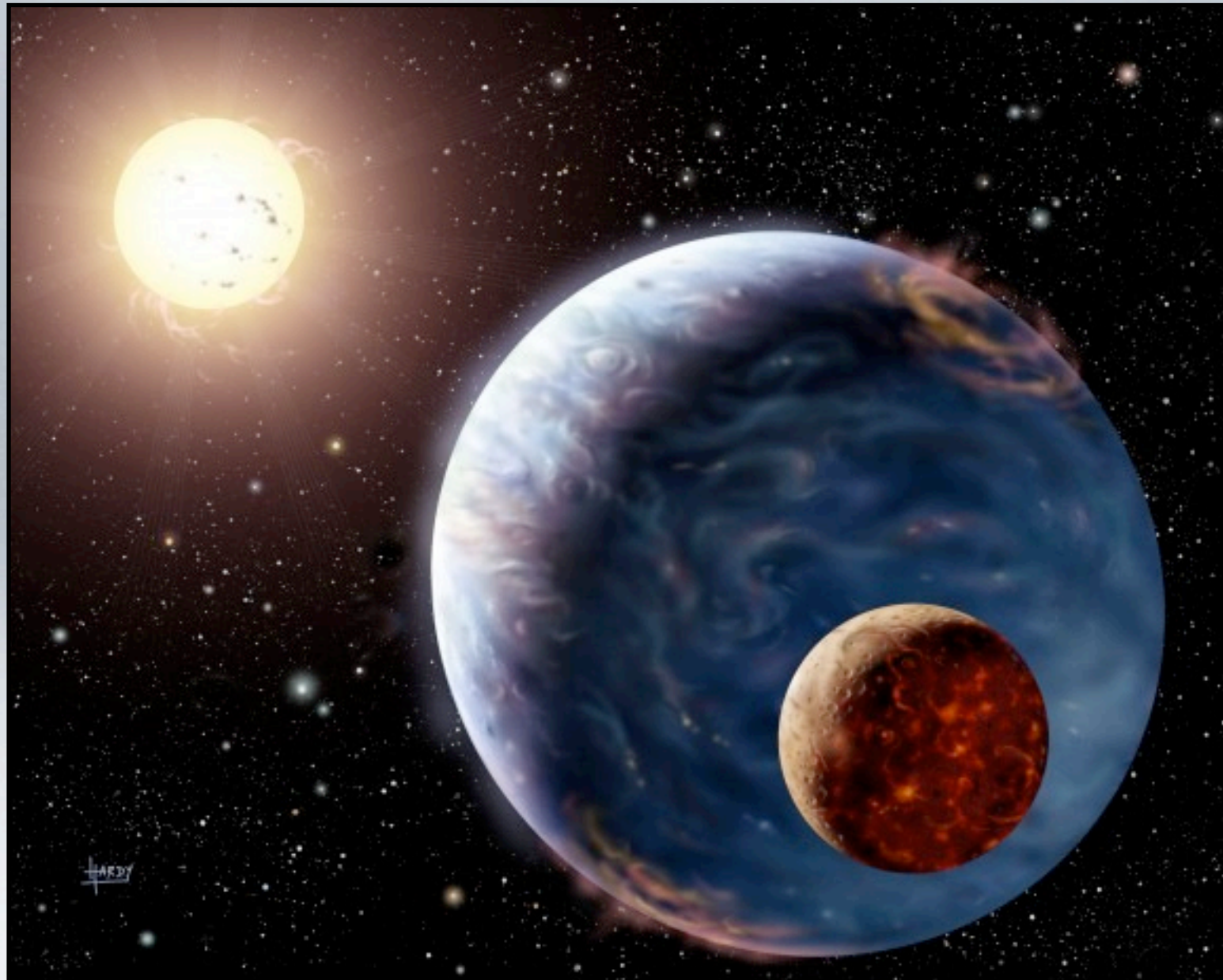
New Horizons (NASA)



The edge of the solar system



Exoplanets



Summary

- We study other planets because they are different
- The planets teach us a great deal about Earth...
- ...and other more distant astrophysical bodies
- An active programme of solar system research is underway