JUICE

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January 2018

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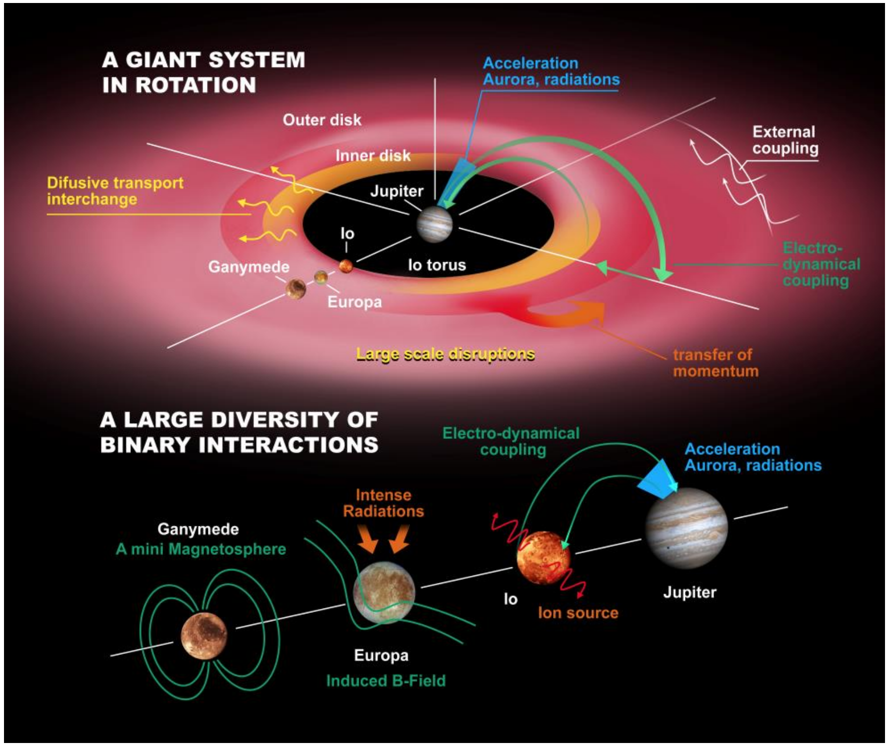
JUICE : Jupiter Icy Moon Explorer

Science themes

Emergence of habitable worlds around gas giants

- Ganymede as a planetary object and possible habitat
- Europas's recently active zones
- Callisto as a remnant of the early jovian system

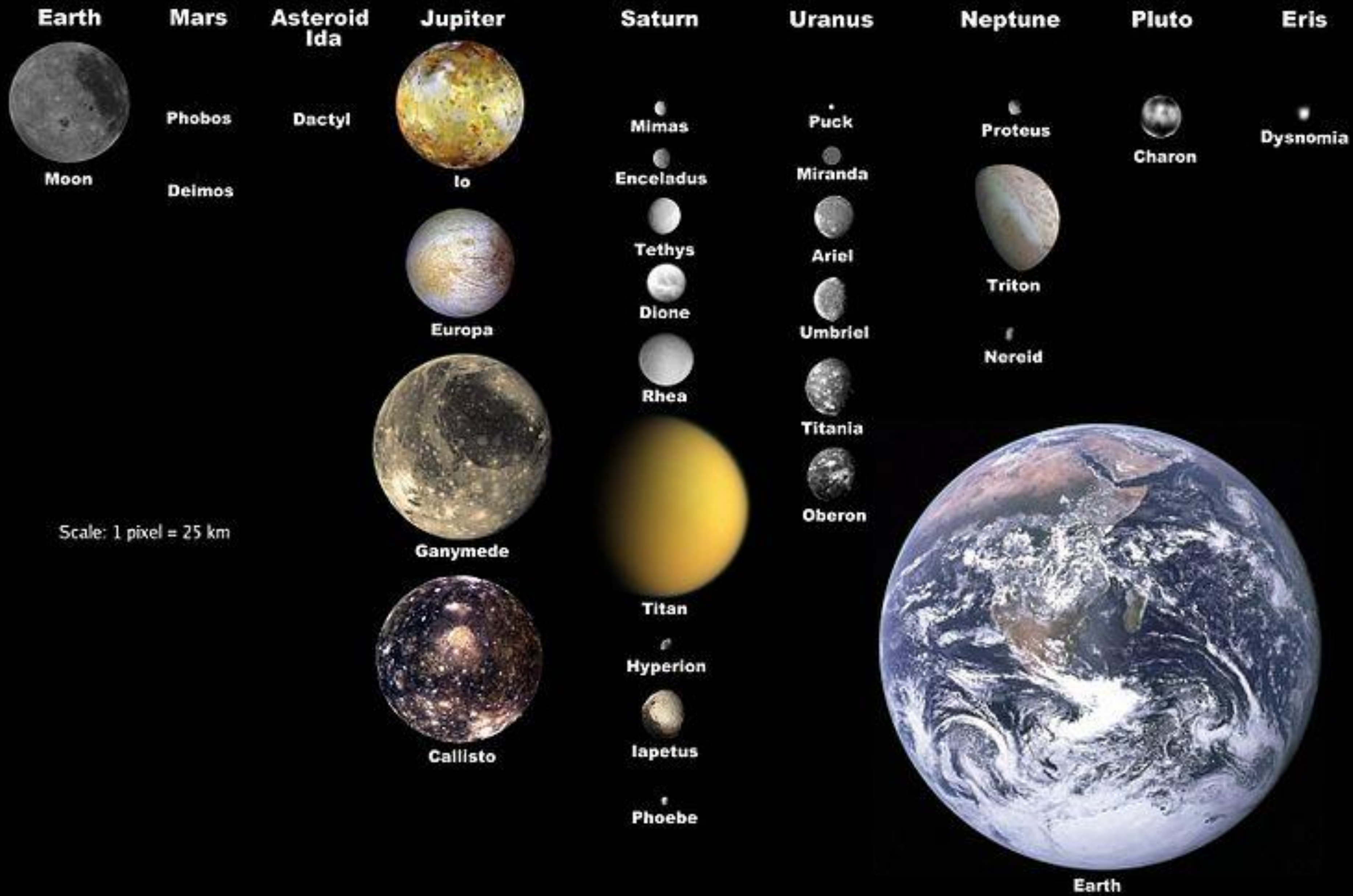


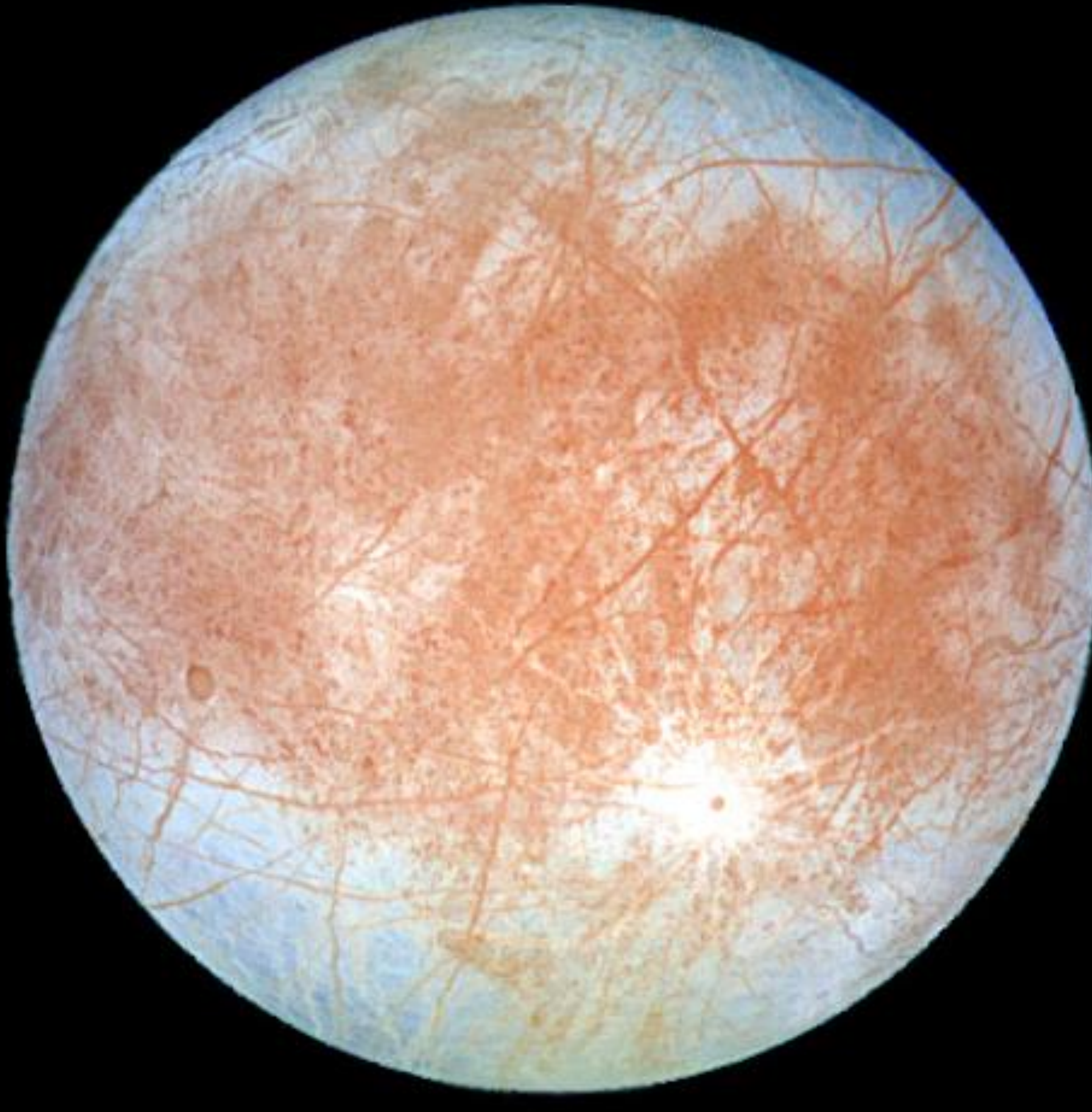
Broad and interdisciplinary science

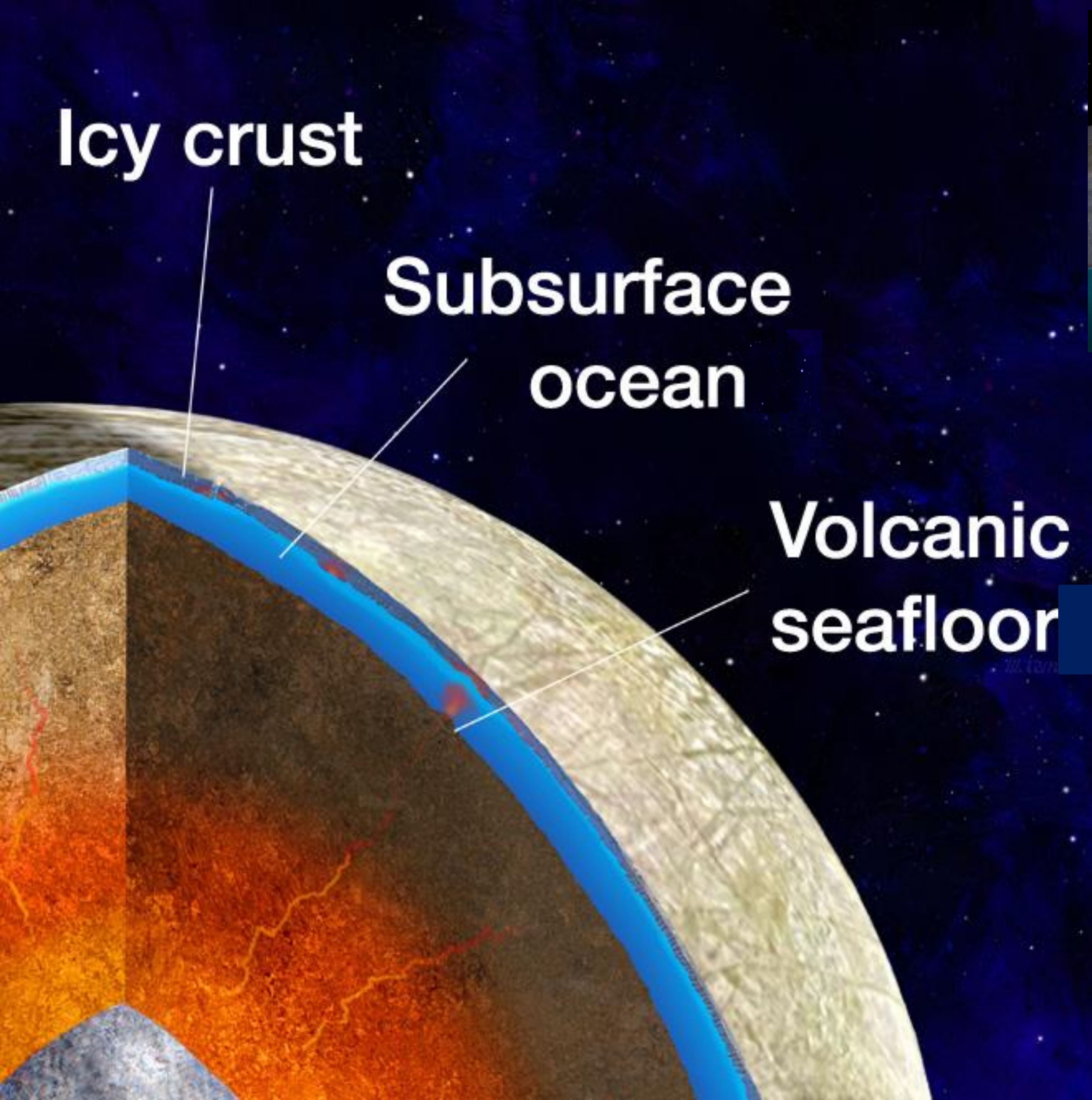
The Jupiter system as an archetype for gas giants

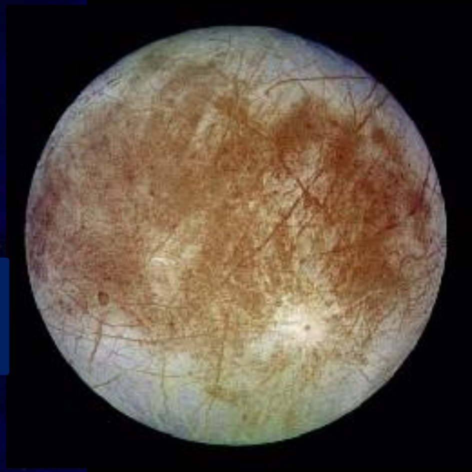
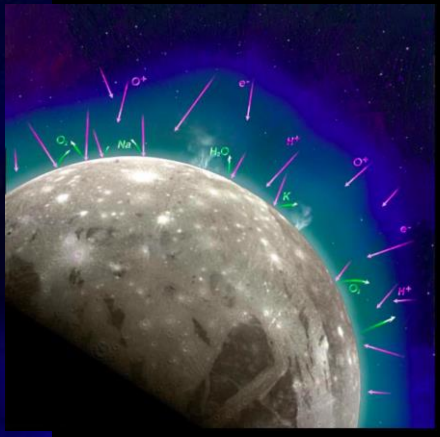
- Jovian atmosphere
- Jovian magnetosphere
- Jovian satellite and ring systems

Selected Moons of the Solar System, with Earth for Scale

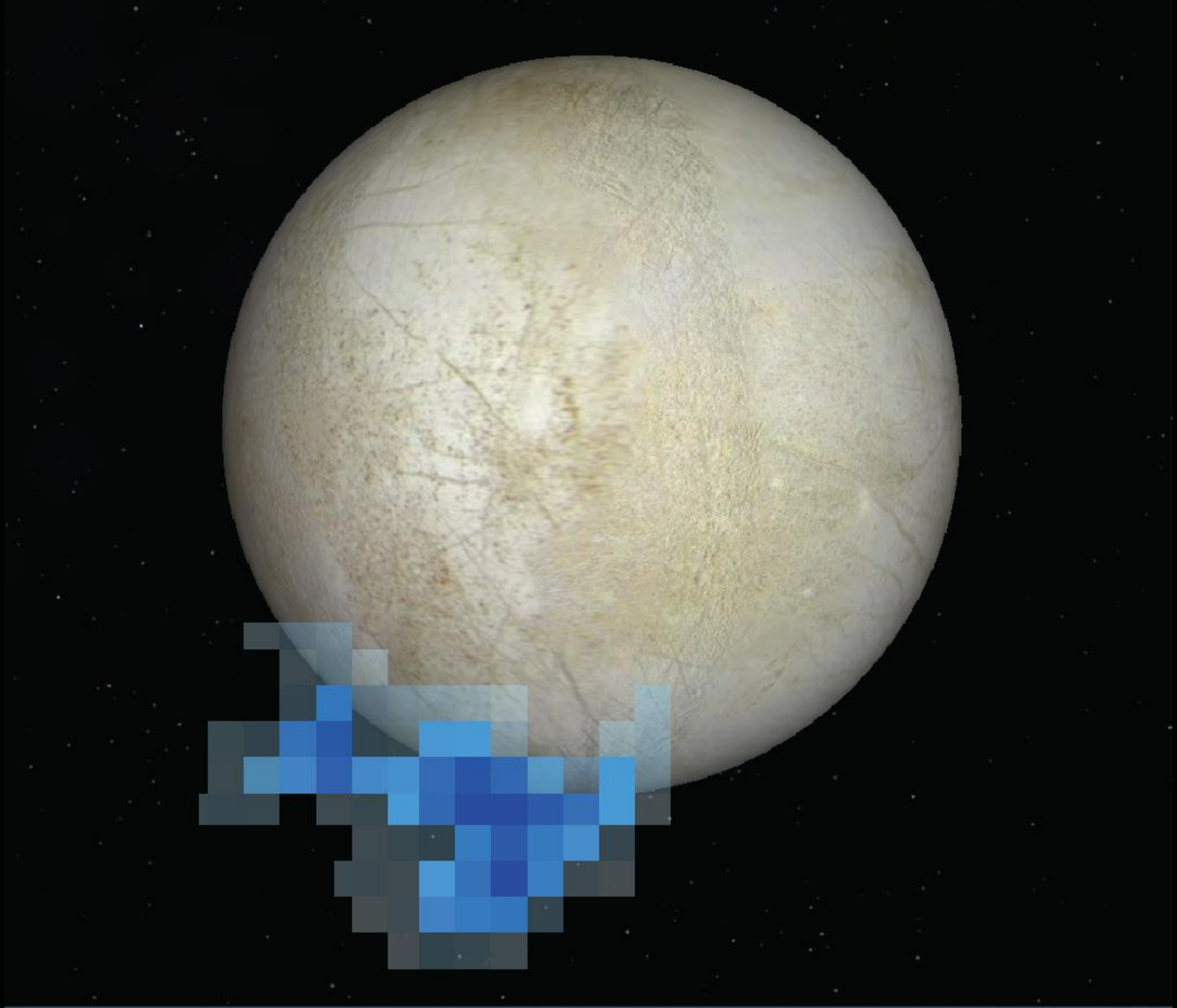




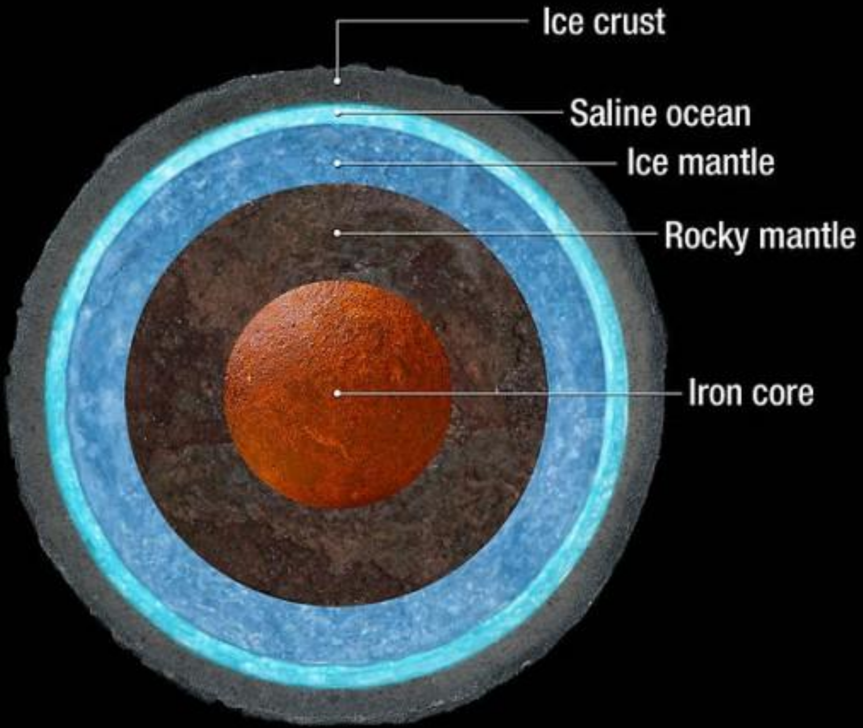

Icy crust
Subsurface
ocean
Volcanic
seafloor

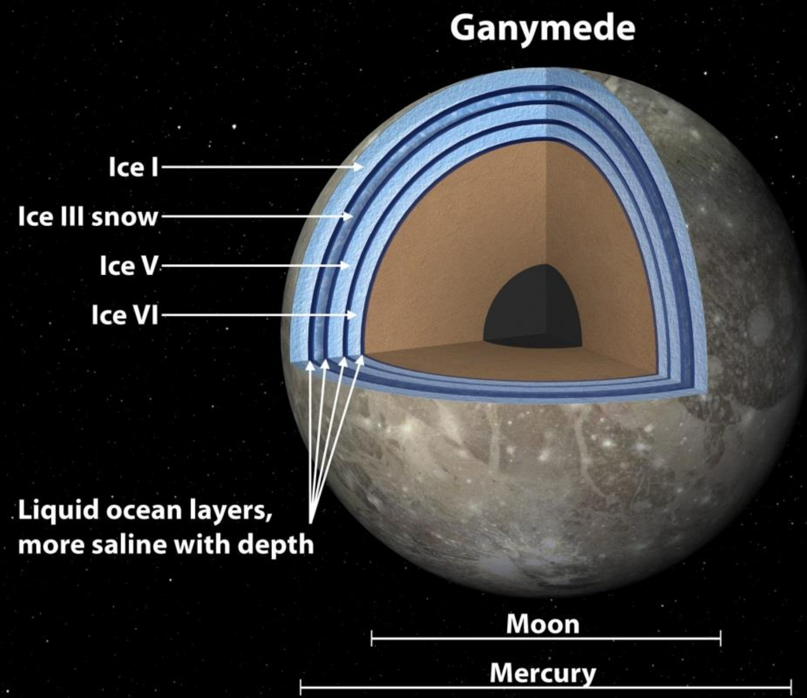



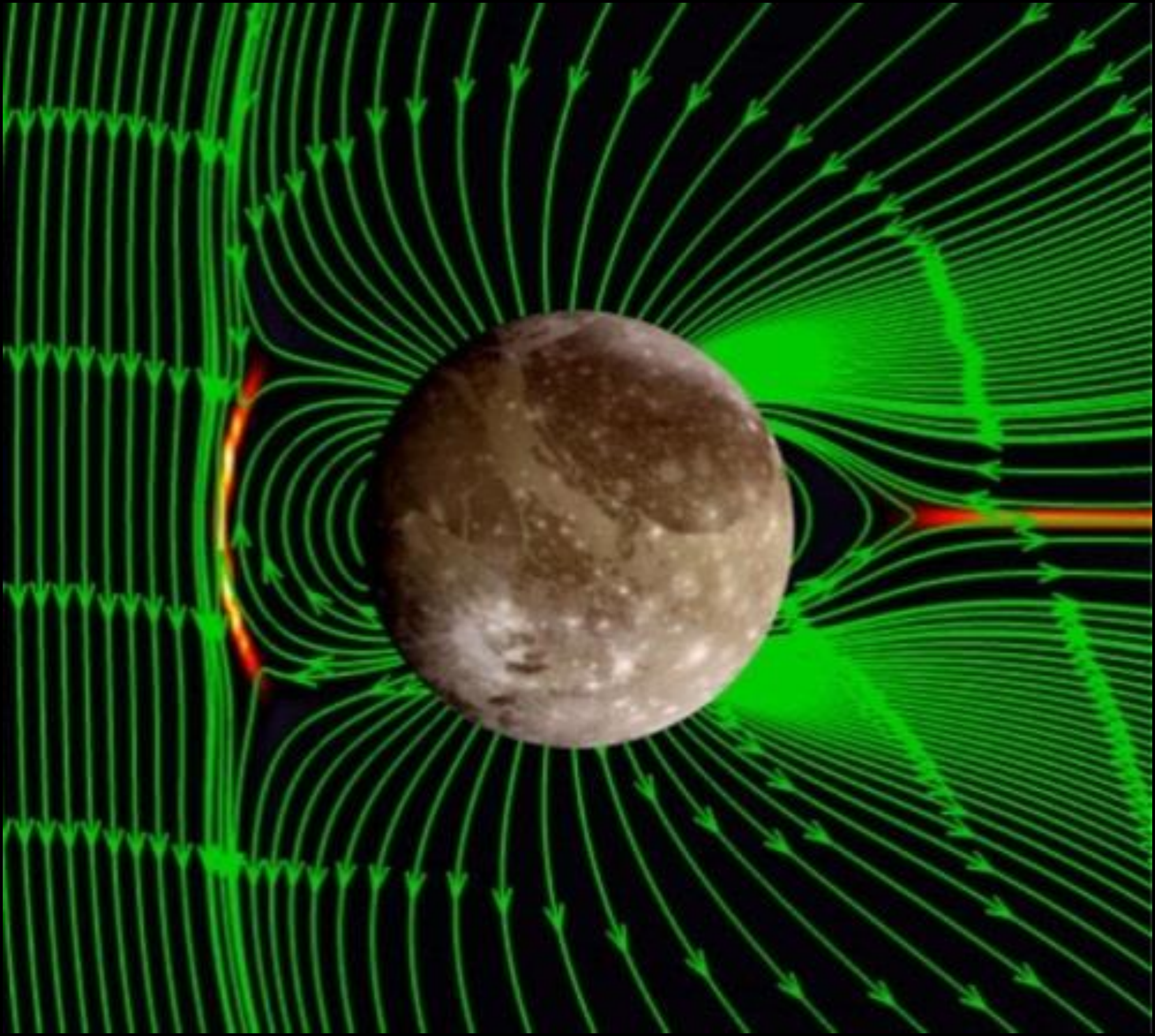
Plumes, geysers?



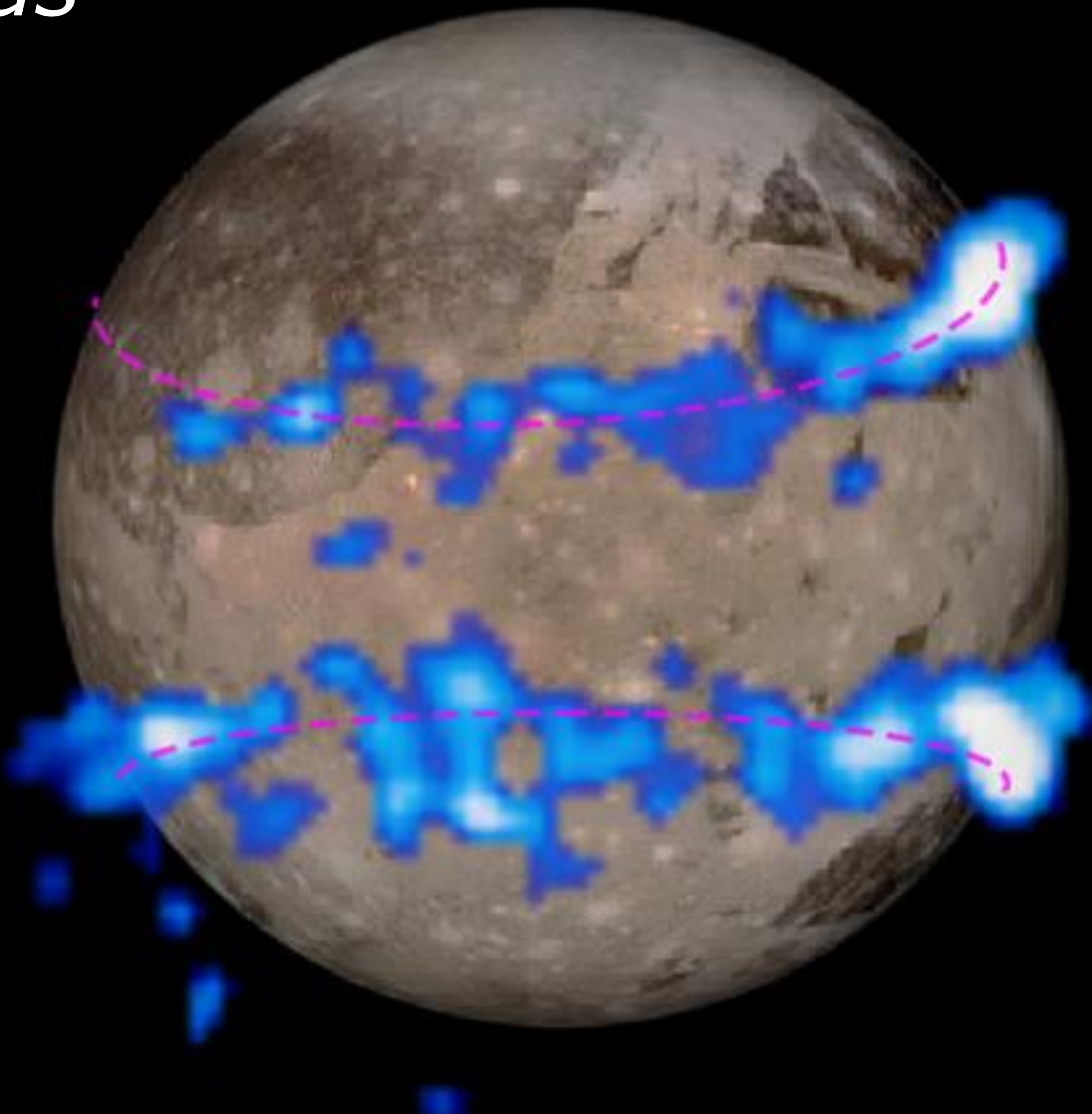
Ganymede Interior

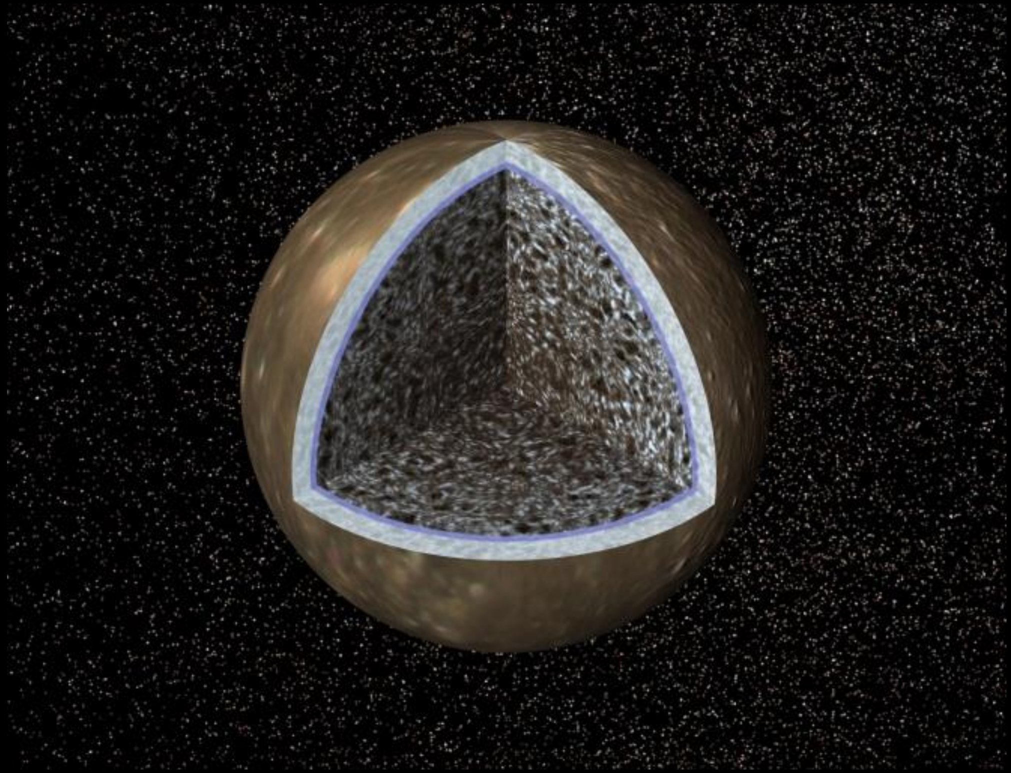






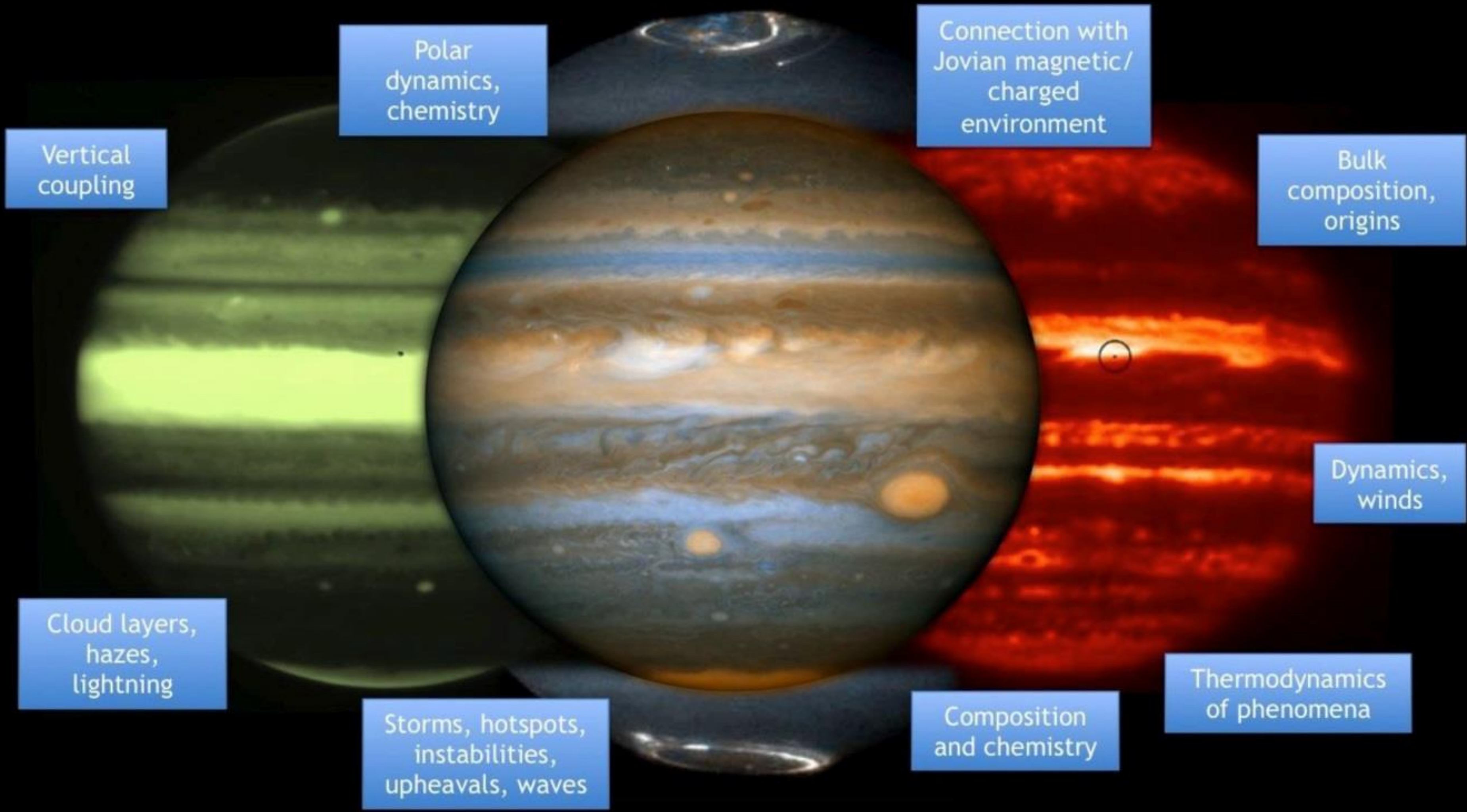
Auroras





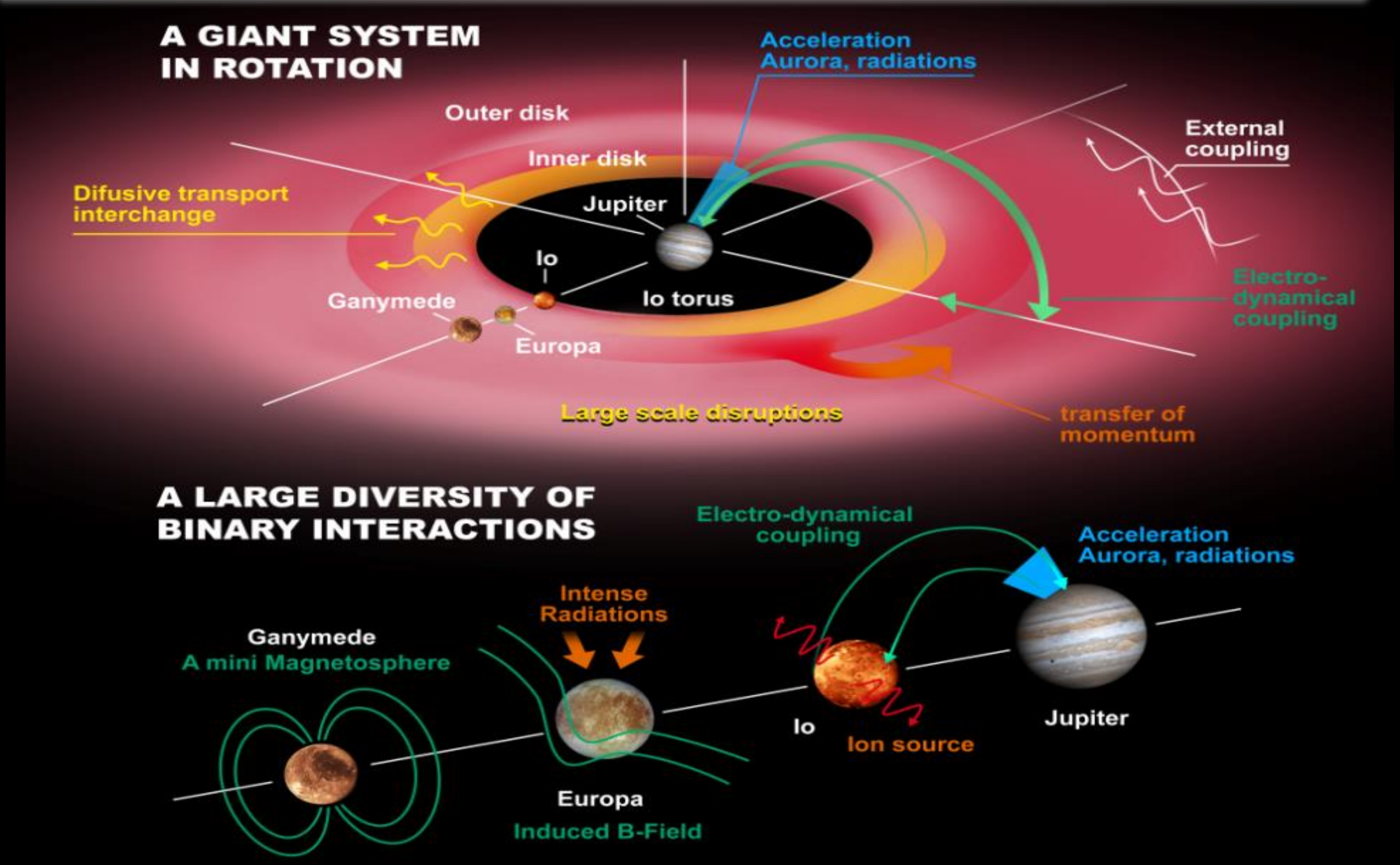
Jupiter atmosphere

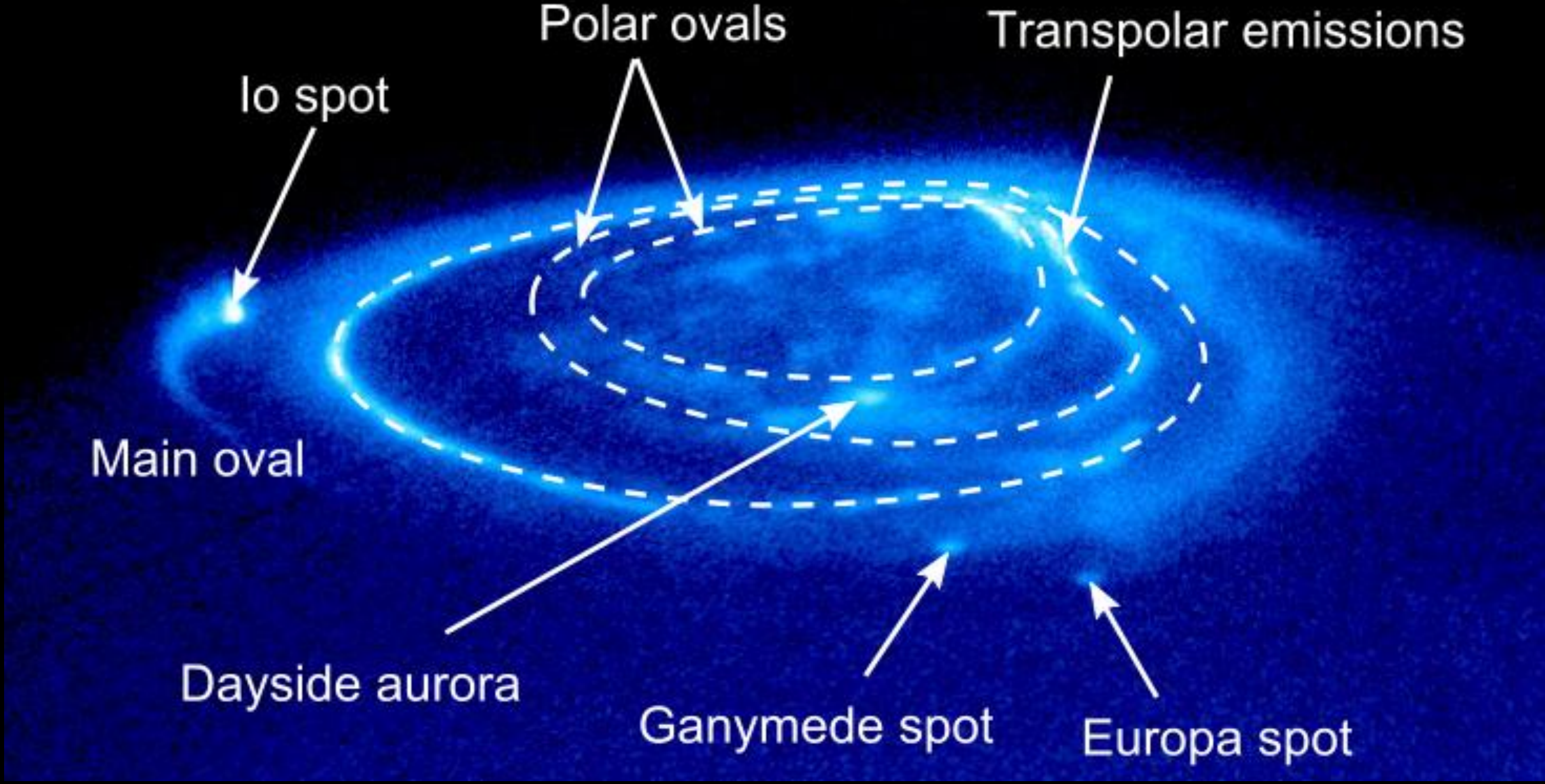
- ***Atmospheric structure, composition and dynamics***
- ***Coupling between troposphere, stratosphere and thermosphere***



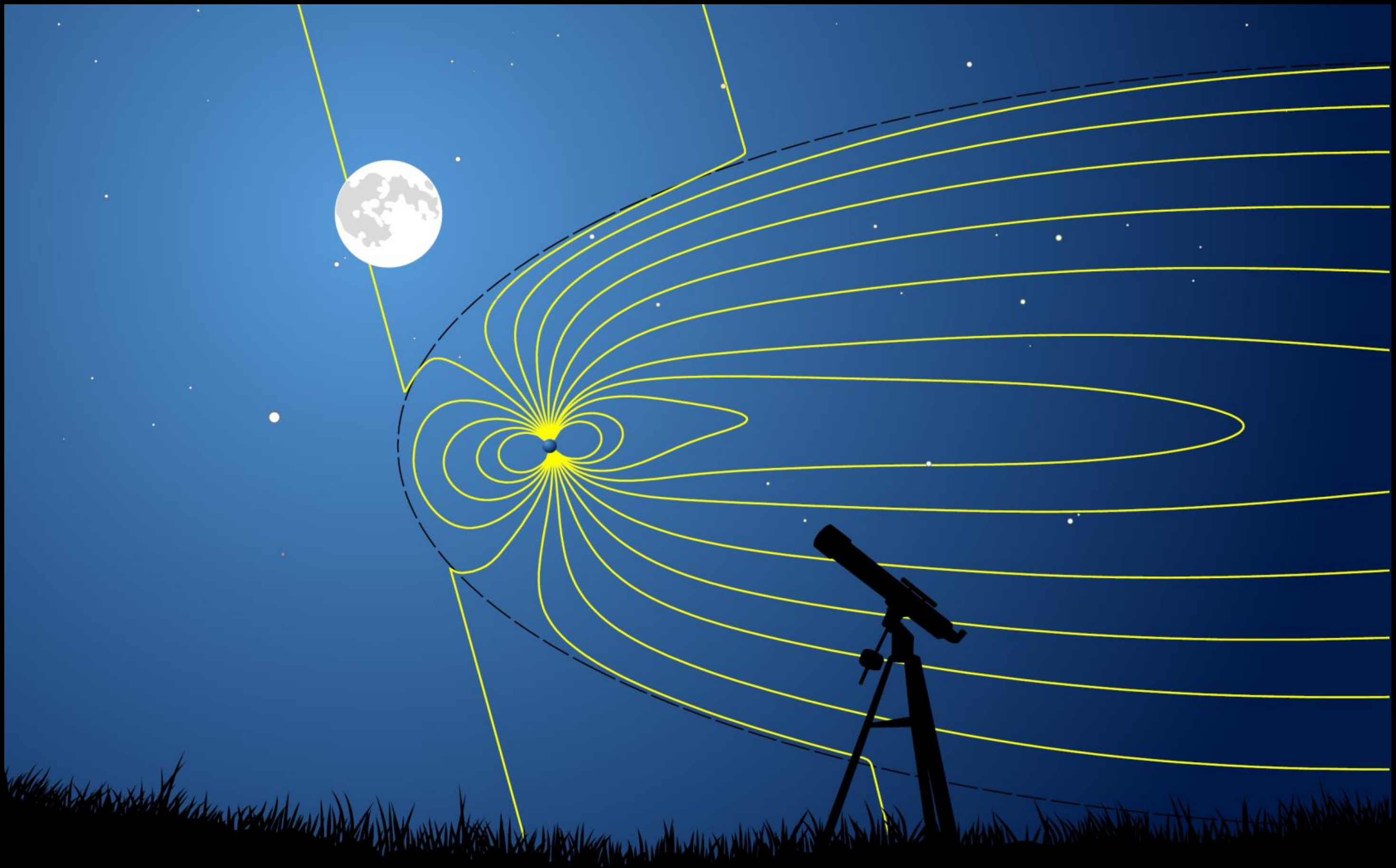
Jupiter magnetosphere

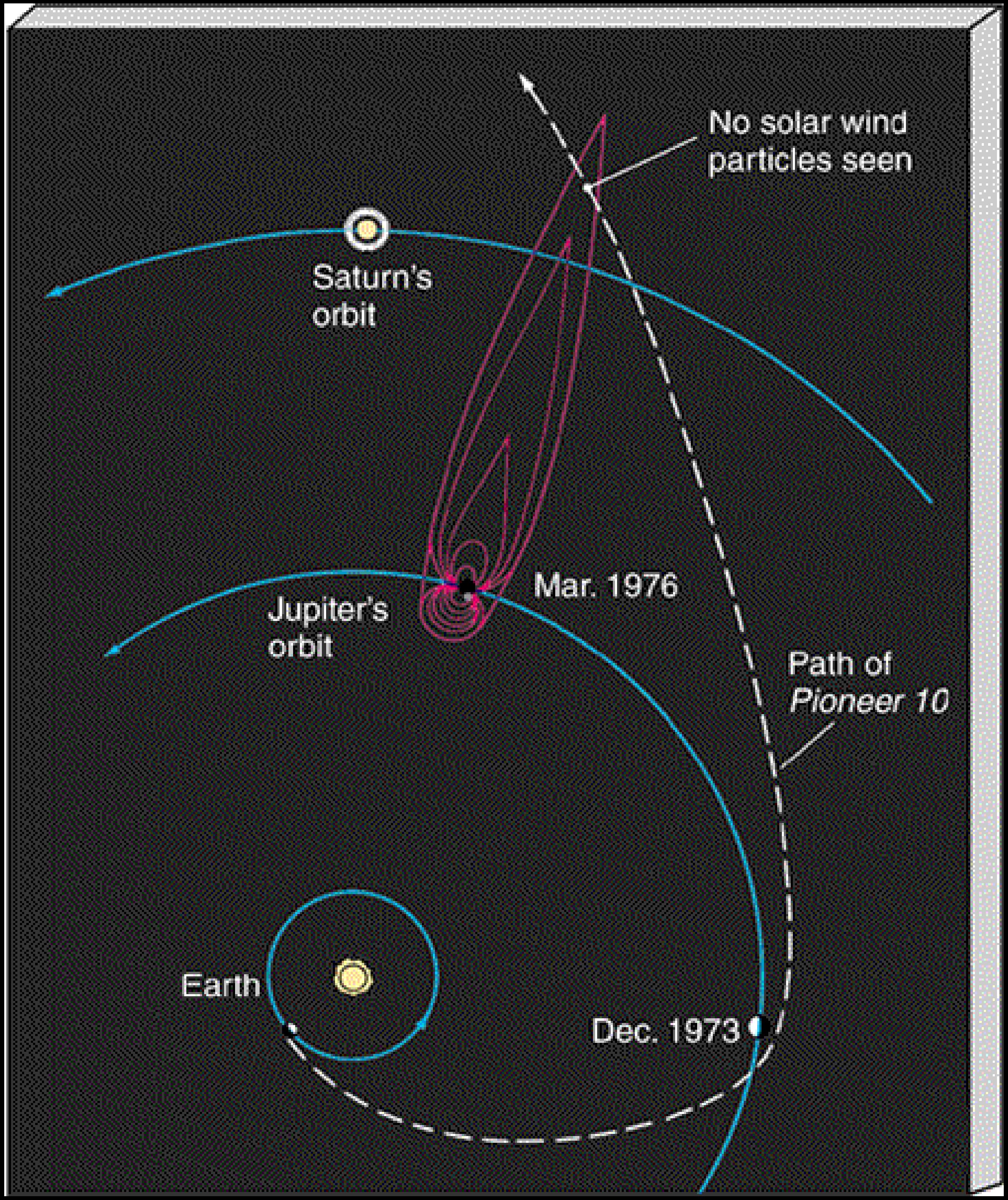
- *Magnetosphere as a fast rotator*
- *Magnetosphere as a giant particle accelerator*
- *Interaction of the Jovian magnetosphere with the moons*
- *Moons as sources and sinks of magnetospheric plasma*




Polar ovals
Transpolar emissions
Io spot
Main oval
Dayside aurora
Ganymede spot
Europa spot

Jovian magnetosphere



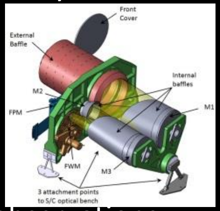


No solar wind
particles seen
Saturn's
orbit
Mar. 1976
Jupiter's
orbit
Path of
Pioneer 10
Earth
Dec. 1973

JUICE Payload

JANUS: Visible Camera System

PI: Pasquale Palumbo, Parthenope University, Italy.
Co-PI: Ralf Jaumann, DLR, Germany

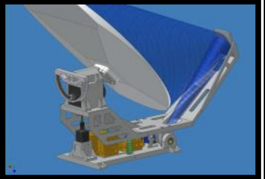


- ≥7.5m/pixel
- Multiband imaging, 380 - 1080 nm
- Icy moon geology
- Io activity monitoring and other moons observations
- Jovian atmosphere dynamics

SWI: Sub-mm Wave Instrument

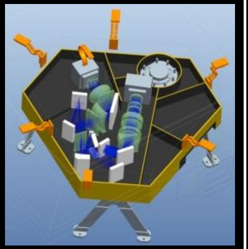
PI: Paul Hartogh, MPS, Germany

- 600 GHz
- Jovian Stratosphere
- Moon atmosphere
- Atmospheric isotopes



MAJIS: Imaging VIS-NIR/IR Spectrograph

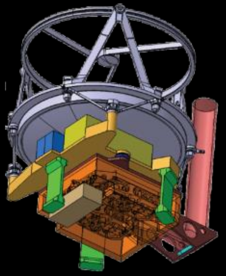
PI: Yves Langevin, IAS, France
Co-PI: Guiseppe Piccioni, INAF, Italy



- 0.9-1.9 µm and 1.5-5.7 µm
- ≥62.5 m/pixel
- Surface composition
- Jovian atmosphere

GALA: Laser Altimeter

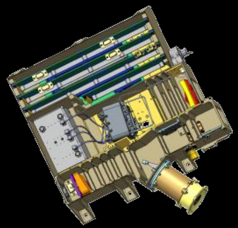
PI: Hauke Hussmann, DLR, Germany



- ≥40 m spot size
- ≥0.1 m accuracy
- Shape and rotational state
- Tidal deformation
- Slopes, roughness, albedo

UVS: UV Imaging Spectrograph

PI: Randy Gladstone, SwRI, USA



- 55-210 nm
- 0.04˚-0.16˚
- Aurora and Airglow
- Surface albedos
- Stellar and Solar Occultation

RIME: Ice Penetrating Radar

PI: Lorenzo Bruzzone, Trento, Italy
Co-PI: Jeff Plaut, JPL, USA

- 9 MHz
- Penetration ~9 km
- Vertical resolution 30 m
- Subsurface investigations

JUICE Payload

JMAG: JUICE Magnetometer

PI: Michele Dougherty, Imperial, UK

- Dual Fluxgate and Scalar mag
- ±8000 nT range, 0.2 nT accuracy
- Moon interior through induction
- Dynamical plasma processes

3GM: Gravity, Geophysics, Galilean Moons

PI: Luciano Iess, Rome, Italy
Co-PI: David J. Stevenson, CalTech, USA

- Ranging by radio tracking
- 2 µm/s range rate
- 20 cm range accuracy
- Gravity fields and tidal deformation

PEP: Particle Environment Package

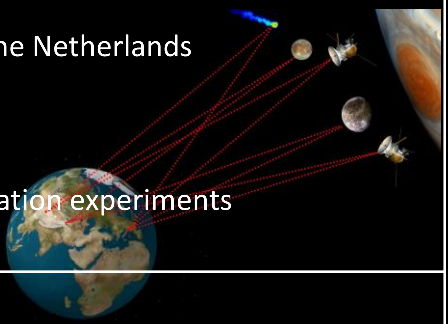
PI: Stas Barabash, IRF-K, Sweden
Co-PI: Peter Wurz, UBe, Switzerland

- Six sensor suite
- Ions, electrons, neutral gas (in-situ)
- Remote ENA imaging of plasma and torus

PRIDE: Planetary Radio Interferometer & Doppler Experiment

PI: Leonid Gurvits, JIVE, EU/The Netherlands

- S/C state vector
- Ephemerides
- bi-static and radio occultation experiments



RPWI: Radio and Plasma Wave Investigation

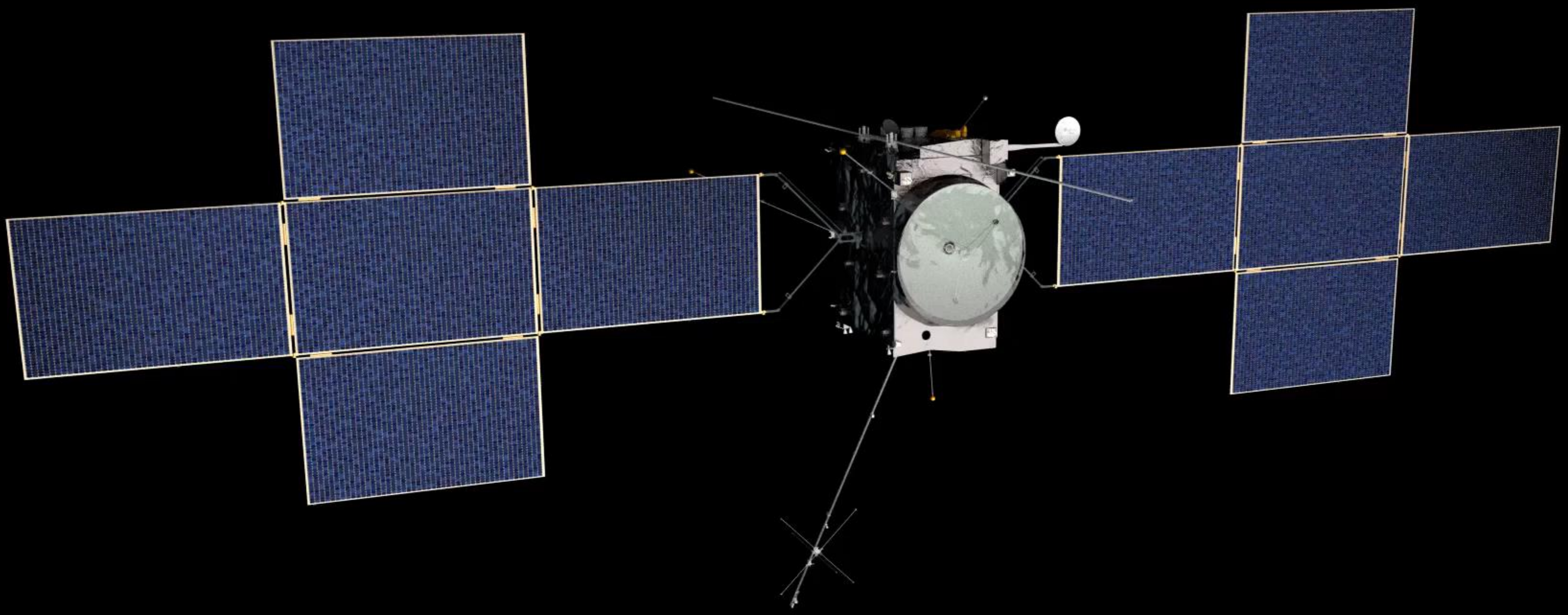
PI: Jan-Erik Wahlund, IRF-U, Sweden

- Langmuir Probes
- Search Coil Magnetometer
- Tri-axial dipole antenna
- E and B-fields
- Ion, electron and charged dust parameters

JUICE Spacecraft

- Prime industrial Contractor: Airbus Defence & Space (Toulouse, France), selected in July 2015

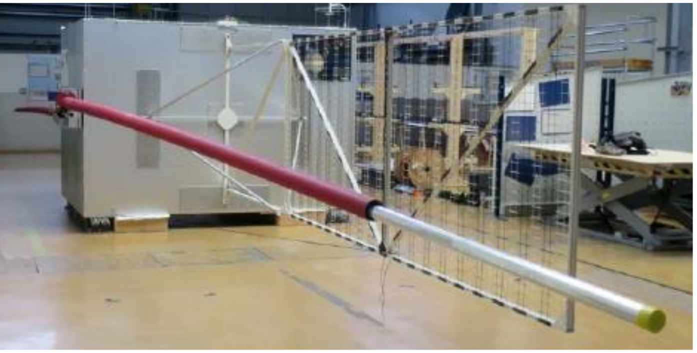
- Spacecraft:
  - 3-axis stabilised
  - Mass:
    - Launch mass: ~5100 kg
    - Instruments: ~280 kg
    - Propellant: ~2900 kg
  - Solar array ~90 m^2 (~850 W at Jupiter)
  - Fixed High Gain Antenna (X, Ka Bands)
  - Steerable Medium Gain Antenna (X, Ka Bands)
  - Data Volume ~ 1.4 Gb per day



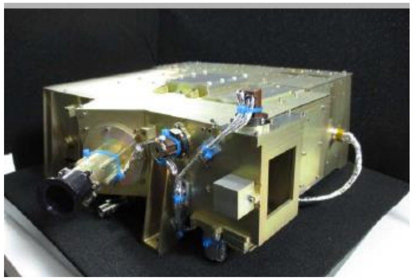
JUICE Spacecraft

Courtesy Airbus D&S

Hardware (1)



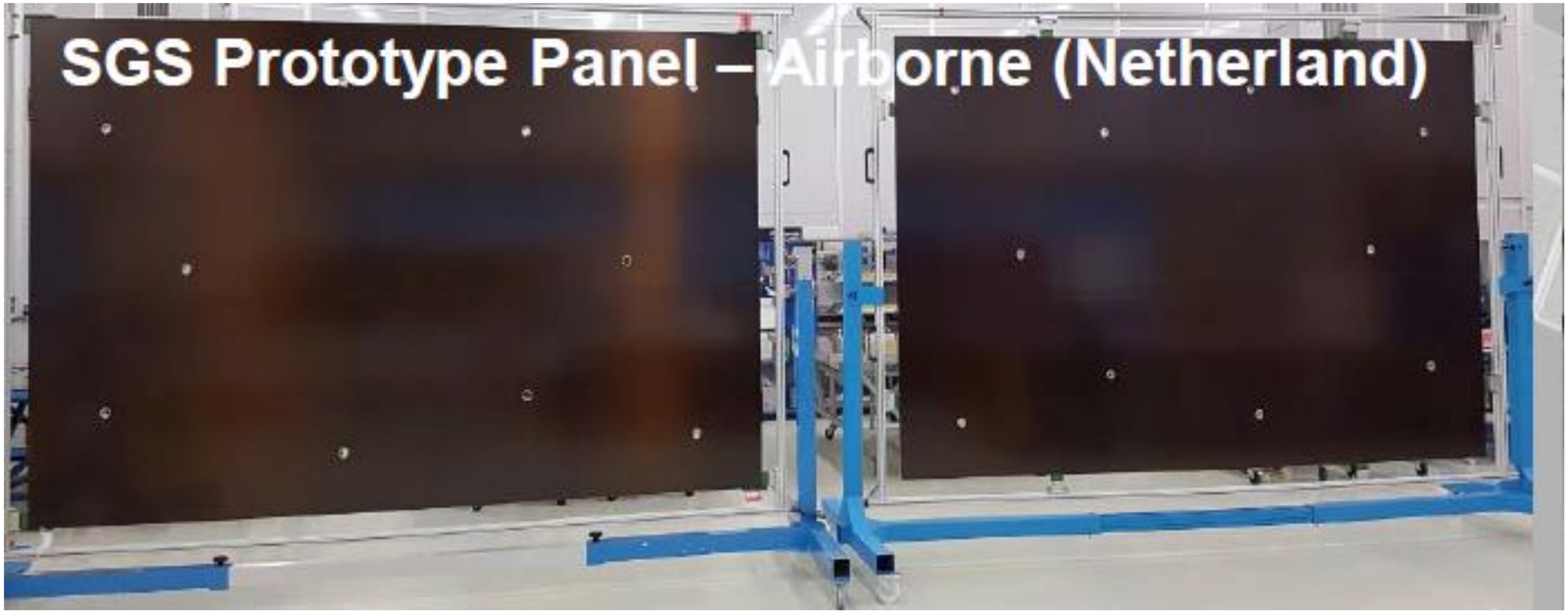
Radar antenna and s/c mock-up



UV spectrometer (EM)

Magnetometer lab models

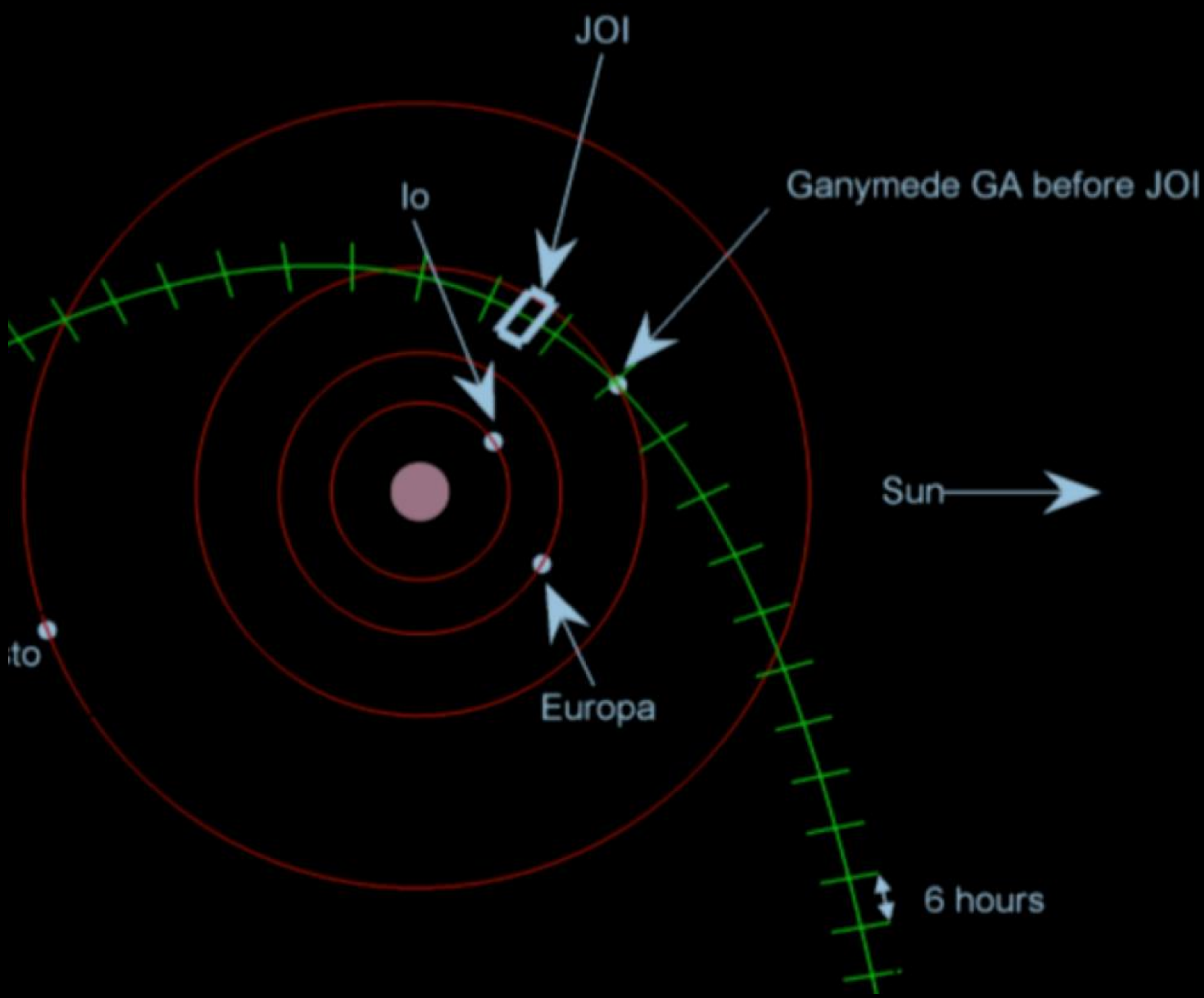
Hardware (2)



Schedule and milestones

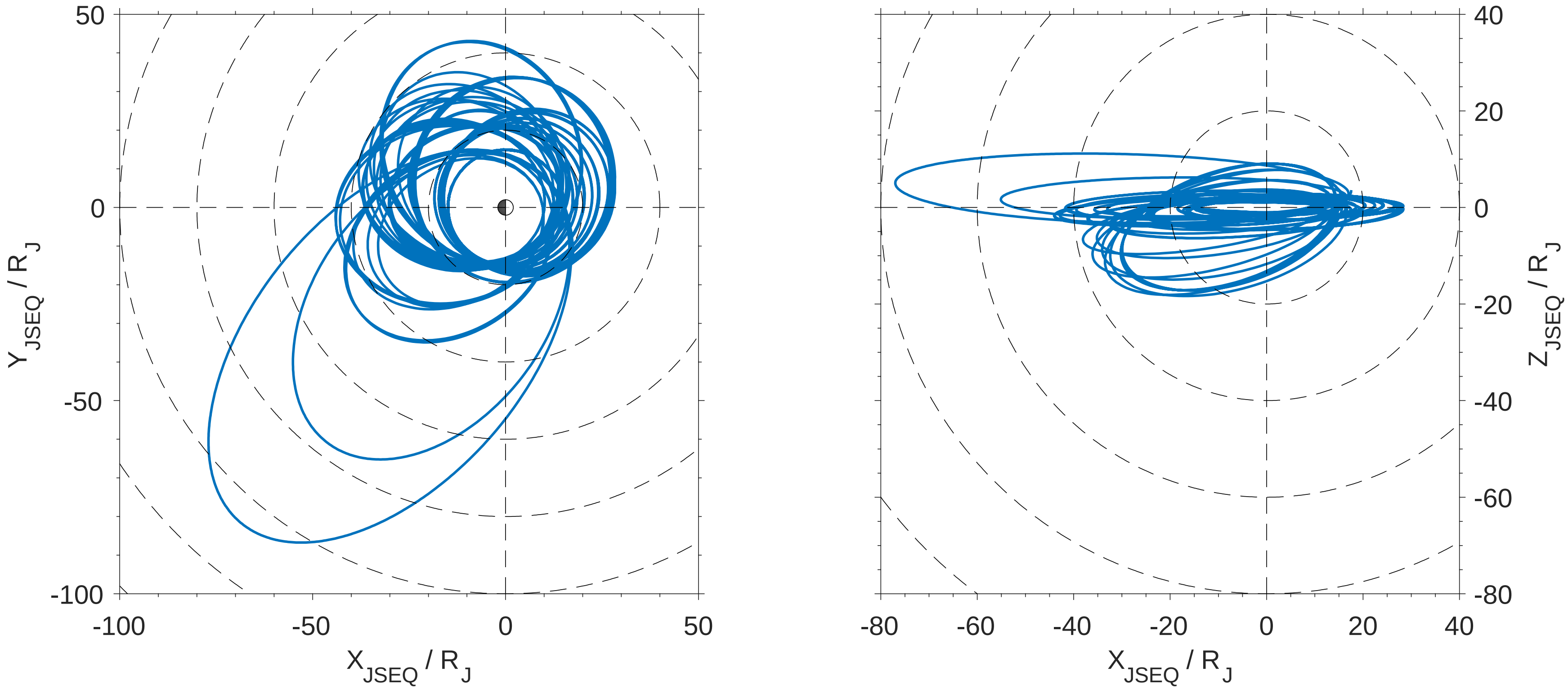
- March 2007: ESA call for proposals
- May 2012: Mission selected
- February 2013: Payload selected
- July 2015: Prime industrial contractor selected
- June 2022: Launch from Kourou (Ariane 5)
- October 2029: Jupiter orbit insertion
- August 2032: Ganymede orbit insertion
- September 2033: End of mission

Jupiter Orbit Insertion

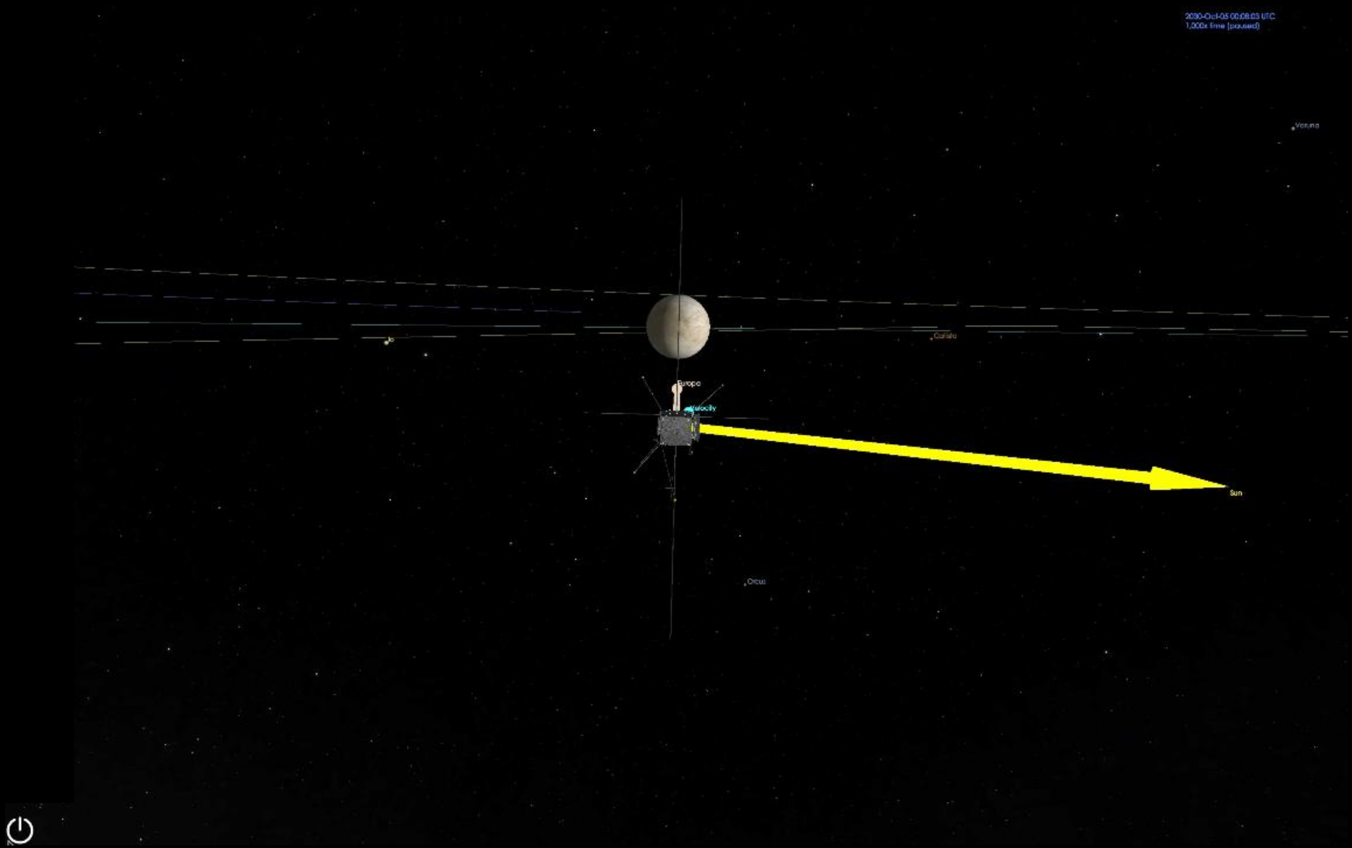


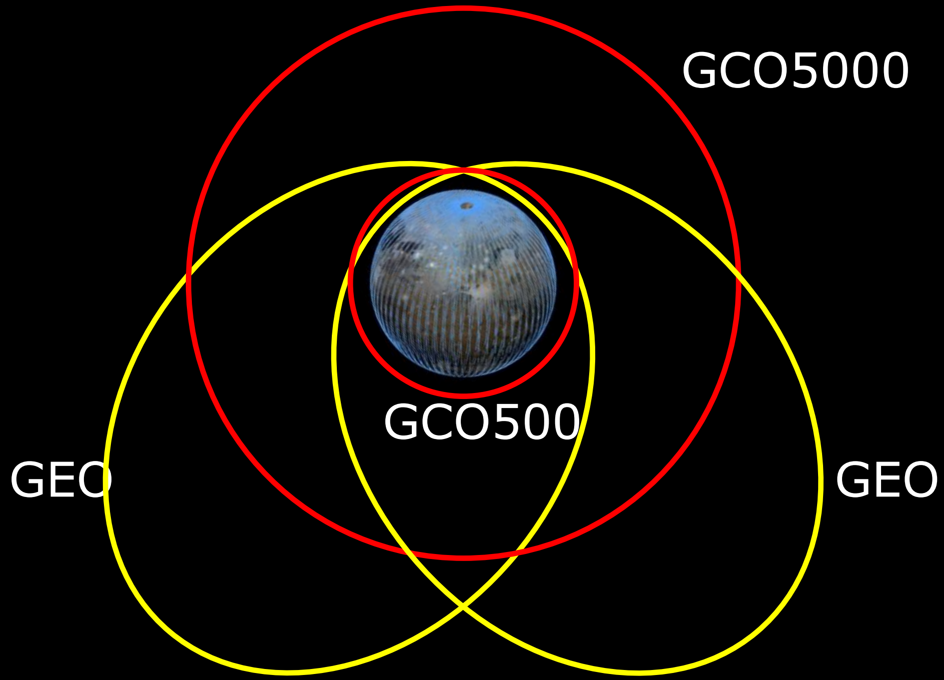
JUICE trajectory

Moon flybys: 2 Europa, 12-13 Callisto, 12-15 Ganymede

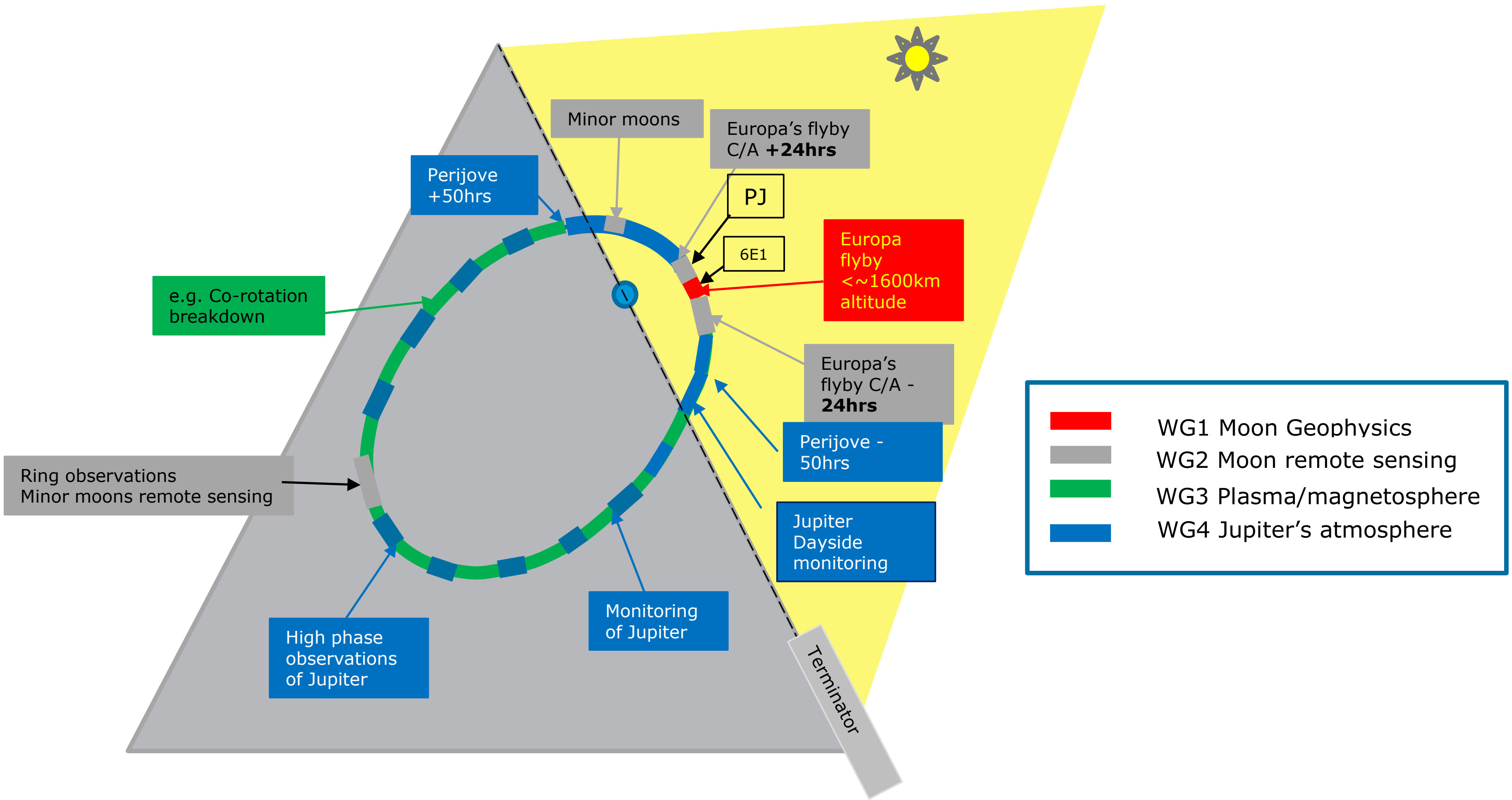


A Europa flyby




GCO5000
GCO500
GEO
GEO

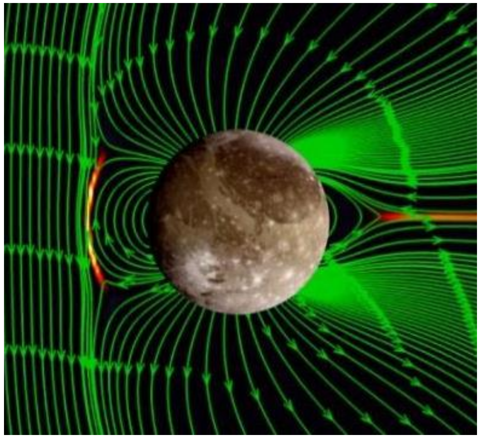
Example of trajectory segmentation: orbit with a Europa flyby



How to detect and characterise oceans ?

How to detect and characterise oceans (1)

Magnetic induction: Electrical currents in salty oceans can generate secondary magnetic and electric fields in response to the external rotating Jupiter magnetic field. Measurements at multiple frequencies with the J-MAG and RPWI instruments will constrain the electrical conductivity and extent of the ocean.

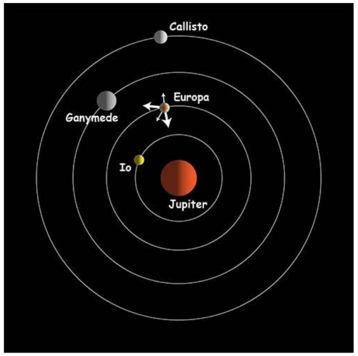


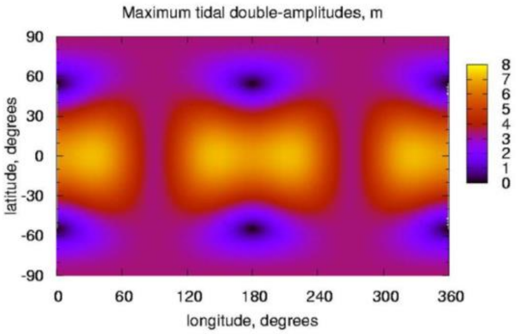
Credits: X.Jia (Univ. Michigan) and M. Kivelson (UCLA).

How to detect and characterise oceans (2)

Tides

- The tidal response of the icy shells depends on the presence of ocean: ice shell decoupled from the interior. The amplitudes of surface deformation will be measured by the laser altimeter.
- VLBI may provide complementary information on the shape of the moon.
- Time variability of the gravitational potential of the moon because of the formation of the tidal bulge, to be measured by radio-science.

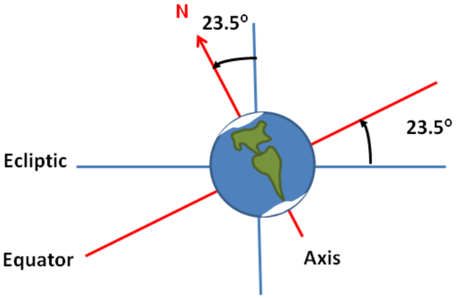




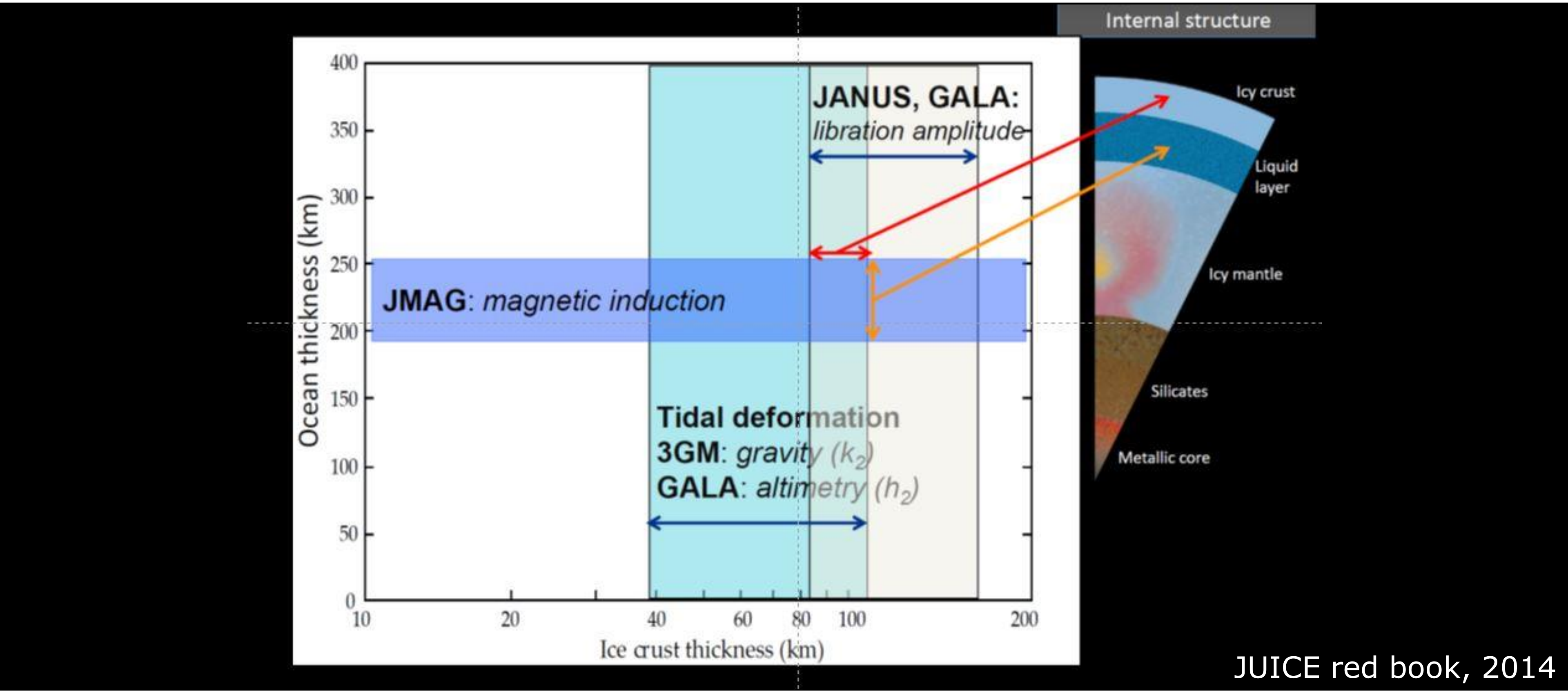
How to detect and characterise oceans (3)

Librations and obliquity: The Galilean moons are locked in a stable 1:1 spin-orbit resonance. However, slight periodic variations in the rotation rate (physical librations) and the amplitudes associated with these librations can provide further evidence for a subsurface ocean. Obliquity varies also with a decoupled ice shell.

Radio-Science, laser altimeter and camera will measure precisely the rotation rate, pole-position, obliquity, and libration amplitude.



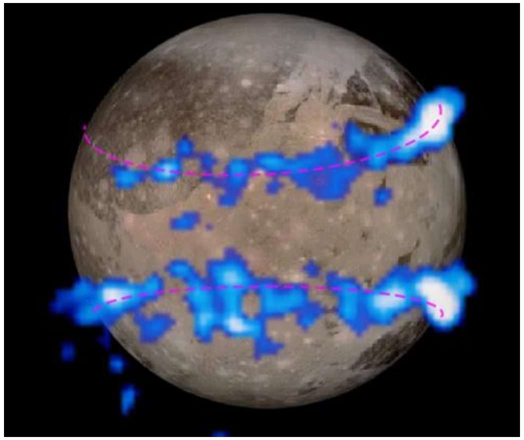
Ganymede interior structure



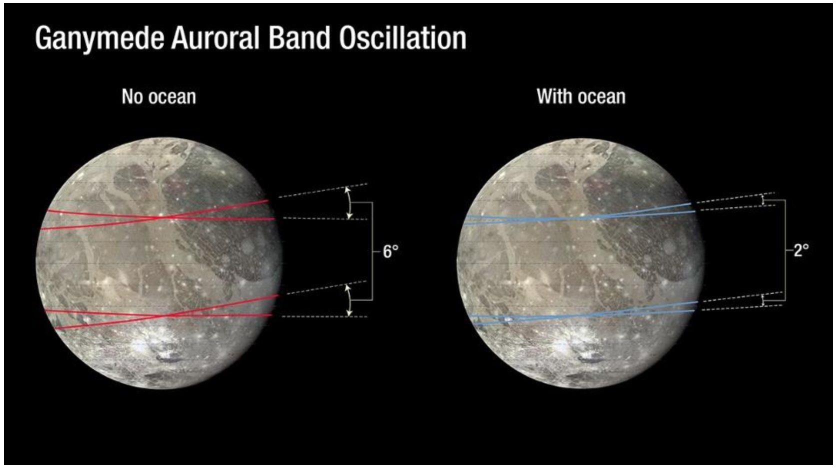
JUICE red book, 2014

How to detect and characterise oceans (4)

Ganymede auroral oval: The locations of the auroral ovals oscillate due to Jupiter's time-varying magnetospheric field seen in the rest frame of Ganymede. If an electrically conductive ocean is present, the external time-varying magnetic field is reduced due to induction within the ocean and the oscillation amplitude of the ovals decreases. The remote sensing and plasma/field instruments will characterise the auroral oval.

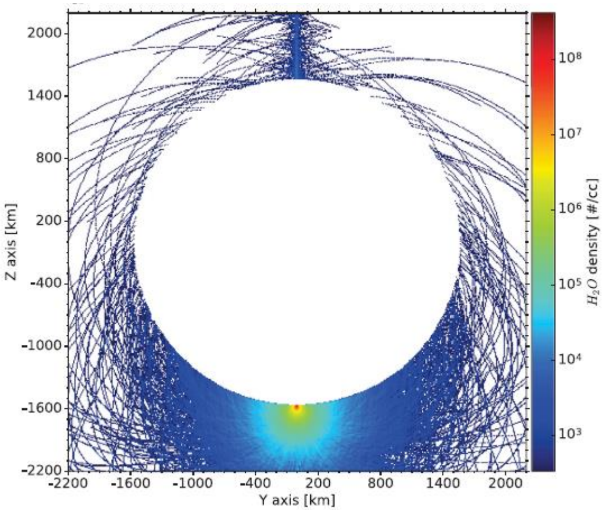


Saur et al., 2015



How to detect and characterise oceans (5)

Analysis of the exosphere: analysis of the Moons' tiny atmosphere issued from plumes, sputtering and sublimation of surface material, diffusion from the interior, as well as sub-surface breaching of ocean material, with PEP, SWI, J-MAG, RPWI, JANUS, MAJIS, UVS.



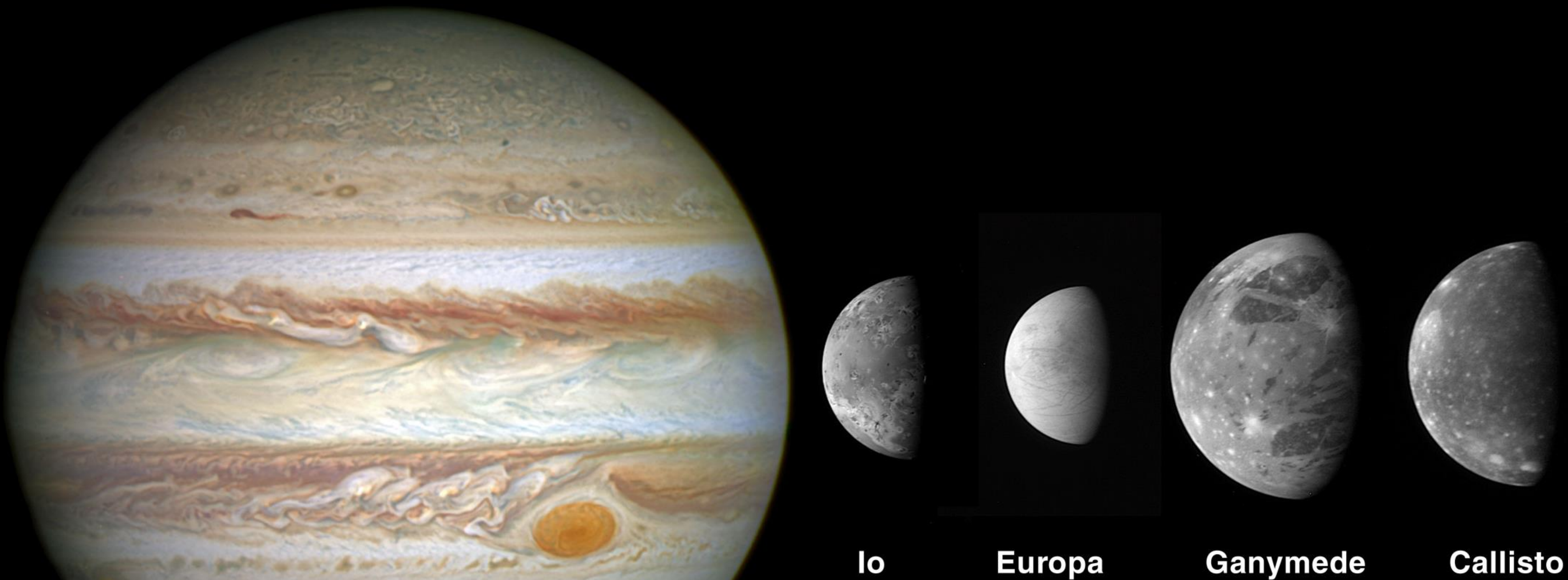
Huybrighs et al., 2017

Challenges of the mission

- Trajectory and navigation

- Radiation environment
- Power and thermal
- Spacecraft electromagnetic cleanliness

- (relatively) Low data rate
- Mission duration (2007-2037…)



Thank you for your attention

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