JUICE: a European mission to Jupiter and its icy moons

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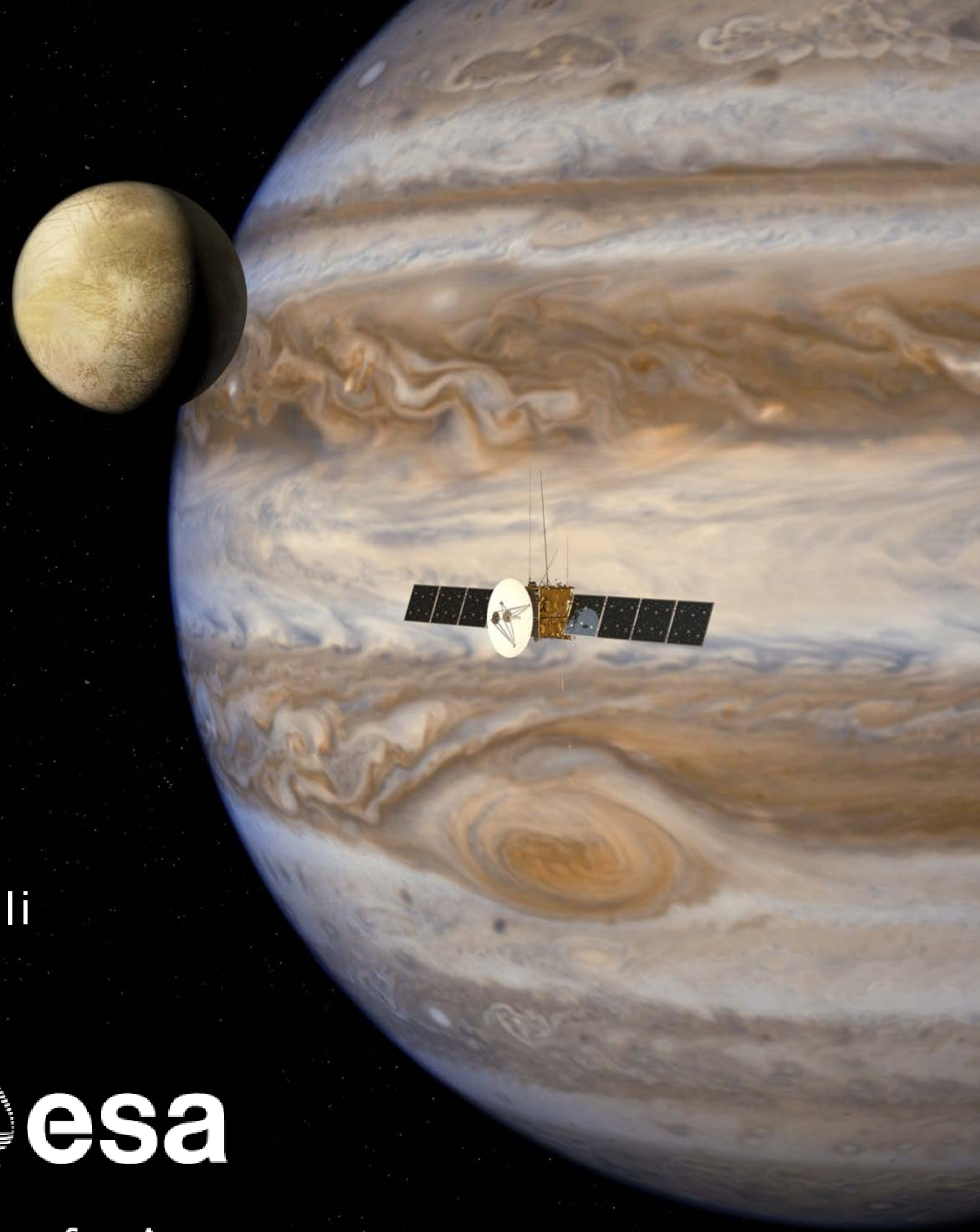
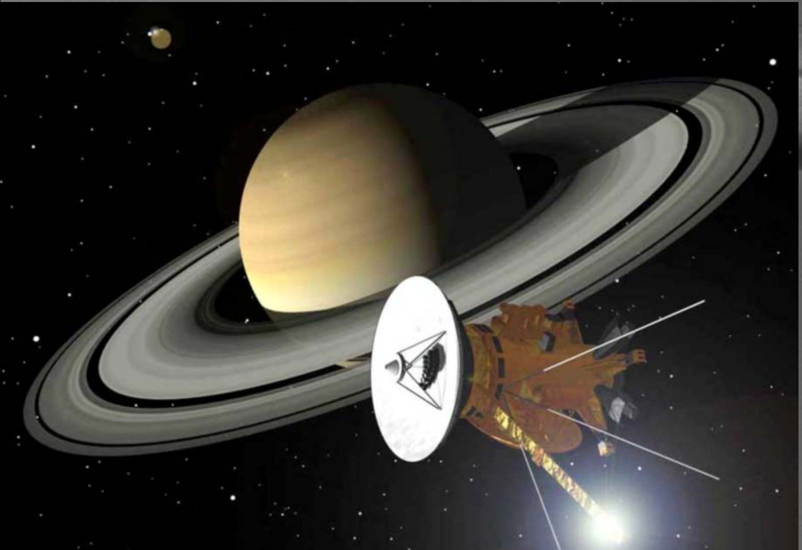
Agence spatiale européenne

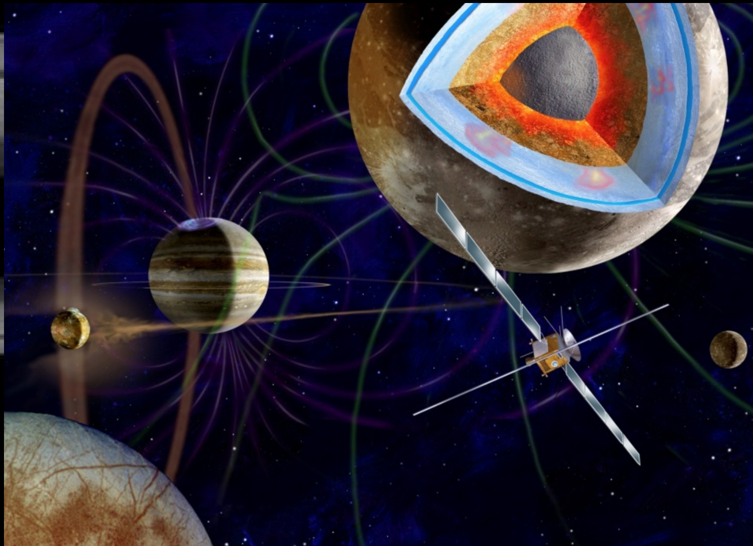


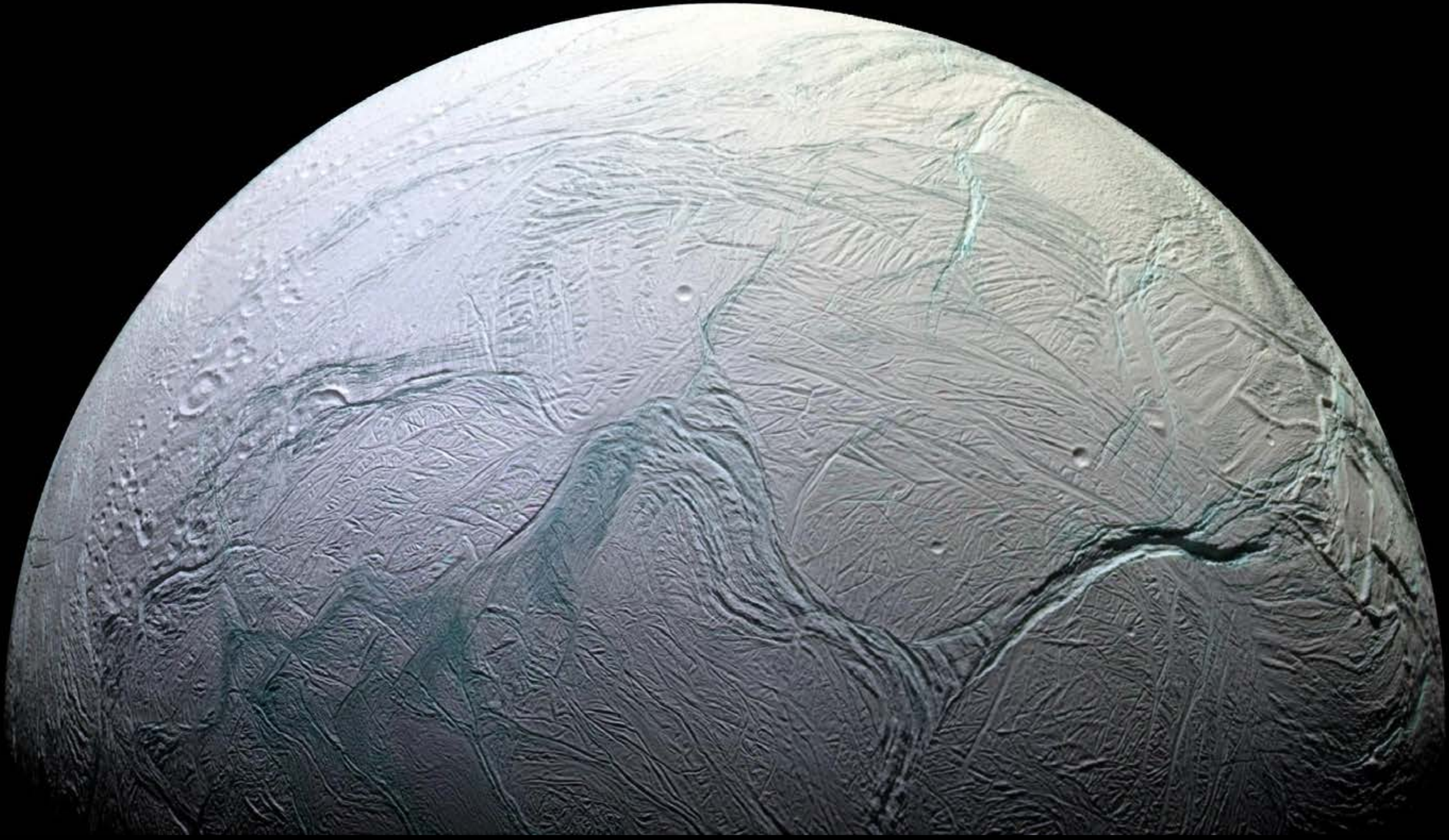
JUICE artist impression (Credits ESA, AOES)

FROM CASSINI TO JUICE

‚Study the habitability of Icy Moons around Gas Giants‘ (Cosmic Vision)

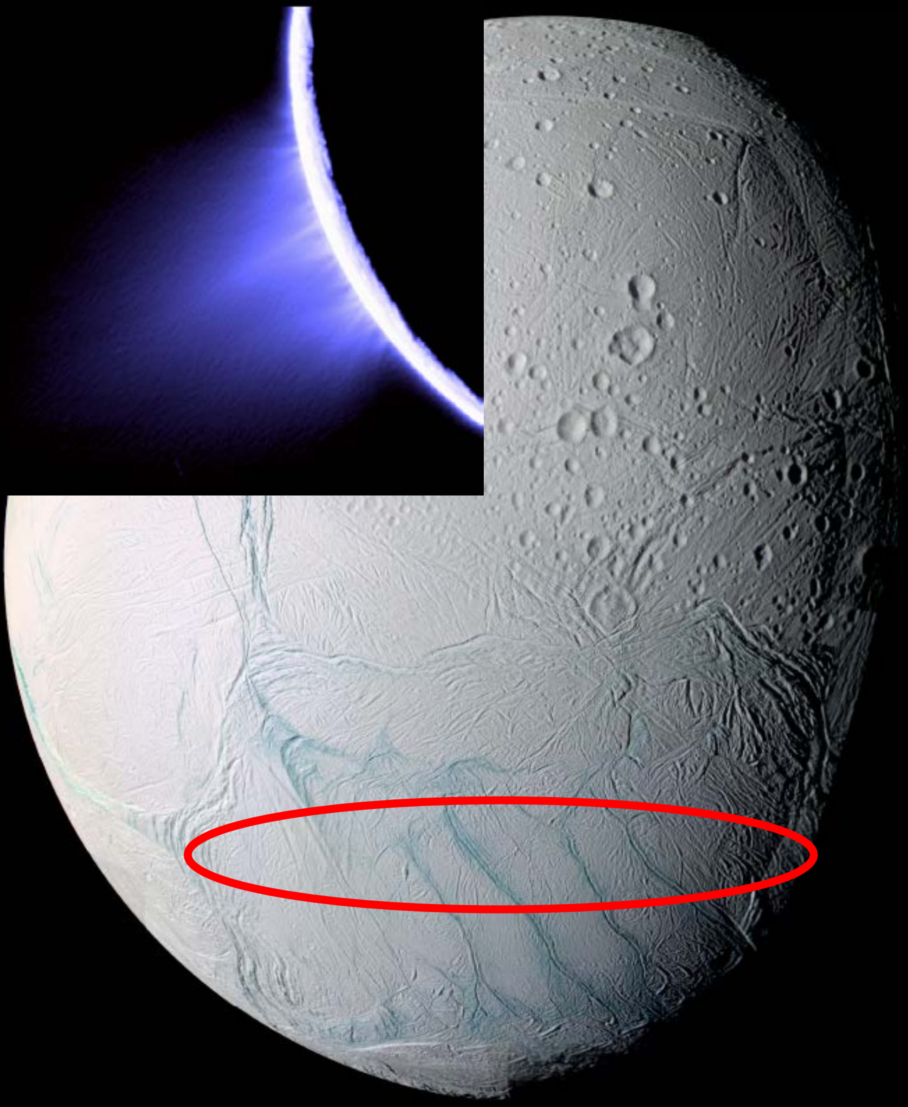


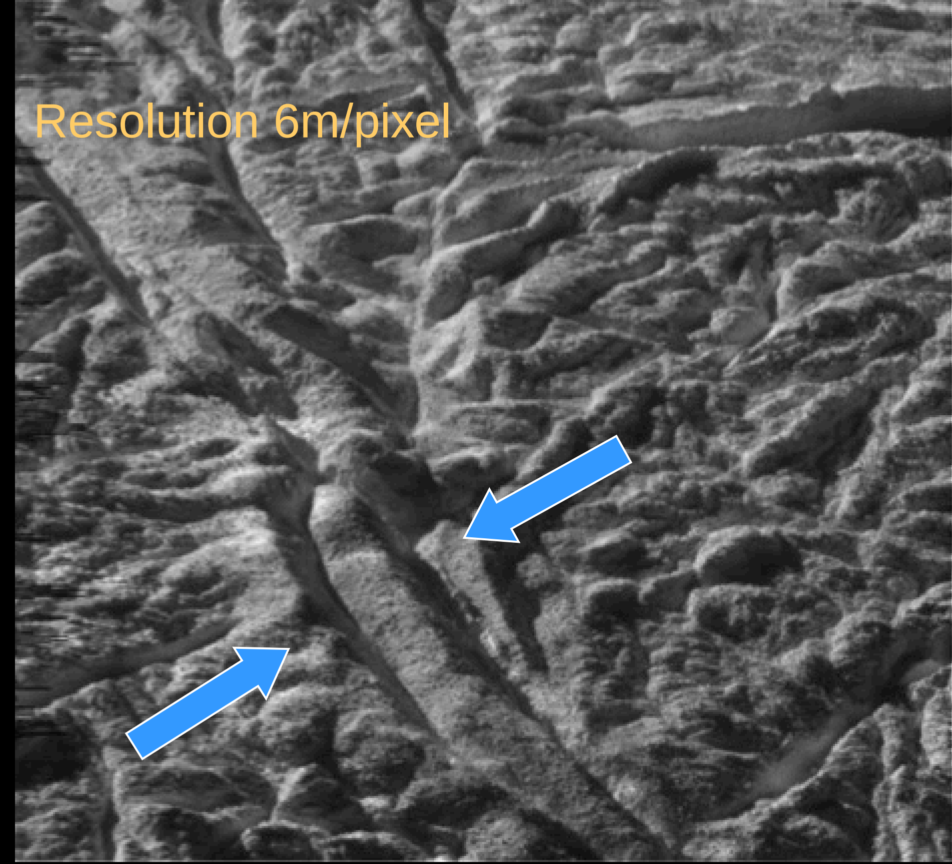




ENCELADUS !!

An icy crust…
Liquid water below the crust…
And heat !!

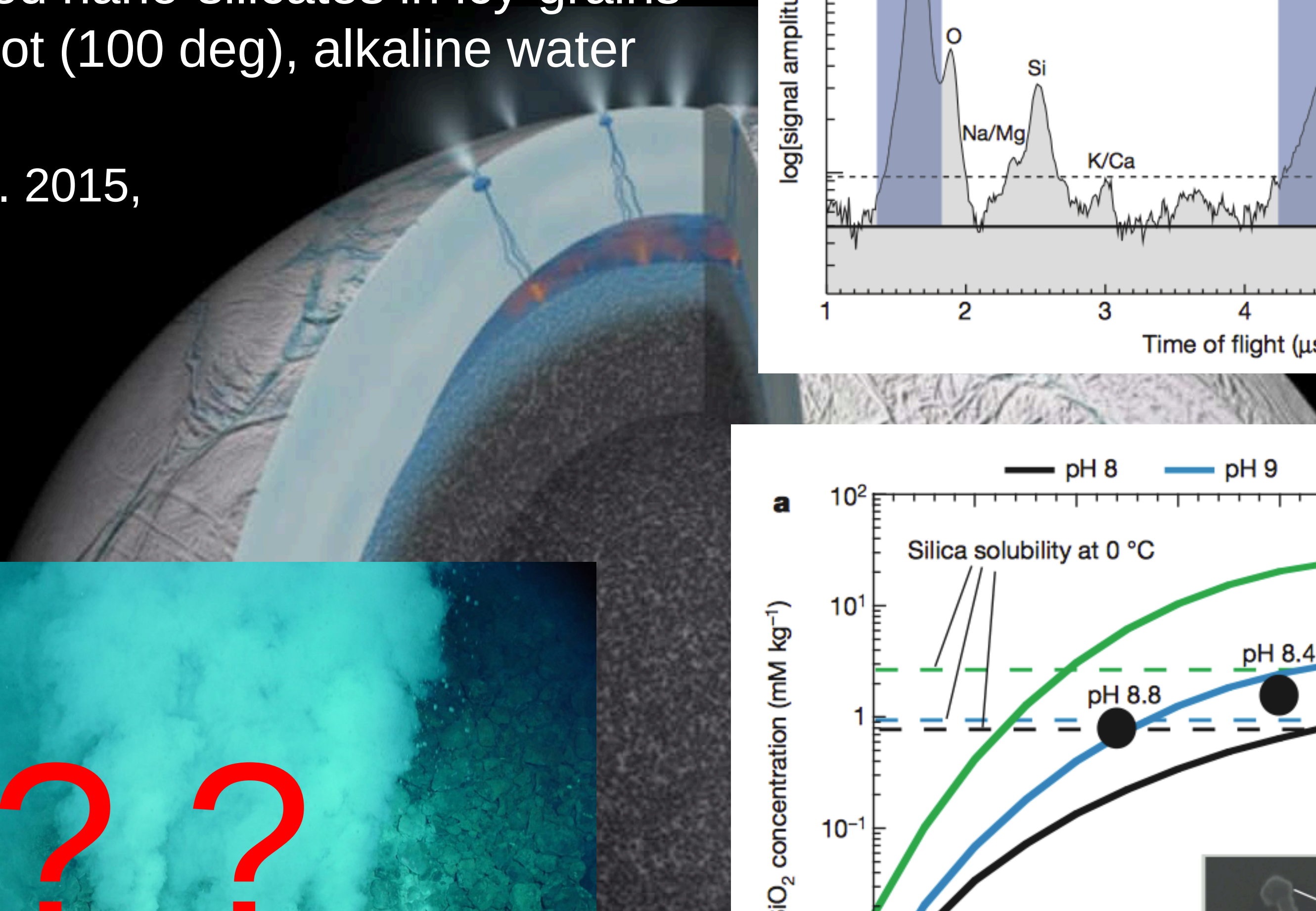


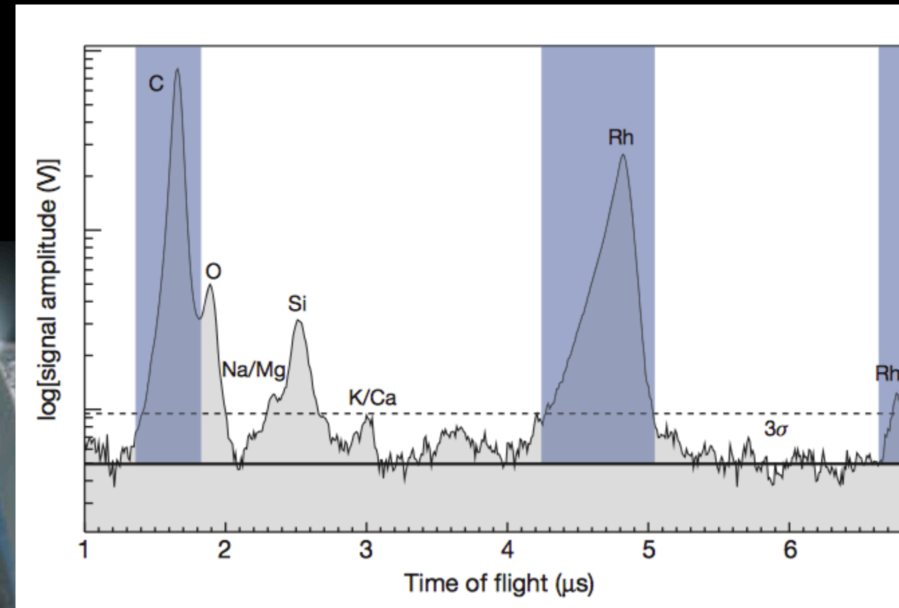


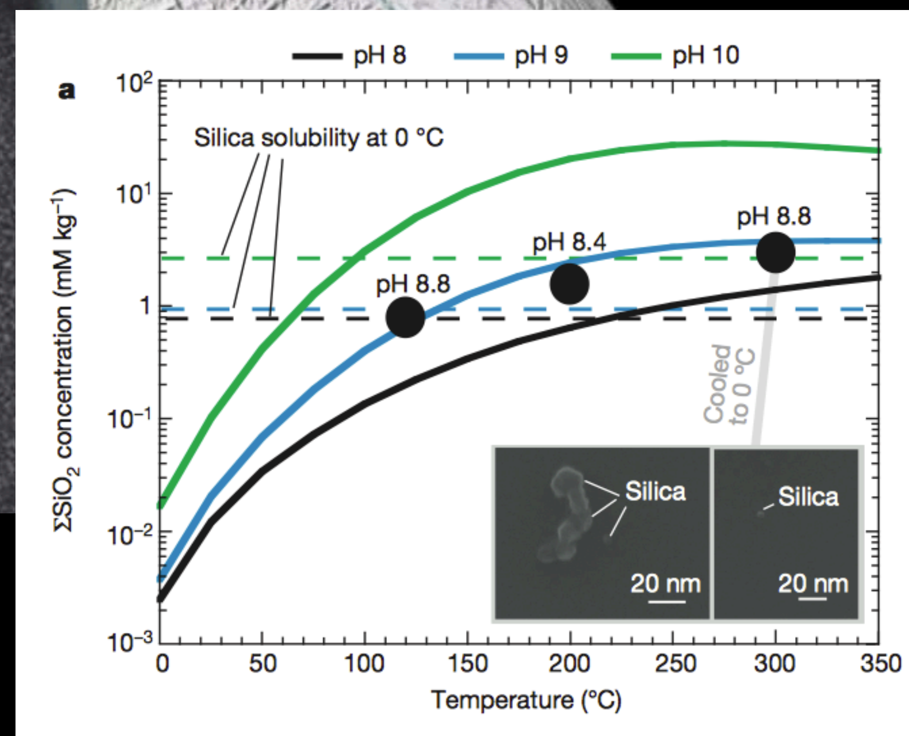
Ongoing hydrothermal activities at sea floor

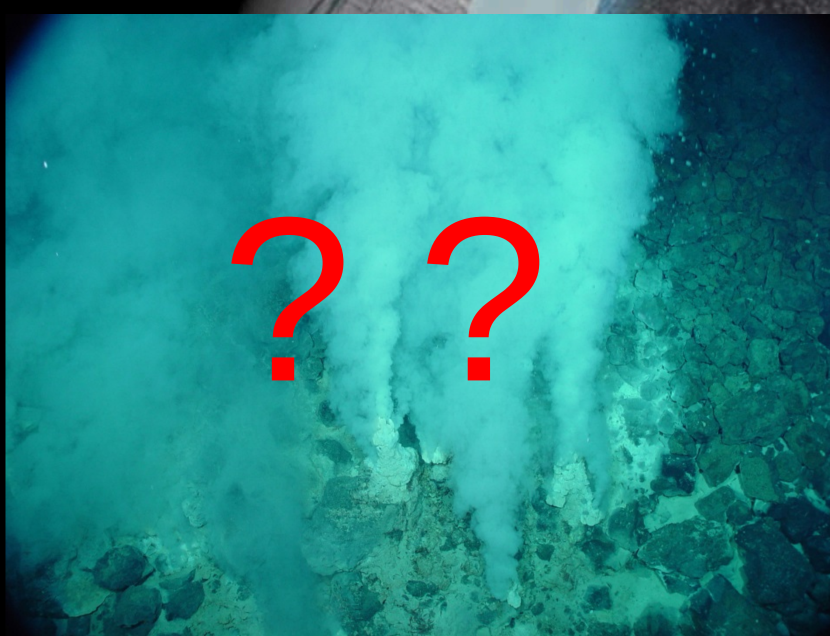
Embedded nano-silicates in icy-grains require hot (100 deg), alkaline water

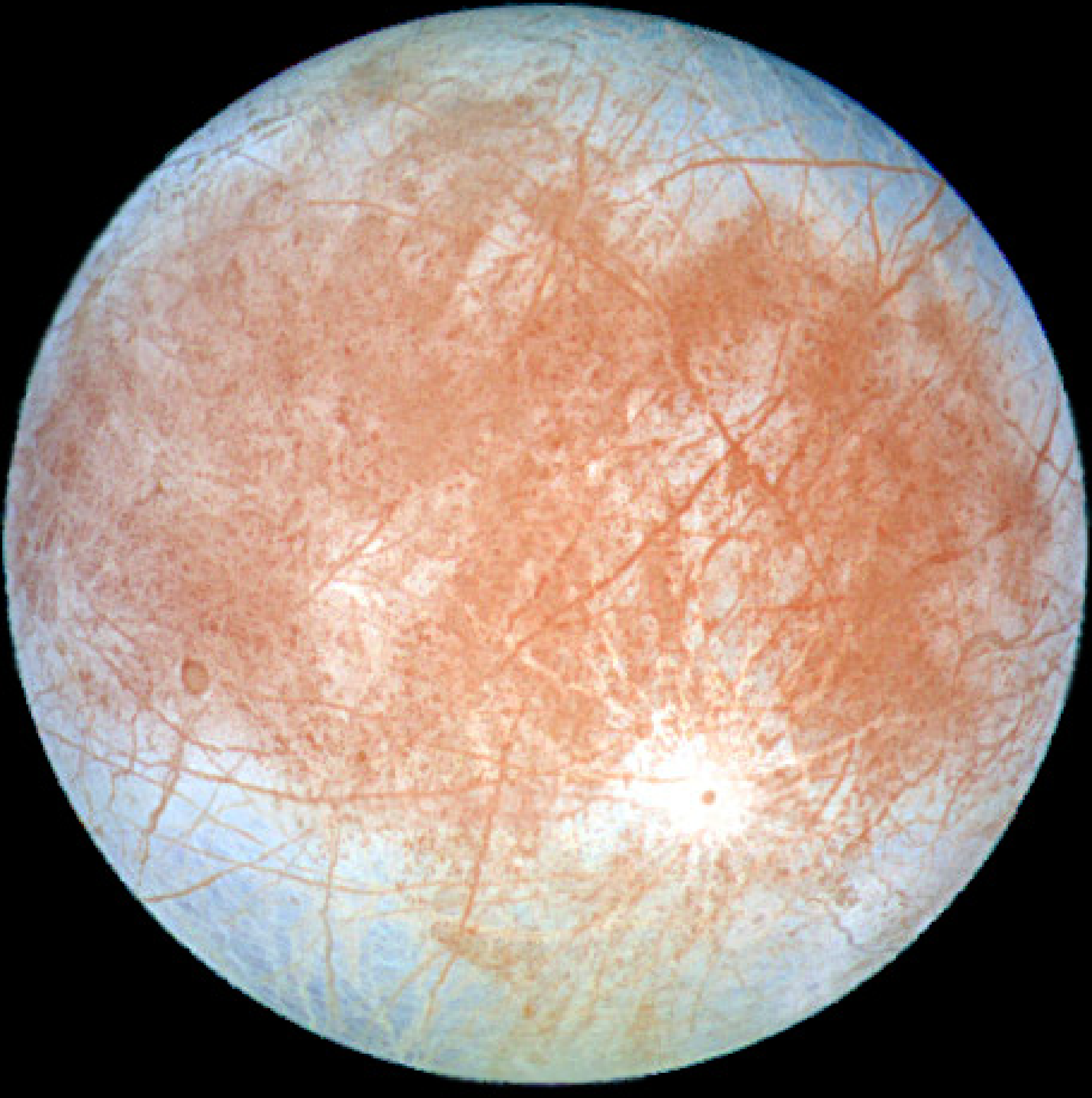
Shu et al. 2015, Nature



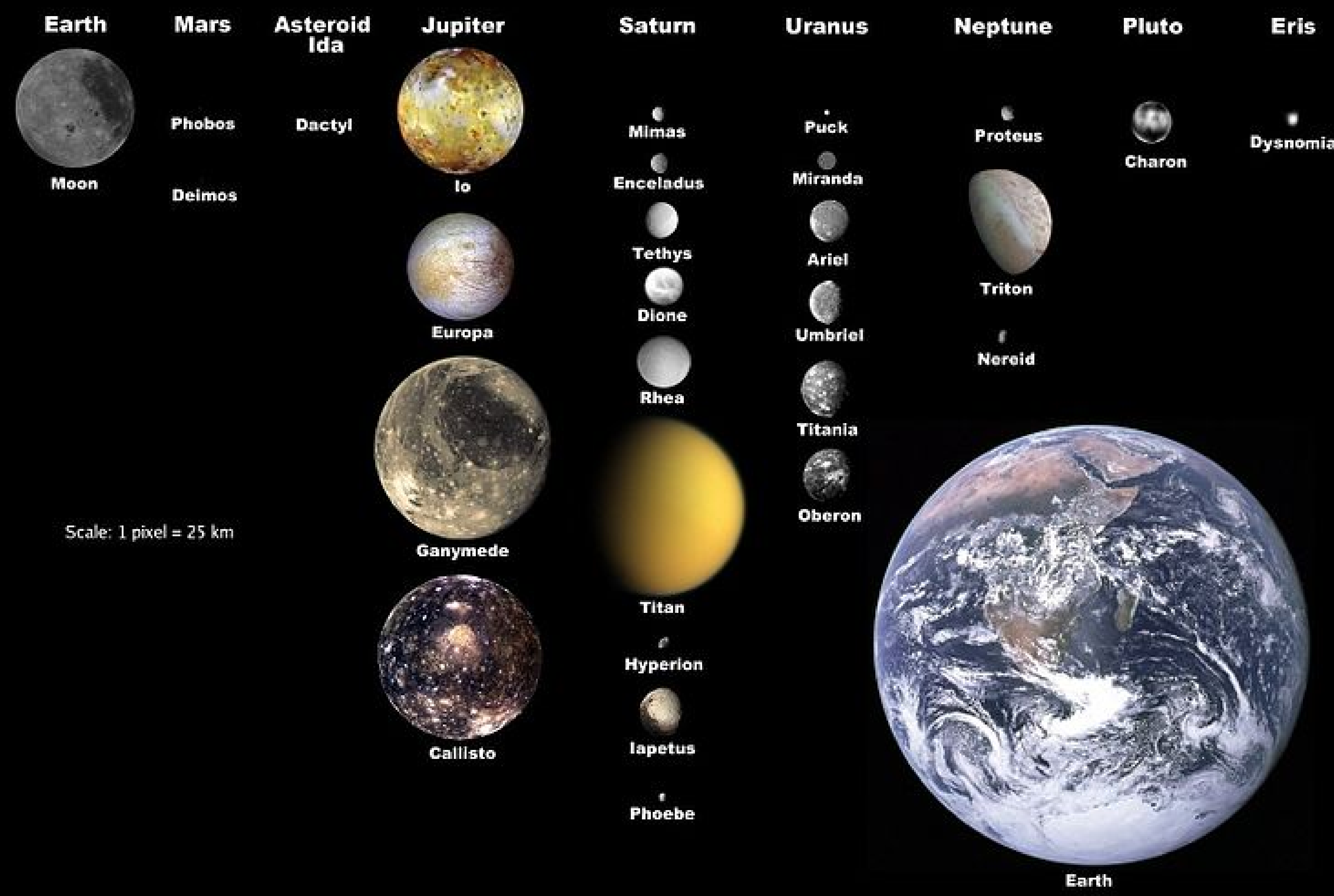




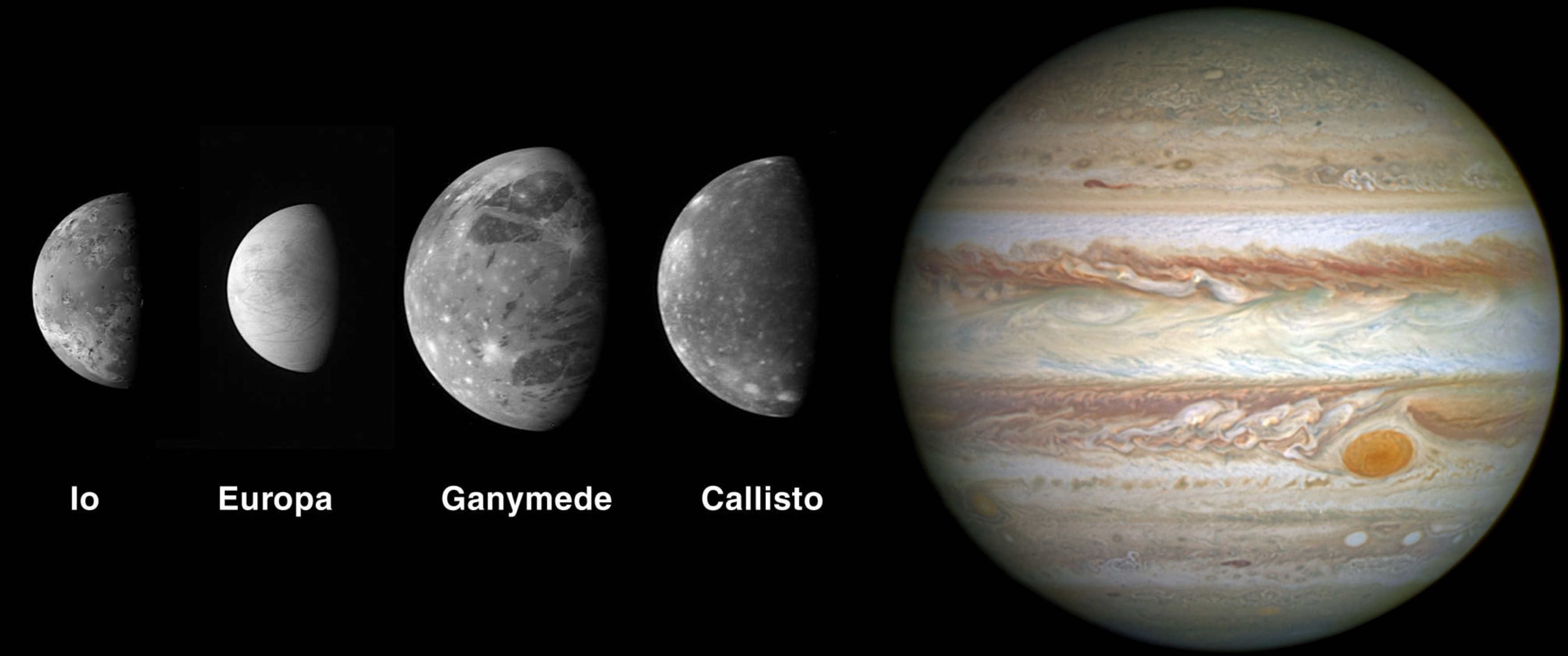




Selected Moons of the Solar System, with Earth for Scale

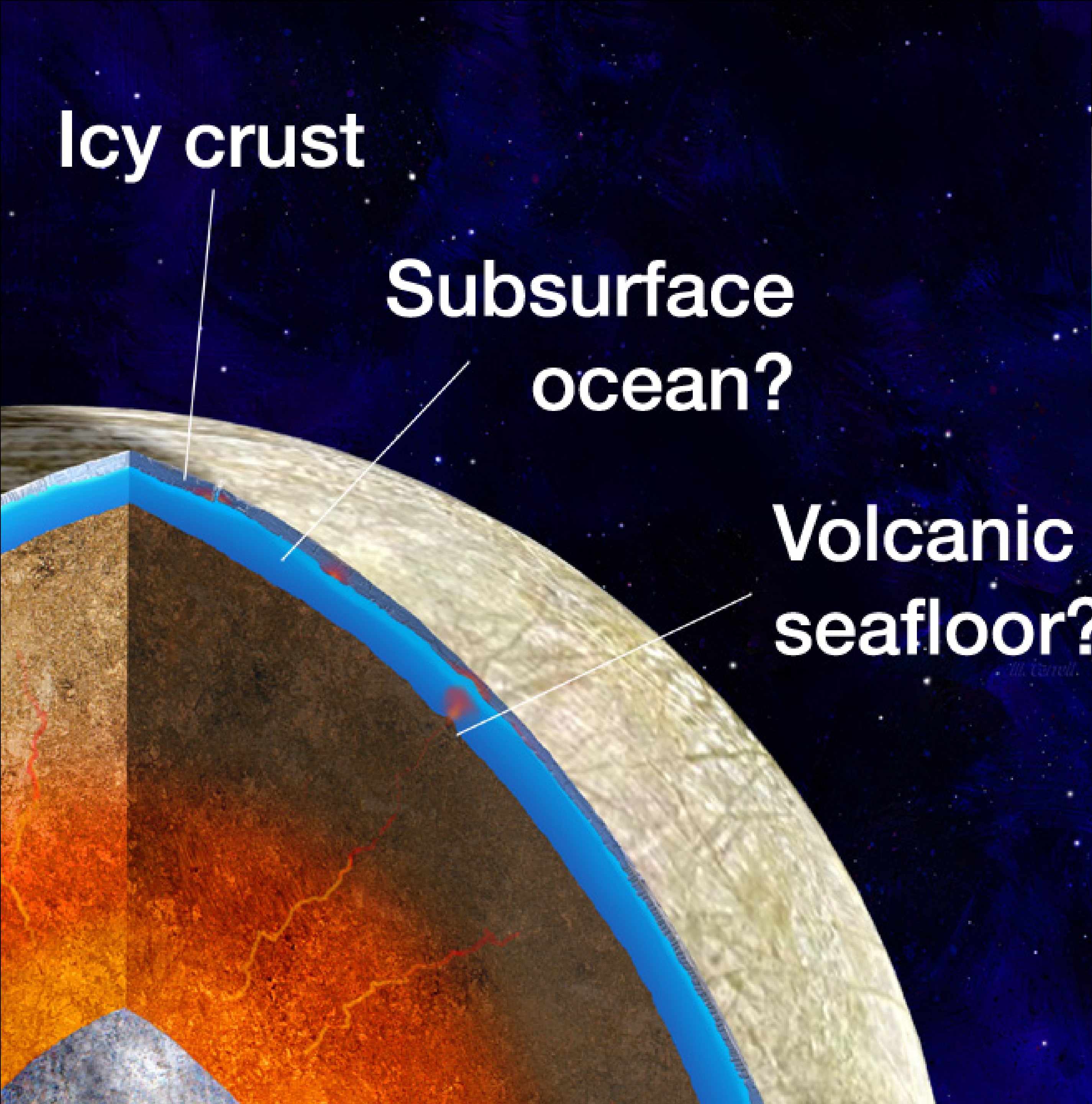


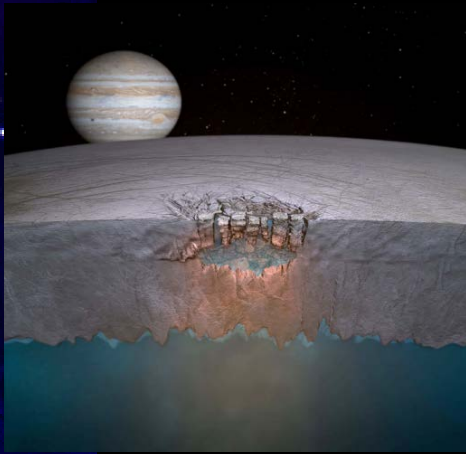
Jupiter Icy Moons Explorer

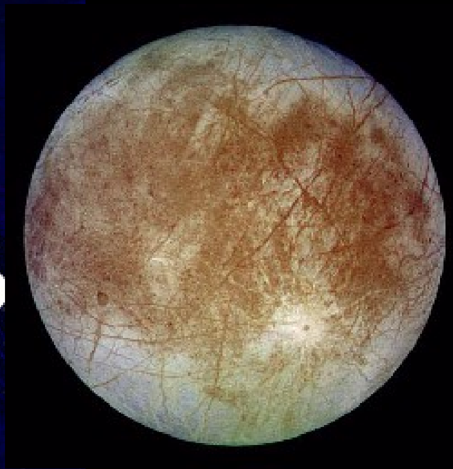


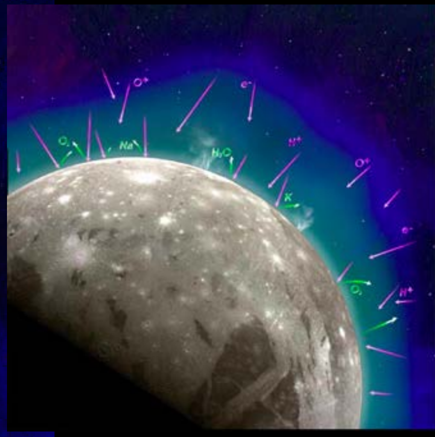
Emergence of habitable worlds around gas giants

Jupiter system as an archetype for gas giants

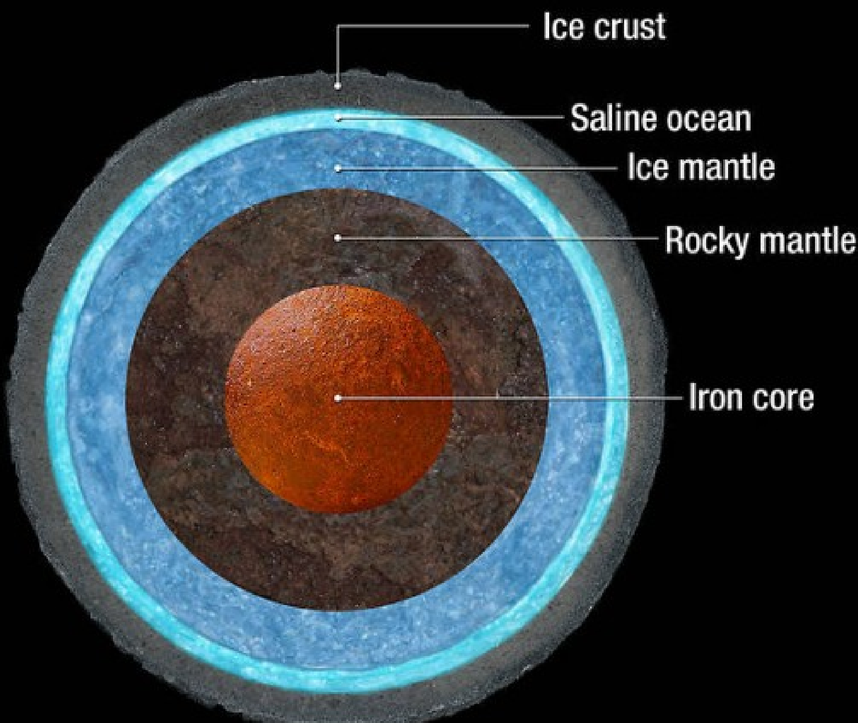

Icy crust
Subsurface ocean?
Volcanic seafloor?

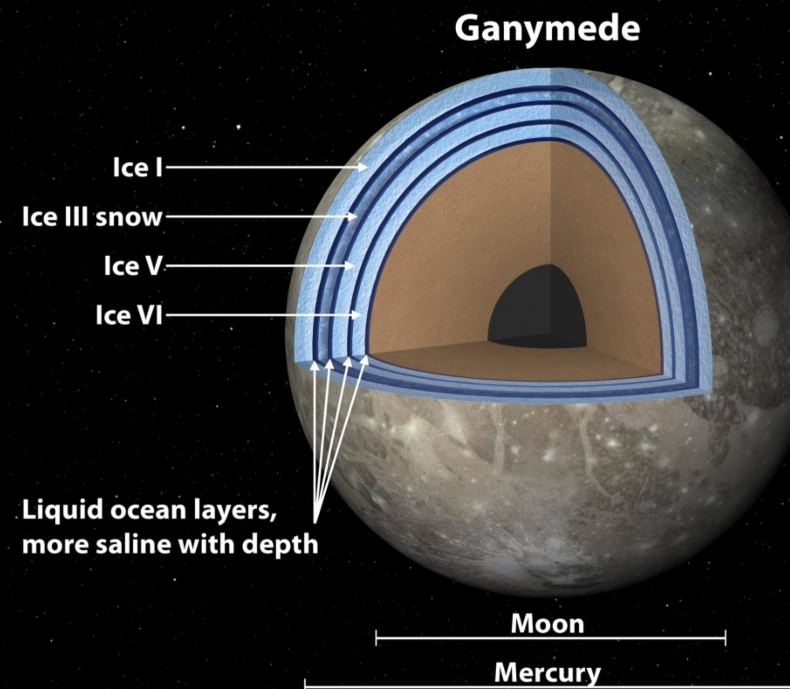


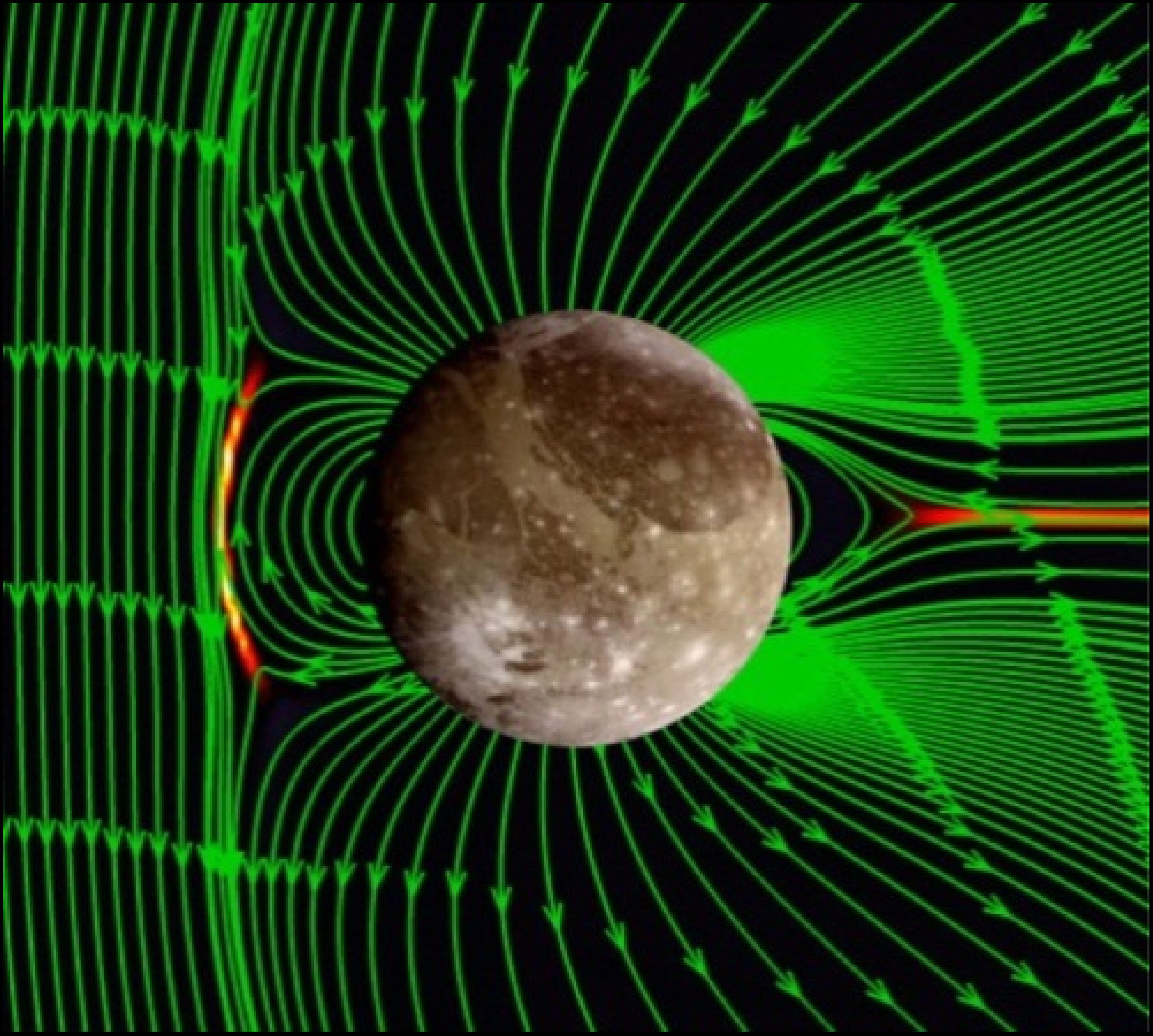


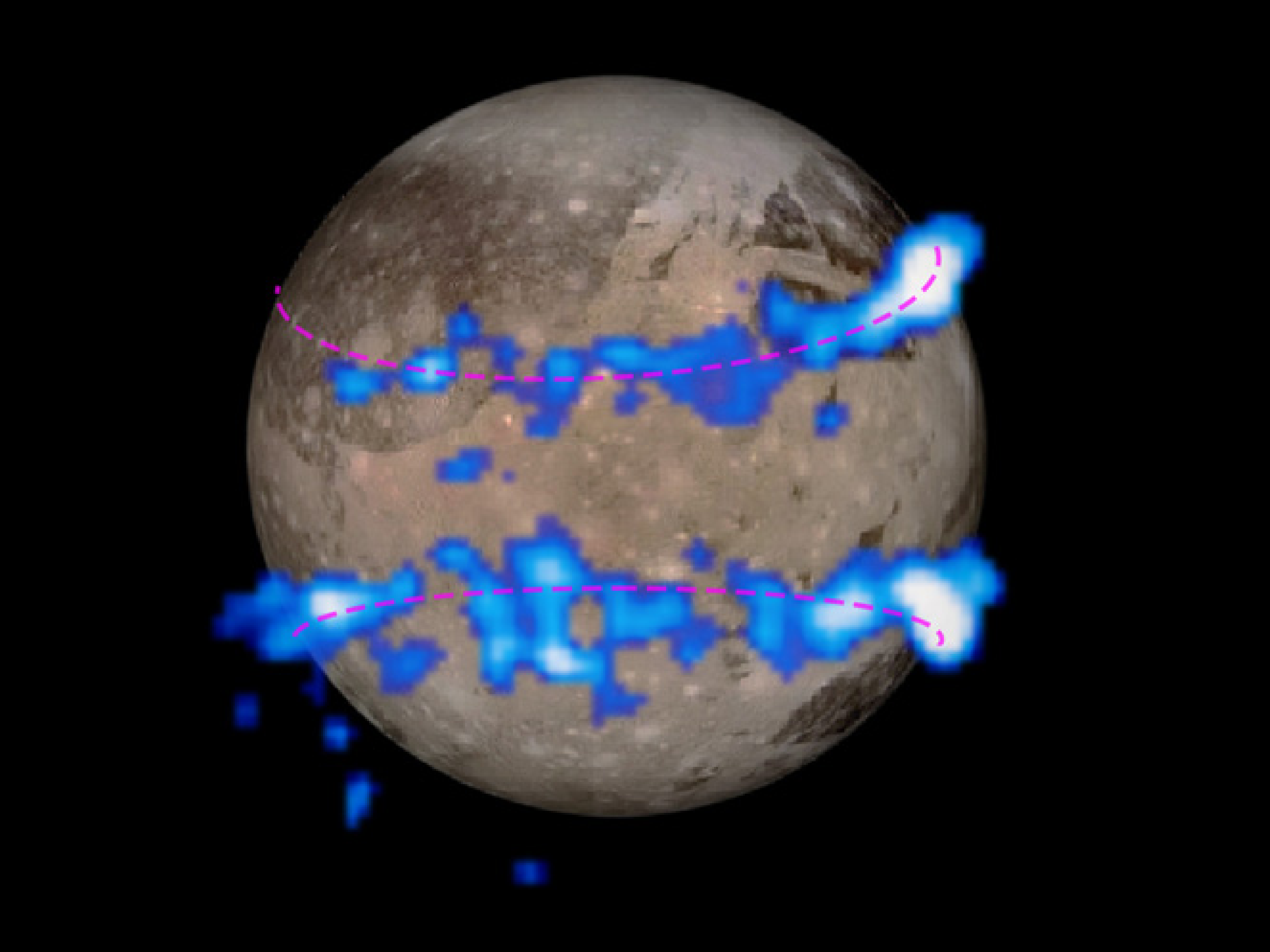


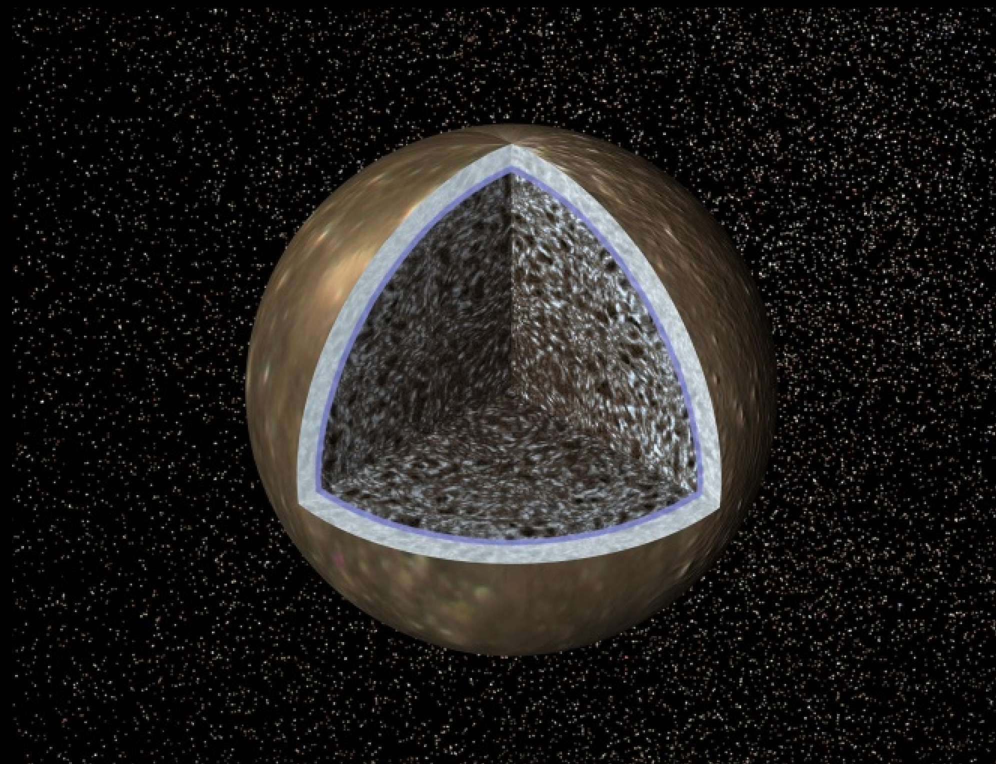
Ganymede Interior





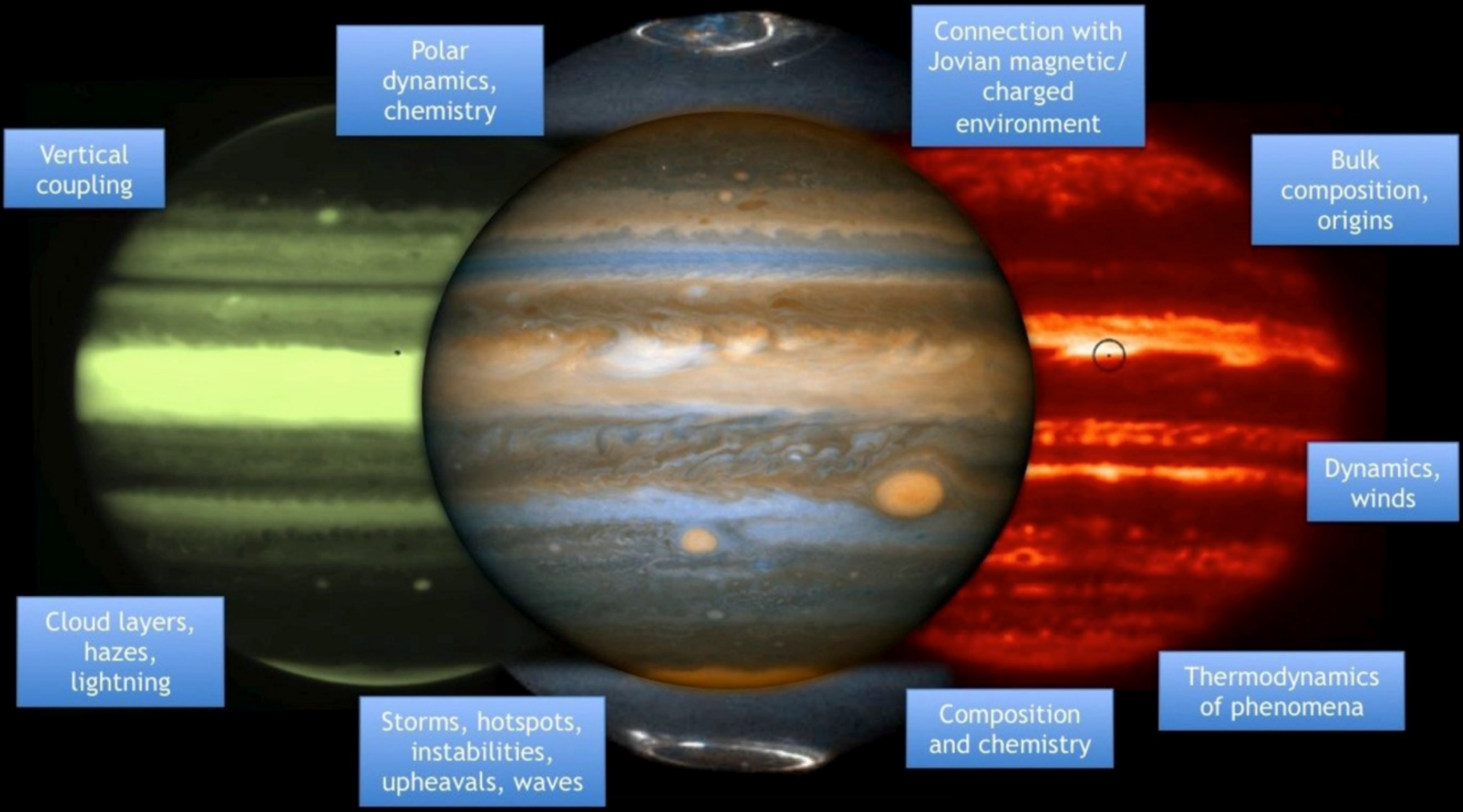






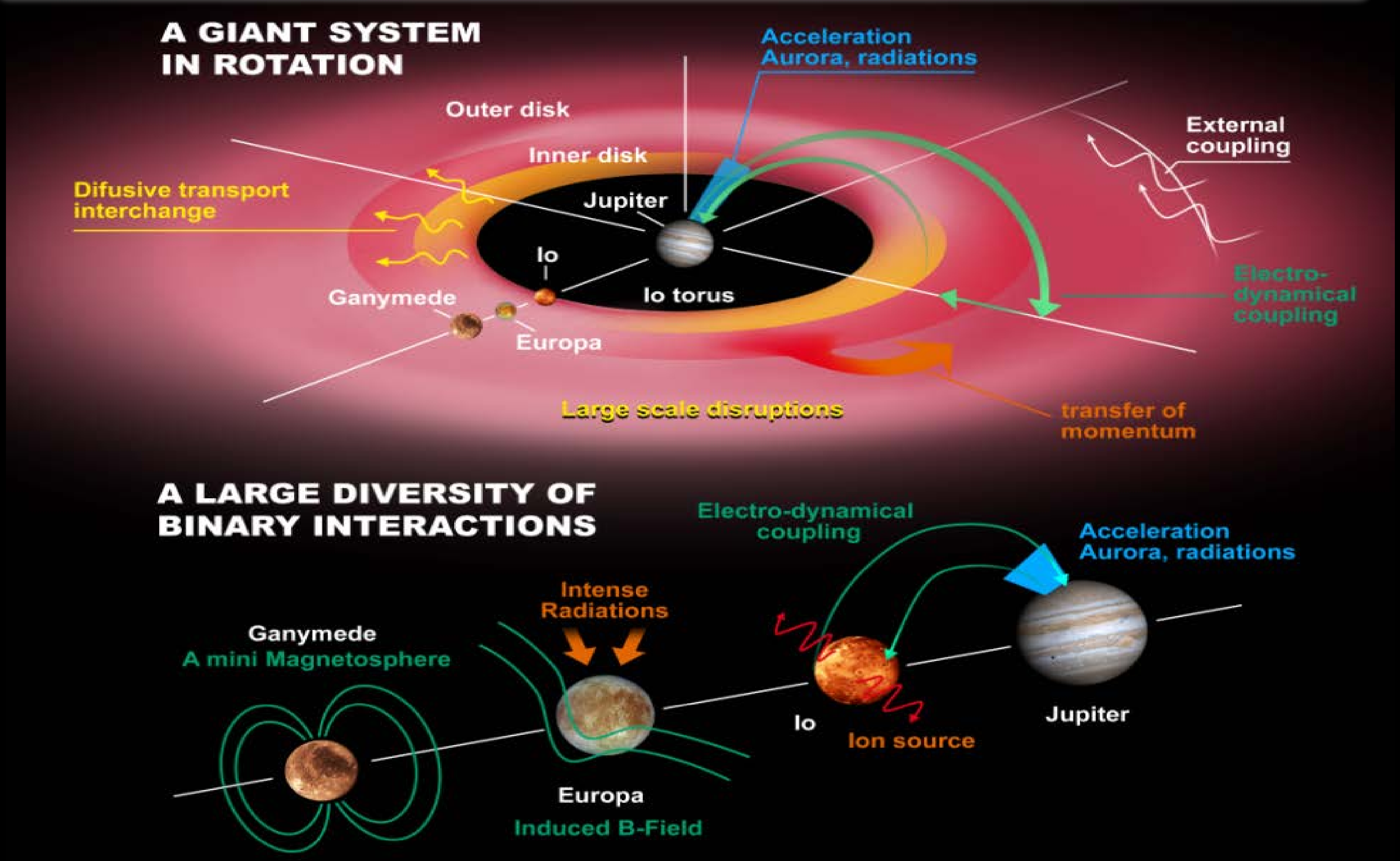
Jupiter atmosphere

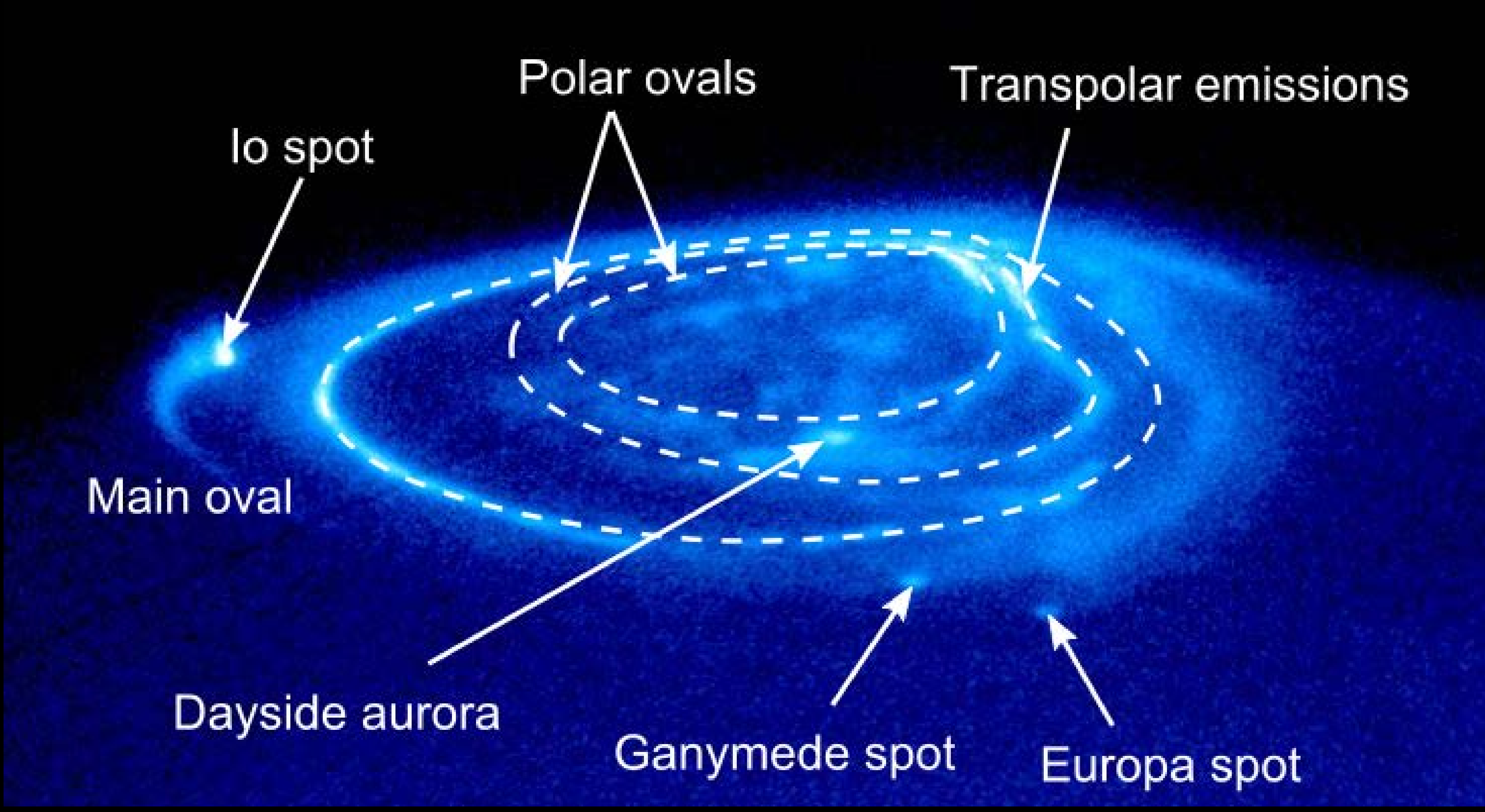
- *Atmospheric structure, composition and dynamics*
- *Coupling between troposphere, stratosphere and thermosphere*



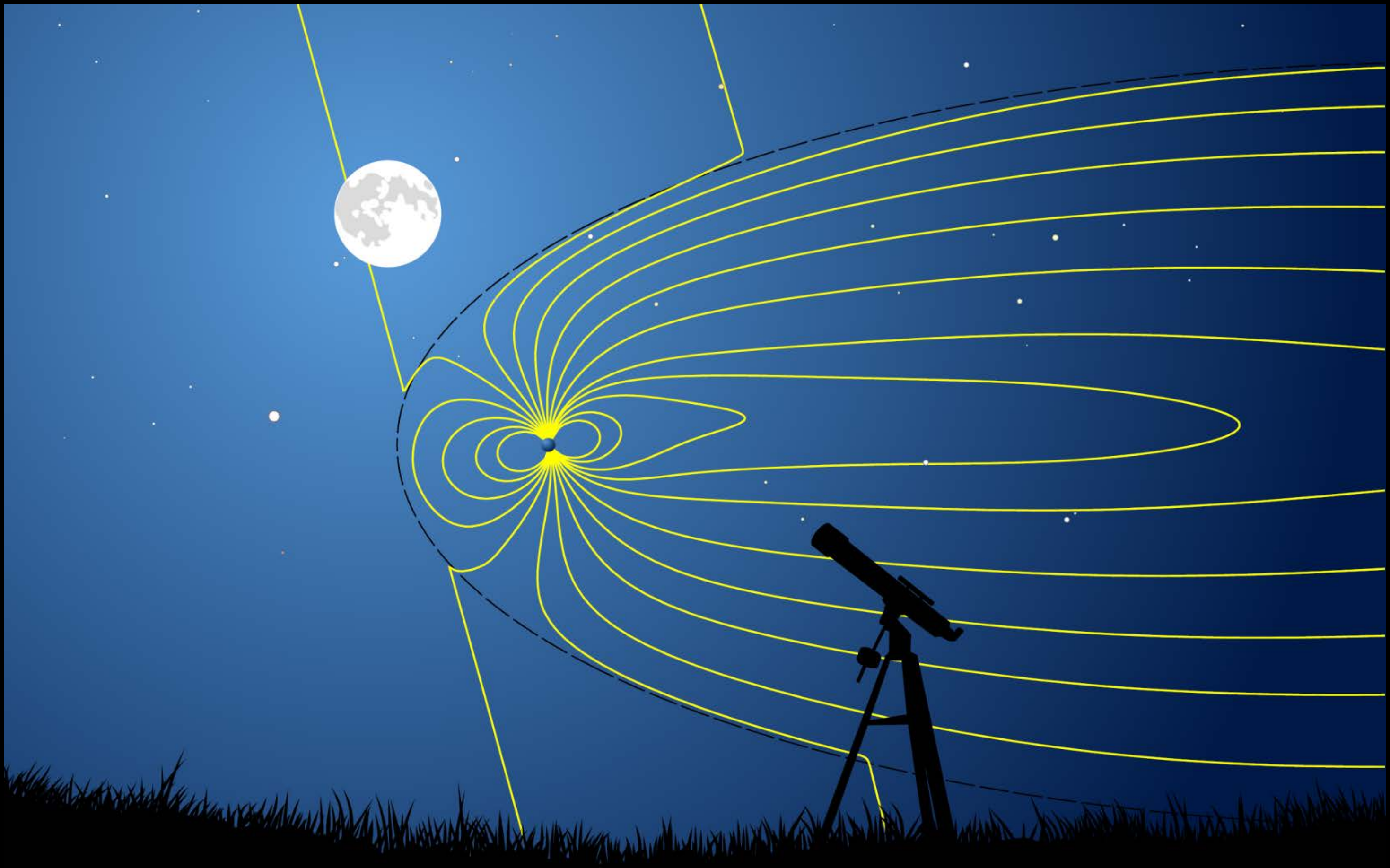
Jupiter magnetosphere

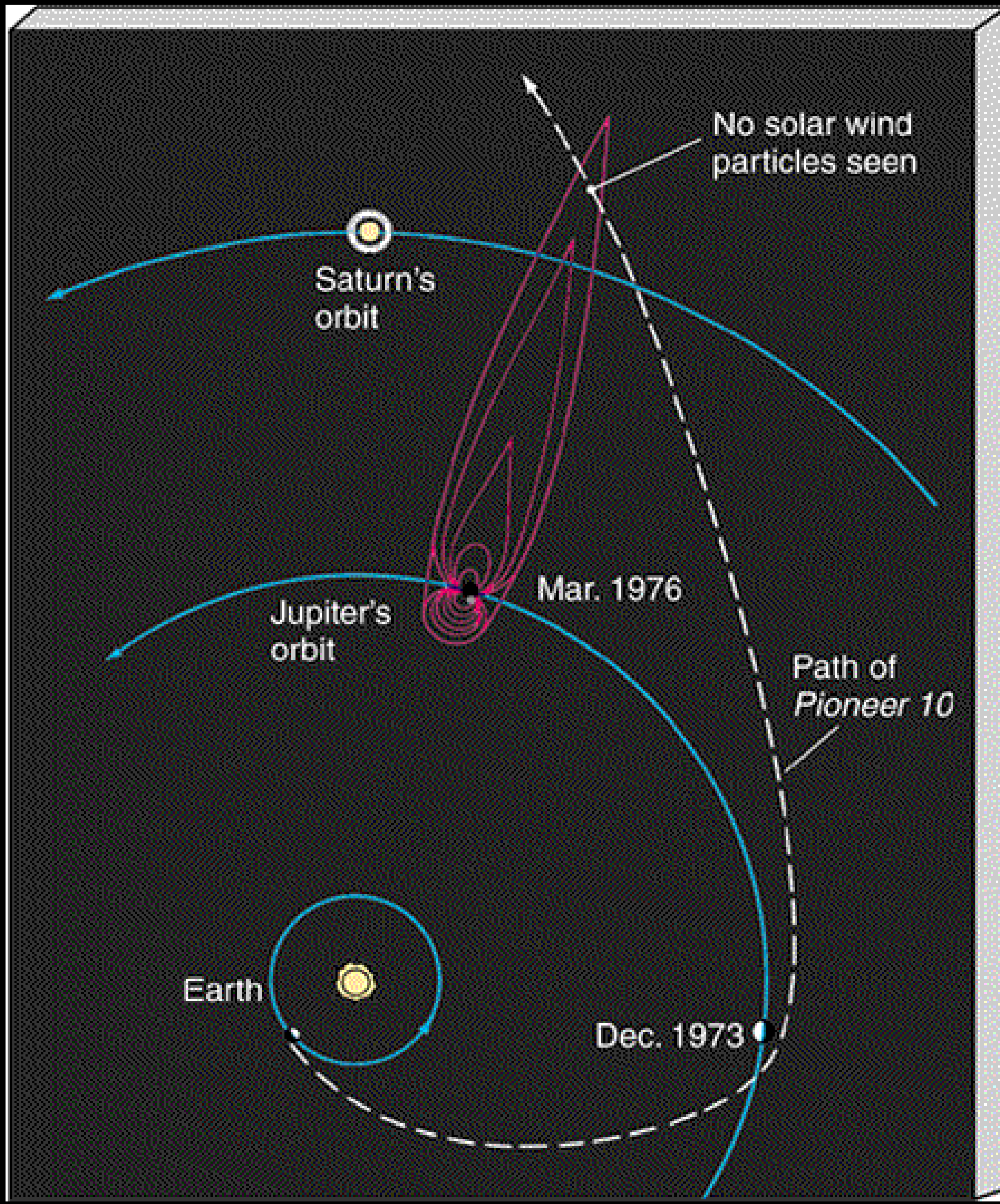
- *Magnetosphere as a fast rotator*
- *Magnetosphere as a giant particle accelerator*
- *Interaction of the Jovian magnetosphere with the moons*
- *Moons as sources and sinks of magnetospheric plasma*




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

Jovian magnetosphere



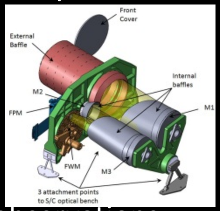


No solar wind
particles seen
Saturn's
orbit
Mar. 1976
Jupiter's
orbit
Path of
Pioneer 10
Earth
Dec. 1973

JUICE Payload

JANUS: Visible Camera System

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

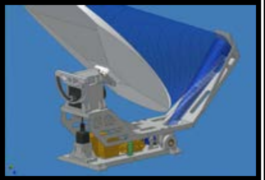


- ≥7.5m/pixel
- Multiband imaging, 380 - 1080 nm
- Icy moon geology
- Io activity monitoring and other moons observations
- Jovian atmosphere dynamics

SWI: Sub-mm Wave Instrument

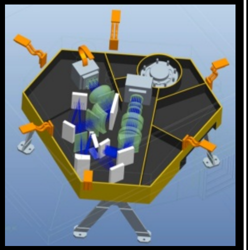
PI: Paul Hartogh, MPS, Germany

- 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

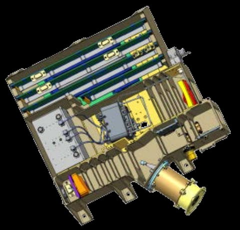
GALA: Laser Altimeter

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

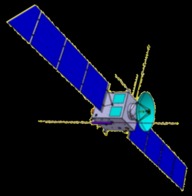
PI: Randy Gladstone, SwRI, USA



- 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

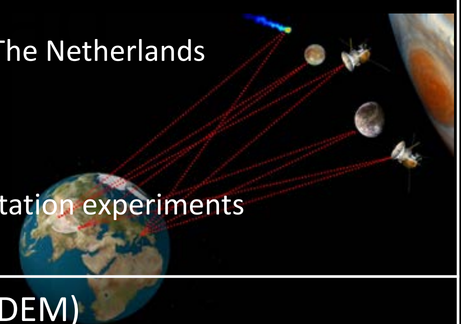
PI: Stas Barabash, IRF-K, Sweden
Co-PI: Peter Wurz, UBe, Switzerland

- 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

+ Radiation Monitor (RADEM)

JUICE Spacecraft

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

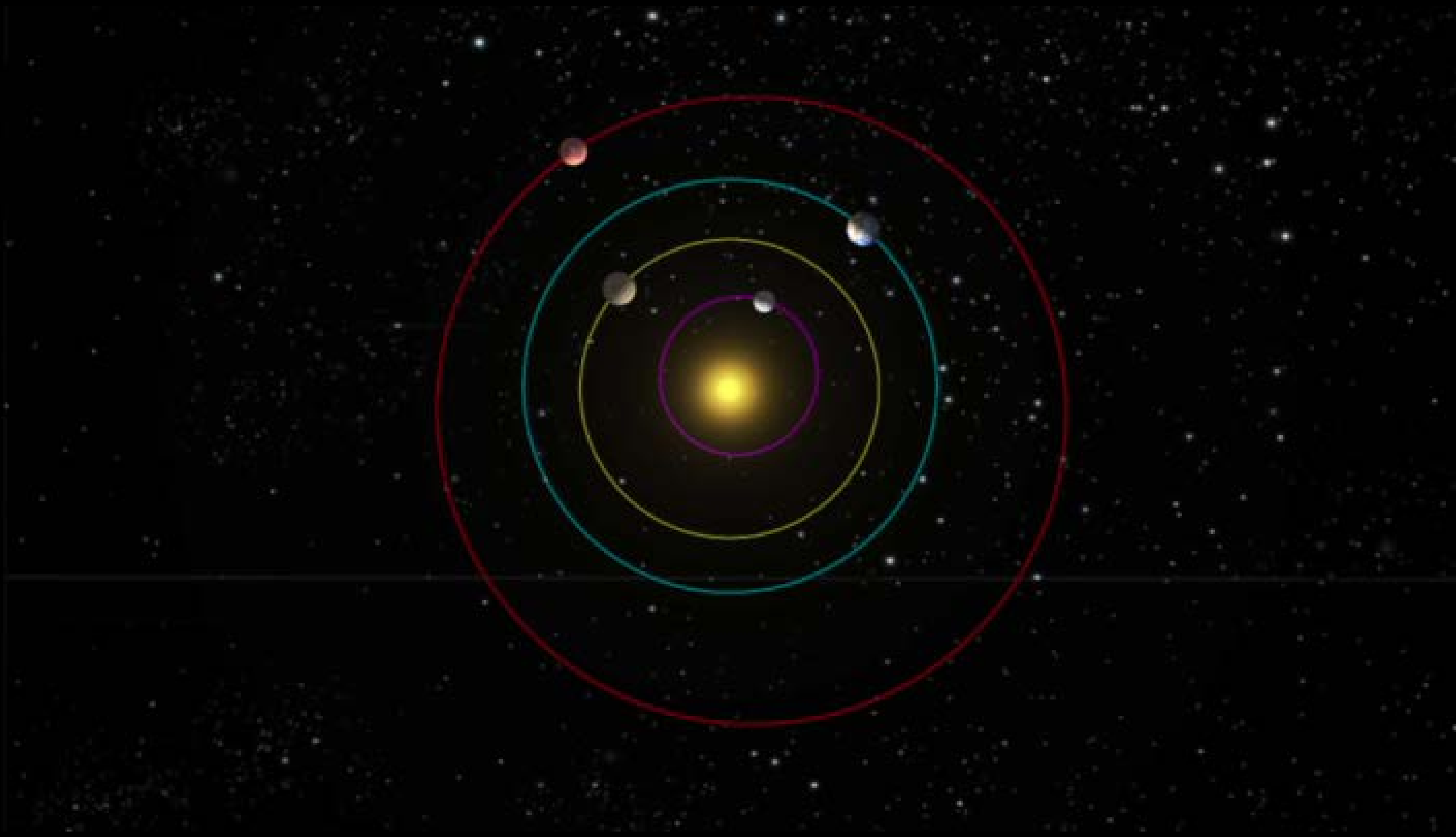
- Spacecraft:
  - 3-axis stabilised
  - Mass:
    - Launch mass: 5264 kg
    - Instruments: 219 kg
    - Propellant: 2857 kg
  - Solar array 97 m^2 (~850 W at Jupiter)
  - Fixed High Gain Antenna (X, Ka Bands)
  - Steerable Medium Gain Antenna (X, Ka Bands)
  - Data Volume > 1.4 Gb per day

JUICE Spacecraft

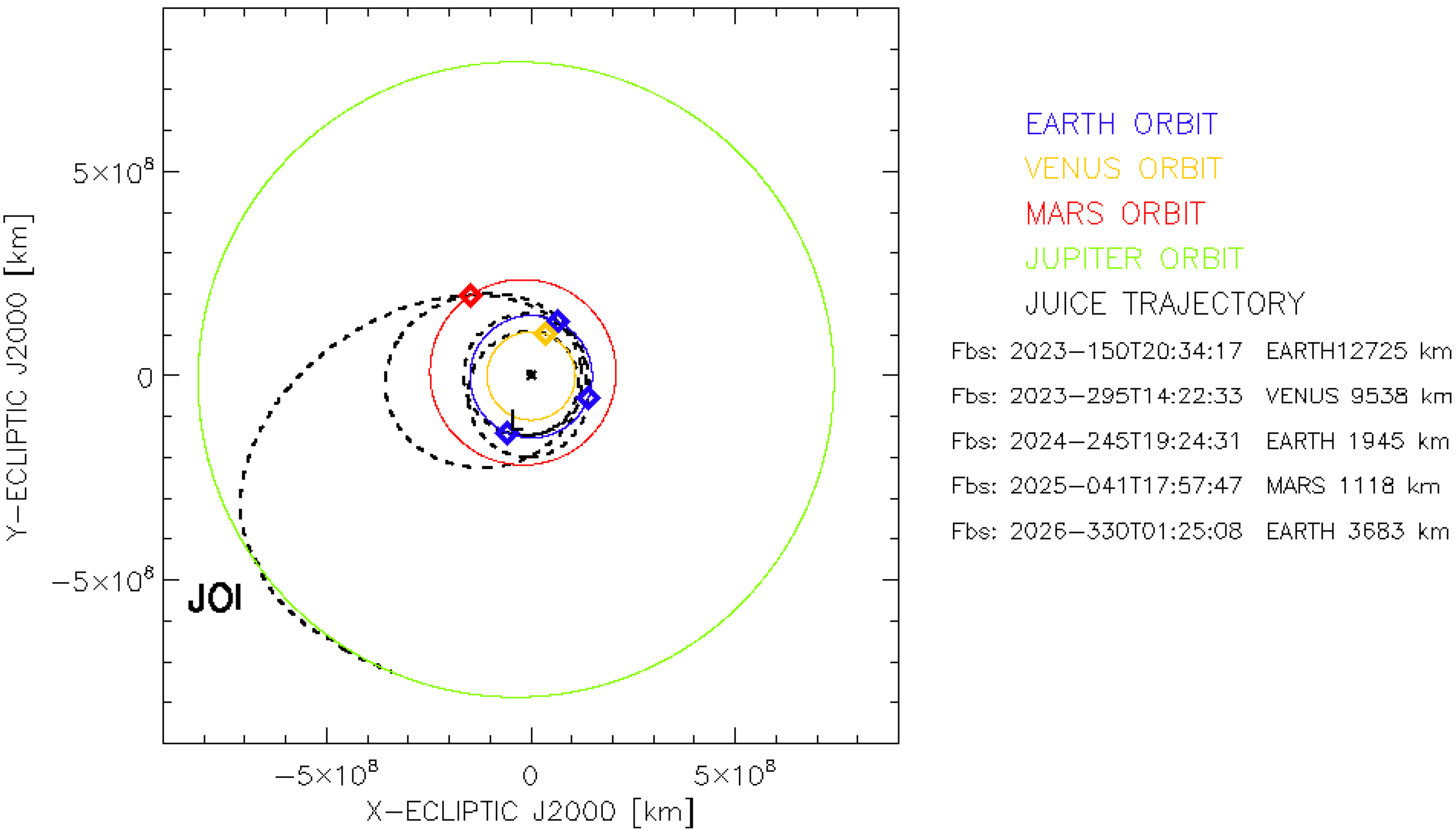
Courtesy Airbus D&S

Overall Mission Profile

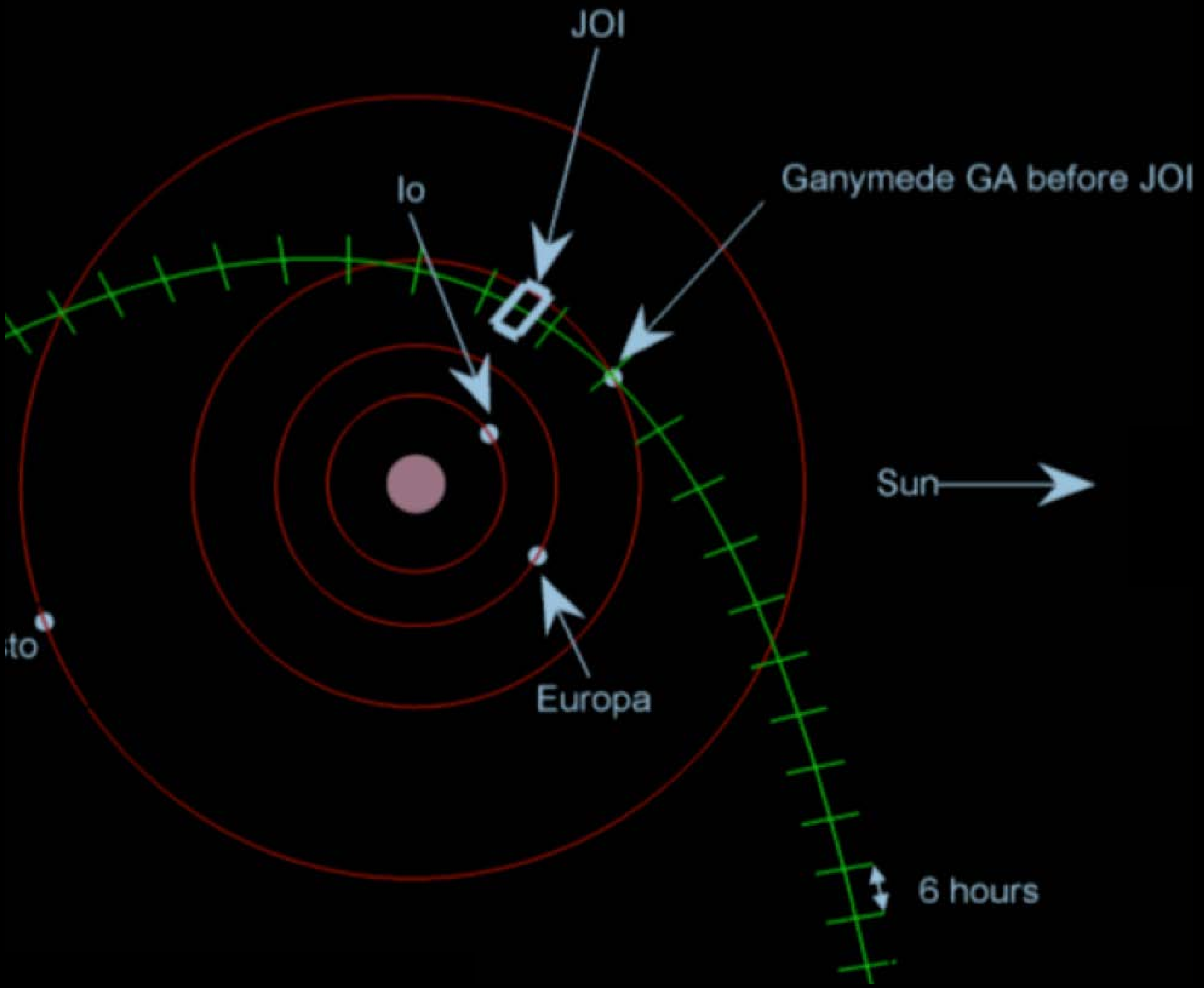
Launch	May / June 2022
Interplanetary transfer (Earth-Venus-Earth-Mars-Earth)	7.6 years
Jupiter orbit insertion	October 2029
2 Europa flybys	October 2030
Jupiter high-latitude phase	Dec 2030-May 2031
Transfer to Ganymede	June 2031-July 2032
Ganymede orbit insertion	August 2032
Ganymede elliptical orbit / 5000 km circular orbit	August-Dec 2032
Ganymede 500 km Circular Orbit	January-June 2033
End of mission	June 2033



Cruise Phase with 5 Planetary Flybys

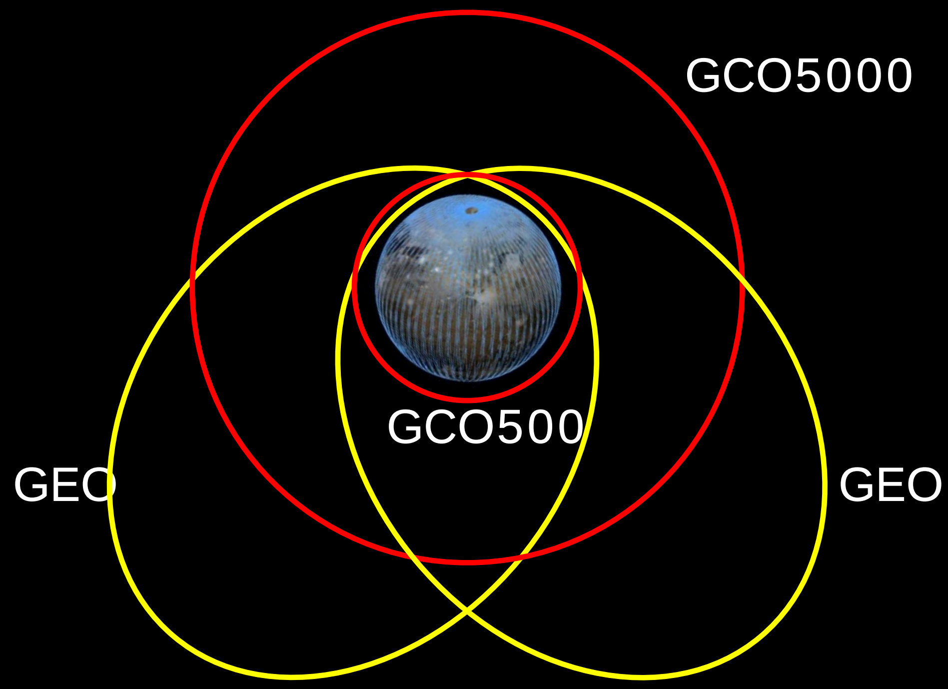


Jupiter Orbit Insertion



Icy Moon Flybys

- 2 EUROPA @ 400 km
- 11 GANYMEDE @ 400-33 000 km
- 13 CALLISTO @ 200-6000 km


GCO5000
GCO500
GEO
GEO

JUICE SOC activities

SOC development concept

- Main challenge for SOC: **VERY** long cruise phase (7 years) **NO SCIENCE** during cruise phase

→ No need for full SOC functionalities at launch – main development during Cruise phase, driven by functionalities need-dates

- **However:**

→ need to have SOC-embryo **as early as possible** to **keep development consistency** of MOC/Instrument Teams/SOC
→ check **Science Feasibility within S/C sizing during iterations Project/Industry**

- **HENCE:**

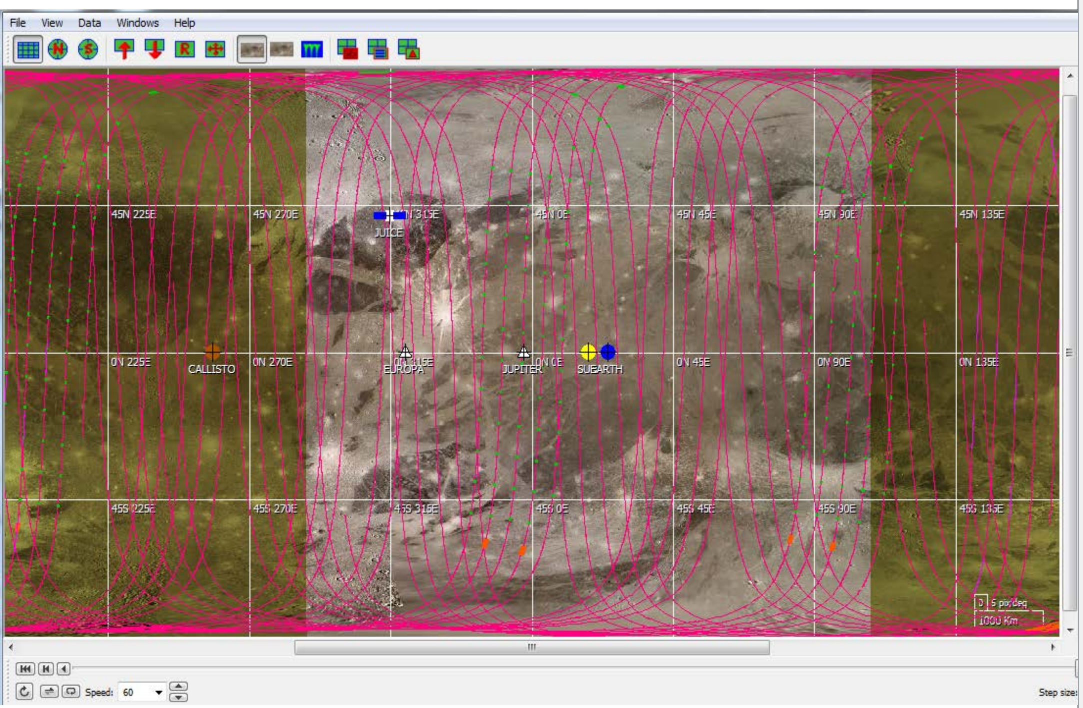
→ SOC **exists formally** since mission adoption [November 2014]
→ Main work package: simulation of Science Ops Scenarios *(Supporting SWT/PS **AND PROJECT**!)*
→ RE-use available tools….

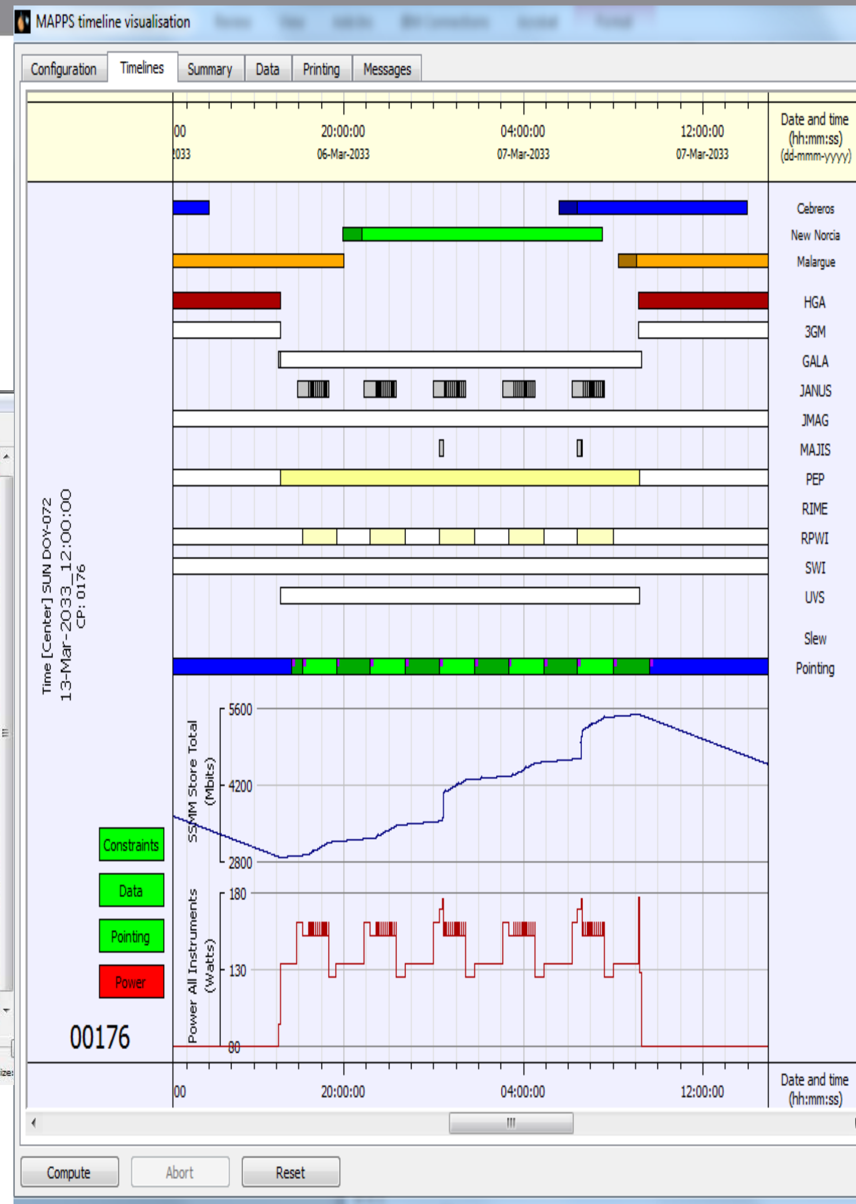
SOC Current activities

1- Support to the SWT:

- Support and coordinate the work of ***4 Working Groups*** (one per discipline: Geophysics/Surface-exosphere/Plasma/Jupiter)
- Start collecting observations and observation campaigns details (***centralized observations library***)
- ***Science scenarios simulations and analysis***:
  - Europa flyby (Closest Approach *+/- 12hours*)
  - Jupiter equatorial phase (*20 days* scenario covering Jupiter equatorial orbit and Ganymede flyby)
  - Ganymede circular orbits at 500 km altitude (*4months* duration, end of nominal mission)

GCO-500 simulations





SOC Current activities

2- Support to industry :

- Development of engineering scenarios for thermal and power analysis

(Difficulties: boundary conditions for SWT and Industry scenario diverged...)

3- Support reviews:

- SRR Q1 next year (documentation, scenarios)
- IPDR review next year (10 instruments)

4- Support SOC planning system development: Identify planning tools requirements:

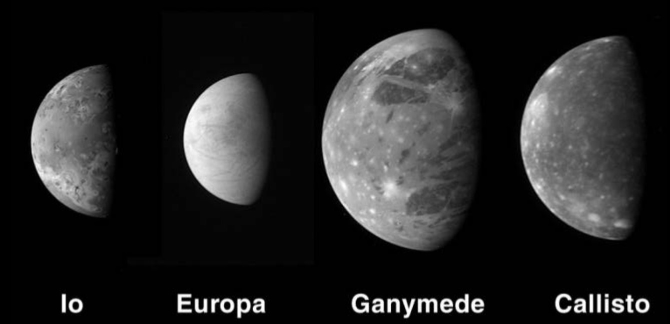
- Currently using already existing tools (MAPPS), in-house scripts and manual process.
- Book keeping of currently missing functionalities that will be needed as part of the system development.

Concluding remarks

Very broad and interdisciplinary investigations : interior, subsurface, geology and surface composition, atmospheres, plasma, rings, dust, habitability, origins, exoplanets

Challenges:

→ Big mission
→ Long cruise phase
→ Radiation environment
→ Power and thermal
→ Data rate
→ Complex navigation in the Jupiter system



Jupiter system: largest planet, largest storm, fastest rotation, largest magnetic field, largest moon, largest moon system, most active moons