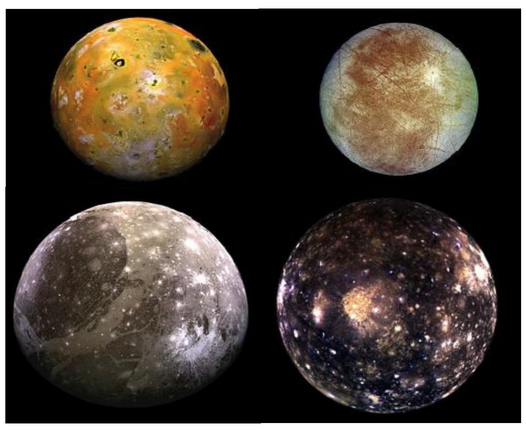
Moons and Jupiter Imaging Spectrometer (MAJIS): an exobiological instrument for Jovian system

P. Guiot[1], J. Carter[1], M. Vincendon[1], Y. Langevin[1], G. Piccioni[2], F. Poulet[1], G. Filacchione[2] and MAJIS team

1. Institut d'Astrophysique Spatiale (IAS), CNRS/Université Paris-Sud Paris-Saclay, building 121, 91405 Orsay, France
2. Istituto di Astrofisica e Planetologia Spaziale (IAPS), INAF, 100 via del Fosso del Cavaliere, Rome, Italy

Contact: pierre.guiot@ias.u-psud.fr

Introduction



Jupiter's system is an extraordinary small-scale model of planetary system, with a great complexity, that mostly remains to be understood:

➔ Strong **Jupiter magnetosphere** generating material exchanges

➔ Exobiological potential of the **subsurface liquid water oceans** of Europa and Ganymede

➔ Active **geology resurfacing satellites**, along with **exogenous processes**

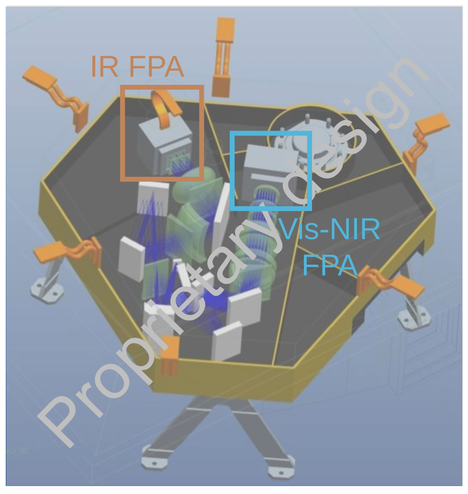
➔ Highly dynamical **Jupiter's atmosphere**

Most spectral imaging data of the Jovian system available so far come from Galileo/NIMS, though the dataset has recently increased with Juno/JIRAM. However, NIMS was highly impeded by noise levels due to the **harsh radiative environment.**

The MAJIS instrument design

The instrument characteristics:

- Thermal: **90K for IR FPA** (cold-shielded), **140K for Vis-NIR FPA** and optics, passive cooling.
- Spectral: grating spectrometer (Δλ < 10 nm) with **two channels** for **0,5-2,35 µm** and **2,25-5,54 µm** ranges, using the same telescope.
- Spatial: two 1024x1024 H1RG detectors, binned 2x2 for a 36 µm pitch, yielding a **150 µrad IFOV**.
- **Radiative:** need for shielding and mitigation strategies → **despiking.**



The IAS contribution

- Instrument currently in development **phase B/C.**
- IAS has instrument PIship and is responsible for the **Focal Plane Array**: detector, electronics and linear filter.
- Instrument **calibration facilities** will also be provided by IAS.

First characterization bench in its thermal vacuum chamber for detector's optical characterization

Main development challenges:

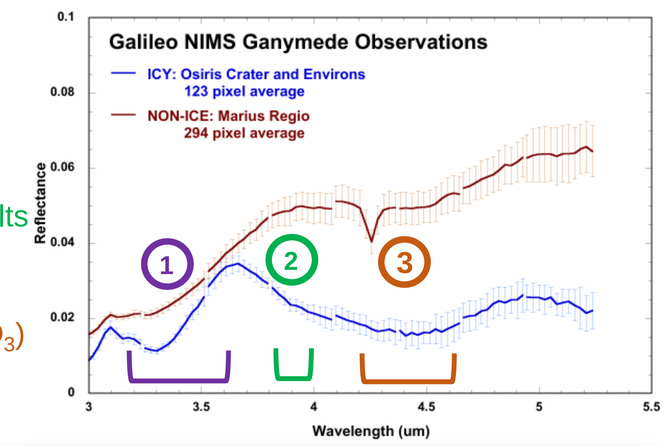
- Readout strategies for despiking.
- Extended spectral range > 5 µm, making parasitic thermal flux a major issue.
- Achieving high SNR along the spectral range.

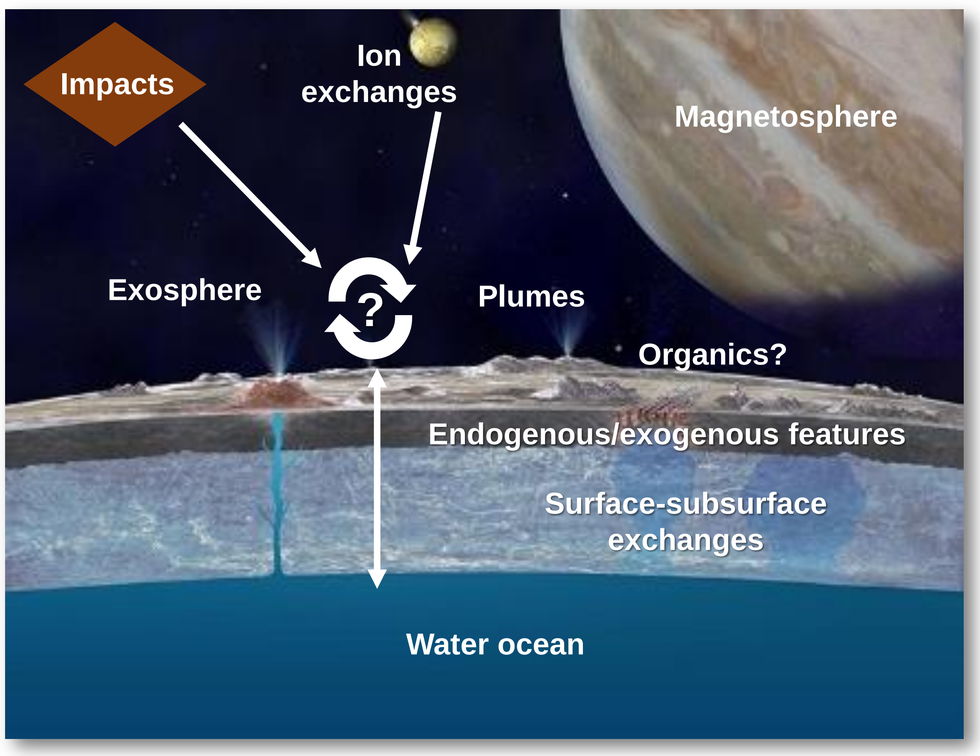
Scientific case of astrobiological potential

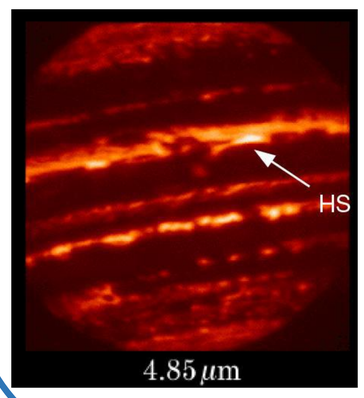
Galilean Satellites:

- Distinguishing endogenous processes from exogenous contributions (impacts and plasma torus) by mapping surface **icy and non-icy compounds** in their geological context **at various scales** during flybys and orbit.
- Detecting possible surface **manifestations of water ocean, such as organics**. The average **spectral resolution of 6.56 nm/band** in the IR was chosen to optimize detection and discrimination of organic bands.
- Characterizing **exospheres and plumes** as a probe of exchanges with subsurface and outer environment via **limb observations.**

1. Organic compounds
2. Distinction between hydrated non-icy minerals such as salts and sulphuric acid
3. Non-LTE exosphere compounds (CO_2, O_3)





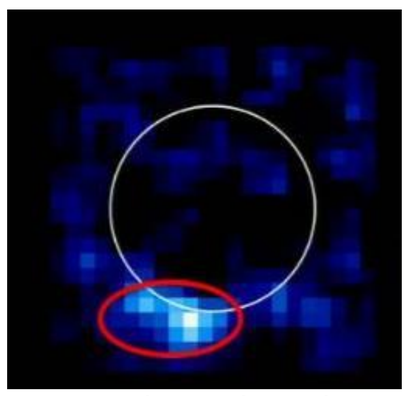


Jupiter and its atmosphere:

- Monitoring **auroras activity** (H_3+ at 3.67 µm) in coordination with other instruments to better understand the **magnetosphere.**
- Measuring troposphere composition and dynamics, using **hotspots** where the cloud coverage is thinner in the 5 µm window, allowing H2O and NH3 detections down to **7 bar altitude.**

Planned observations

- JUICE will perform a **1 year Jupiter tour** including several close flybys of Europa, Ganymede and Callisto. Several areas on Europa, Callisto and Ganymede will be observed **at 75 m/px.**
- Distant observations will be available for Io, small satellites and rings. The time coverage for Io's activity will help understanding the highly dynamic phenomena of this moon.
- A 9-months Ganymede orbit will follow, at 500 km altitude, yielding **full coverage at 2.5 km/px**.
- To allow plumes and exospheres detections the probe will perform **limbe observations at high phase angles**.



HST plume detection on Europa (2015)

- Several **night side observations** are planned for Io's and Jupiter's hotspots.
- The MAJIS images will use 400x400 pixels. Those images will cover 30 km on Europa's surface at closest flyby. The following picture compares this sampling to Galileo/SSI images (800x800 pixels).