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MAJIS (Moons And Jupiter Imaging Spectrometer) for JUICE: objectives for the Galilean satellites

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Abstract

The MAJIS instrument is an imaging spectrometer on board the JUICE mission and it is perfectly suitable to obtain a comprehensive picture of the Jupiter system by combining information of the surfaces of the Galilean satellites, the Jupiter's atmosphere, and the other targets of opportunity. The level of details and the extended mapping capabilities of MAJIS will unveil crucial aspects of the Jovian system. In particular, MAJIS will play a major role in characterizing the surfaces of Galilean satellites. Surface constituents (water ice, salts/brines, minerals or CO2 ice on Europa, Ganymede and Callisto, SO2 frost on Io…) have distinctive signatures in the VIS-NIR range (0.4 to 5.2 µm). Surface composition is a critical element for understanding the formation and evolution of Galilean satellites as well as space weathering in the Jovian environment. A companion paper [1] is dedicated to the goals of MAJIS for the atmosphere of Jupiter and its environment.

1. Introduction

MAJIS stands for Moons And Jupiter Imaging Spectrometer and it is a selected instrument for the JUICE mission. It is an advanced imaging spectrometer that in one compact instrument combines two spectral channels able to cover from 0.4 to 5.7 µm range. It can operate both in push-broom and in scanning mode, according to the different operational phases and scenario of the mission. The instrument can collect simultaneously 480 spectra taken across the spectrometer's slit, corresponding to a 3.44° × 125 µrad FOV and allowing image reconstruction during time. To meet the scientific requirements a spectral sampling of 2.3-6.6 nm/band is needed, respectively, for the 0.4-1.9 and 1.7-5.7 µm ranges. Two HgCdTe sensors arrays are foreseen as focal planes for the VIS-NIR and IR spectral channels. The instrument will be designed to survive in the harsh radiation environment as well as to be compliant with the decontamination procedures imposed by the planetary protection rules.

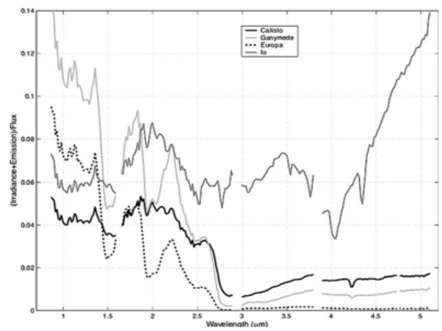

Fig. 1: spectra of Io (dominated by SO_2 bands), Europa, Ganymede and Callisto (water ice, hydrates, minerals and organics) obtained by VIMS/Cassini [2]

2. Objectives for Galilean Satellites

The JUICE mission profile will make it possible to obtain a wealth of new information on the Galilean satellites, with 2 Europa fly-bys, 12 Callisto fly-bys and 12 Ganymede fly-bys (closest approach at an altitude of 200 km) followed by a one year orbital phase around Ganymede (elliptical orbit, then circular orbit at 5000 km, 500 km and 200 km altitude). The major limitation on coverage is the bandwidth. The spectral resolution of MAJIS is 3 times that of NIMS/Galileo or VIMS/Cassini and the spatial resolution(0.125 mrad) is 4 times better than NIMS. Extended coverage of Ganymede will be obtained at a resolution of 2.5 km/pixels, and regions of interests will be imaged with a resolution up to 0.125 mrad (62 m per pixel at 500 km) using a motion compensation scanner.

The spectral diversity of Galilean satellites (Fig. 1) as observed by VIMS [2] demonstrates that a wide range of ices, brines [3], minerals and radiolytic compounds [4] are present on the surface of the satellites.

An example of the diagnostic power of Vis-NIR imaging spectrometry for brines is provided on Fig. 2, compared with Ganymede non icy material.

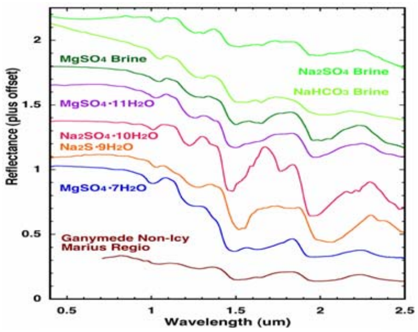

Fig.2 : VIS/NIR spectra of brines [3]

Non-icy constituents such as minerals and organic compounds are key tracers for the formation of the satellites, convection processes within the ice or an underlying ocean, and irradiation chemistry at the surface. Thermal and radiolytic processes are also responsible for the transition between crystalline and amorphous water ice, which has distinctive spectral signatures at 1.6 µm and 3.1 µm [5].

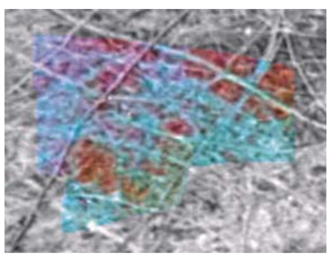

Fig. 3 : map of hydrated material (red) versus water ice (blue) on the surface of Europa [4]

Maps of spectral features on Galilean satellites have already been obtained by Galileo/NIMS (Fig. 3), but the coverage and spatial resolution has been severely hampered by the acquisition rate (8 s for a full spectrum) and the very limited downlink (10 – 40 bits/s) due to the non-deployment of the high gain antenna (JUICE: ~ 30 kbits/s). When combined with up to date on-board compression capabilities, the total data volume expected from JUICE/MAJIS is at least 5000 times larger than that obtained from NIMS, with major improvements in spatial resolution, spectral resolution and coverage of the surface of Galilean satellites

3. Summary and Conclusions

The MAJIS instrument is perfectly suitable to study the Galilean satellites and the Jupiter system. In this contribution, we have reported the scientific objectives of MAJIS for the Galilean satellites, while a dedicated paper [1] will be focused on Jupiter and its environment.

Acknowledgements

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References

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