THE MAJIS VIS-NIR IMAGING SPECTROMETER FOR THE JUICE MISSION. Y. Langevin[1], G. Piccioni[2], P. Eng[1], G. Filacchione[2], F. Poulet[1] and the MAJIS team. [1]Institut d'Astrophysique Spatiale, Univ. Paris Sud / CNRS (Bat. 121, Orsay Campus, 91405 Orsay, France, yves.langevin@ias.u-psud.fr), [2]Istituto di Astrofisica i Planetologia, INAF (Rome, Italy).

Introduction: MAJIS (Moons And Jupiter Imaging Spectrometer) is the visible and near infrared imaging spectrometer selected in February 2013 for JUICE (Jupiter Icy Moons Explorer), This mission to be launched in 2022 will provide a comprehensive exploration of the Jupiter system, with targeted flybys of Callisto (20), Ganymede (12) and Europa (2), then a 1 year orbital phase around Ganymede

Instrument design: MAJIS is built by a consortium led by IAS Orsay (France) and IAPS Rome (Italy). It implements a dual grating spectrometer design with a VIS-NIR channel from 0.4 to 1.9 µm and an IR channel from 1.5 to 5.7 µm. The spectral and spatial resolution of MAJIS takes full advantage of up to date detector developments with 2 x 640 spectral bands from 0.4 to 5.7 µm over 480 pixels. The S/N will exceed 100 over most of the spectral range, except for deep ice absorption bands such as those observed for Europa above 2.8 µm. The spatial resolution (0.125 mrad/pixel) corresponds to 62.5 m from a 500 km circular orbit over Ganymede and to 125 km for observations of the atmosphere of Jupiter. Spatial and spectral binning will be implemented, in combination with an effective on-board compression scheme, so as to provide extensive spatial coverage of the icy satellites at medium resolution (1 to 5 km/pixel) as well as time evolution sequences for the atmosphere of Jupiter and the exospheres of satellites. A specific spike filtering scheme will be implemented so as to mitigate the impact of the radiation environment.

Scientific goals / satellites: MAJIS will be the prime instrument for determining the surface composition of satellites and rings for ices (*Fig. 1*), organics and minerals. The global medium resolution coverage of Ganymede (2.5 km/pixel) and Callisto (5 km/pixel, *Fig. 2*), the 15% coverage of Europa at a similar resolution during the two flybys and the 3 to 7 nm spectral sampling will represent a major step forward building on the results of NIMS/Galileo [see e.g. 1, 2]. Furthermore, full spectral resolution observations by NIMS (12 nm) were hampered by the acquisition time (8 sec for 20 spectra) and the downlink limitations.

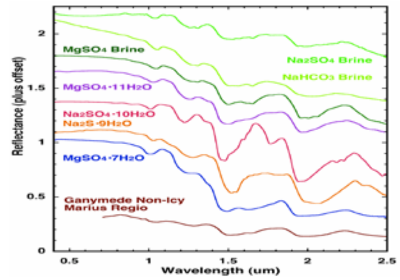

Fig. 1: laboratory spectra of hydrates and brines at 100 K from 0.4 to 2.5 µm (credit: J. B. Dalton, NASA/JPL).

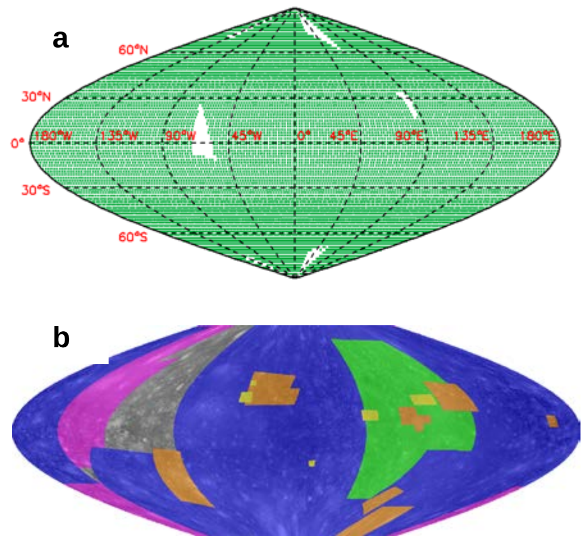

Fig. 2, a: near-global coverage of Callisto at 5 km/pixel by MAJIS from the 20 JUICE flybys; 10% of the surface will be observed at 1 km/pixel or better. Global coverage of Ganymede at 2.5 km/pixel will be obtained during flybys and the orbital phase.
b: most of the coverage of Callisto by Galileo/NIMS is at a resolution of 60-100 km/pixel (blue) with some coverage at resolutions of 30 to 60 km/pixel (green) or less than 30 km (yellow, orange).

Regions of interest identified from Galileo data and from early MAJIS observations will be observed at a high spatial resolution (up to 50 m/pixel for Europa and Callisto, 62.5 m/pixel for Ganymede). 40 distant flybys of Io (500,000 km to 800,000 km) will make it possible to characterize time evolution of the surface with a resolution of 60 to 100 km/pixel both on the day side and the night side (hot spots)

The potential of VIS-NIR spectrometry for observing rings and small satellites has been demonstrated by Cassini/VIMS [e.g. 3, 4]. These observations will be primarily implemented during the 6 months long excursion of the JUICE spacecraft at latitudes up to 30°.

Scientific goals / atmosphere of Jupiter and exospheres: Observations of Jupiter by NIMS/Galileo [5,6], VIMS/Cassini [7], Earth-based observatories or space observatories [8] have demonstrated the remarkable potential of VIS-NIR spectrometry for characterizing the composition and dynamics of planetary atmospheres. The vertical structure of the atmosphere of Jupiter can be probed to pressure levels of up to 7 bars through the 5 µm window (Fig. 3), benefitting from the high S/N and 10 nm spectral sampling of MAJIS. The perijove of JUICE will be close to the orbit of Ganymede except for the first few orbits two Europa flybys). However, the 0.125 mrad resolution of MAJIS will make it possible to efficiently track tropospheric processes such as clouds and hazes (*Fig. 4*).

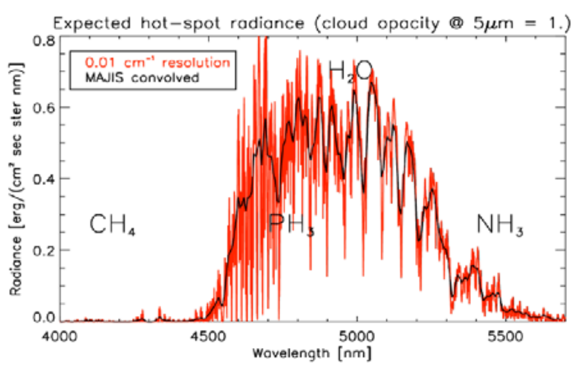

Fig. 3: high resolution spectrum of the transparency window of methane (red) convolved to the spectral resolution of MAJIS (black).

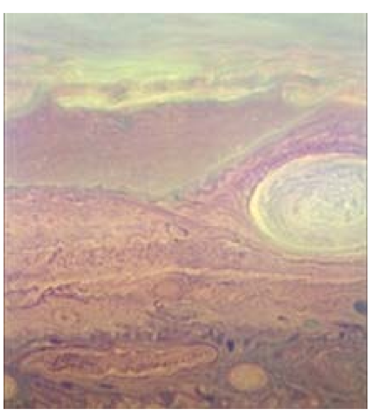

Fig. 4: Simulated false color image of the troposphere of Jupiter with the spatial resolution of MAJIS (0.125 mrad) from the orbit of Ganymed.

MAJIS will investigate the vertical distribution of water and ammonia [9], the major contributors of oxygen and nitrogen to atmospheric chemistry, as well as many other minor species. It is important to note that as the JUICE orbit will be close to equatorial for most of the mission, there will be a comprehensive coverage in local time, complementary to JUNO/JIRAM (terminator orbit).

The spectral range, S/N and resolution of MAJIS make it possible to investigate processes in the upper atmosphere of Jupiter such as stratospheric hazes and auroras, in particular H_3^+ auroras [10]. These processes will be investigated both in nadir pointing and with stellar occultations.

Galilean satellites have tenuous exospheres (O_2 for Ganymede, CO_2 for Callisto) which play a major role as sources of ions and neutral species for magnetosphere of Jupiter. MAJIS will investigate non-LTE exosphere emissions with limb scans at high phase angles so as to assess the column density of exospheric species. The recent observation of transient water vapor over polar regions of Europa [11] outlines the importance of exospheric observations as probes of internal activity.

Conclusion: MAJIS is a state of the art VIS-NIR imaging spectrometer which will provide a wealth of information on the composition and evolution of the atmosphere of Jupiter, the surface of Galilean satellites and their exospheres. The contribution of MAJIS is critical for achieving the science goals which have led to the selection of JUICE as the first large mission of ESA's Cosmic Vision program.

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