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MAJIS (Moons And Jupiter Imaging Spectrometer) for JUICE: Jupiter system objectives

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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. Beyond the Galilean satellites, object of another dedicated paper, MAJIS will explore the satellites' exospheres, also monitoring peculiar aspects (Io and Europa torii, Io's volcanic activity) and studying the Jupiter's atmosphere at different levels (including aurorae and magnetic footprints). It is perfectly suitable to record the spectral characterization of the whole Jupiter system, including the ring system, the small inner moons and other targets of opportunity like irregular satellites.

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.

2. Jupiter system objectives

The orbit of JUICE will allow MAJIS to study Jupiter's atmosphere in all local time conditions. The expected IFOV of MAJIS (125 μrad) allows – from the distance of Ganymede's orbit – a spatial resolution of 124 km at the reference 1-bar level that represents the zero-altitude surface of Jupiter's atmosphere (Figure 1). MAJIS covers the H_3+ bands around at 3.67 μm that are strongly enhanced in the Jovian aurora [2]. The mapping capabilities of MAJIS are ideal to monitor the overall auroral activity and phenomenology of the polar atmosphere and to relate them with in situ measurements by the magnetometer and plasma/neutral packages. MAJIS

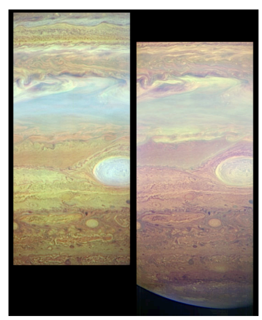

Figure 1 : Troposphere dynamics: Images taken with the LEISA infrared camera on the New Horizons Ralph instrument. MAJIS operating from Ganymede orbit will provide image cubes with comparable spatial resolution.
From New Horizons web site

stellar occultations by Jupiter's disk will allow one to constrain the mixing ratio of methane in the stratosphere as well as the variability of air temperatures. In addition, observations of the nightside hemisphere will be of particular interest, for possible detections of lightings and nightglow emissions. Cloud systems will be continuously monitored by synoptic tracking of features on wide regions of the planet. Particular attention will be devoted to the study of dynamical regimes associated with jet streams, plumes and storms occurrence [5]. The high latitudes reached during the Callisto fly-bys will allow to address the polar vortex dynamics and morphology. Wide spectral coverage of MAJIS will allow to compare the results at different altitudes (approximately between 0.6 and 7 bar, for ideal cloud-free conditions) providing an effective 3D dynamical scenario. The MAJIS range encompasses also the main diagnostic features of H_2O, NH_3 (2.73 μ) and NH_4SH ices, providing with the possible evidence of fresh particles – constraints on convective motions [1]. The extension of the spectral range to wavelengths shortward of 2 μ will allow MAJIS to better constrain the composition and size distribution of different cloud decks, by means of comparison of radiances observed in several CH_4 spectral windows and observations of the same region at different phase angles. Observations in the 5 μ atmospheric window of these relatively cloud-free regions provide insights on the bulk composition

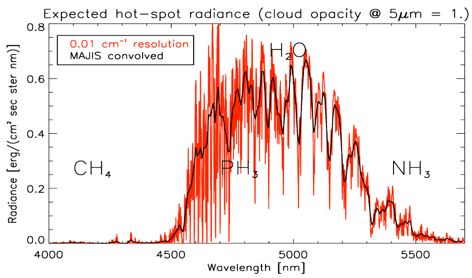

Figure 2: Typical radiance expected for nighttime observations of hot-spots (synthetic spectrum computed assuming a unit optical depth of clouds at 5 μm).

of Jupiter's atmosphere below the level of the main NH_4SH cloud deck, approximately down to the 7-bar level. Contents of NH_3 and H_2O are of particular interest for the constraints they provide on the formation scenarios of giant planets. PH_3 can also be monitored with MAJIS data and used as tracer for the circulation in the Jovian troposphere [4]. Of major interest is the extension up to 5.7 μm of MAJIS spectral range (significantly beyond the 5.2 μm of the JUICE strawman payload), that enables a better coverage of gaseous H_2O and NH_3 bands (Figure 2), with increased vertical resolution and coverage [3]. MAJIS will characterize the physical and chemical properties of the ring system, with VIS-IR mapping of the ring particles' composition and photometric behaviour in a wide range of solar phase angles. Infrared remote sensing will contribute to unveil the bulk composition of the small regular satellites orbiting between 1.8 and 3.1 RJ (at least the largest objects, Thebe and Amalthea), allowing one to confirm them as sources or sinks of the ring particles.

3. Summary and Conclusions

The MAJIS instrument is perfectly suitable to study the Jupiter system and the Galilean Moons. In this paper we have reported the scientific objectives of MAJIS for the Jupiter system, while a dedicated paper will be focused on the Galilean moons specific objectives.

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