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JUICE-MAJIS observations planning for plumes detection on icy Galilean satellites

E.D'Aversa (1), A.Migliorini (1), F.Altieri (1), G.Piccioni (1), F.Tosi (1), G.Filacchione (1), J.Carter (2), Y.Langevin (2), F.Poulet (2).
(1) INAF-IAPS, Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy, (2) Institut d'Astrophysique Spatiale (IAS), Orsay, France. (emiliano.daversa@inaf.it)

Abstract

The existence of plumes at Europa has been suggested by recent observations, carried out over the last seven years. Here we discuss here about the possibility of their detection on Europa, Ganymede, and Callisto by using the MAJIS imaging spectrometer onboard the ESA JUICE mission. The confirmation of this kind of geological activity may have important consequences in our understanding of the relationships among the surface, the interior, and the exosphere of these bodies, ultimately helping in assessing their habitability.

1. Introduction

In recent years, observational evidences are accumulating in suggesting an ongoing geological activity on the Jovian satellite Europa. Hubble Space Telescope UV observations provided tentative detections of off-limb signals ascribed to plume activity ([1], [2]). Although close to the detection limit, these observations appear compatible with the presence of plumes in polar as well as equatorial regions, extending up to 200 km above the surface, and possibly variable over time. Following these discoveries, a reanalysis of *in situ* data acquired by the plasma detector on board the Galileo spacecraft allowed to infer the presence of a plume, with similar extension, in an equatorial region [3].

These findings motivate further observational efforts to clearly establish the presence of such activity and eventually characterize its main spatial and temporal features. The ESA JUICE mission [4] to the Jupiter system offers a good opportunity in this field. Here we will focus on the ongoing observations planning for plumes detection with the MAJIS spectrometer [5,6], within the framework of the planning of Jovian satellites exospheric observations.

2. Plumes with MAJIS

MAJIS is a two-channels imaging spectrometer covering the VIS-NIR (0.5-2.35 micron) and IR (2.25-5.54 micron) spectral ranges with about 4 and 7 nm spectral sampling respectively. The IFOV is 150 µrad while the FOV is 60 mrad.

The abovementioned observations of Europa plumes by remote sensing, both performed in the far-UV spectral range, actually measured off-limb line emission from the dissociation products of water ([1]) and off-limb light extinction as Europa transited Jupiter ([2]). Hence they are sensitive to the gas and solid components of the plumes. In the case of MAJIS, the most effective approach for detecting plumes is to scan the satellite's limb looking for light directly scattered by the solid particles contained in the plume. The expected configuration is very similar to the case of the water ice plume detected by the Cassini mission on the Saturn satellite Enceladus (Fig.1). Hence, we took advantage of the Enceladus observations to derive observational constraints for the Europa's case, in particular from the Cassini-VIMS data (see e.g. [7]) which cover a spectral range similar to MAJIS. The analysis of the phase curve of Enceladus' plume shows that its particles are strongly forward-scattering, making the plume contrast against the dark sky background strongly increasing with increasing solar phase angle. This is especially true for longer wavelengths, that are valuable in covering the near-infrared water ice bands, in particular the 3 micron absorption band (see Fig.2). The shape and strength of these absorption bands can be very useful in constraining the abundance and microphysics of the plume grains. In planning MAJIS observations, a lower limit of about 140° is adopted for the solar phase angle to maximize the detection probability and the signal-to-noise ratio of measurements in a relatively broad spectral interval. The same approach is adopted for Callisto and Ganymede as well, even if no evidence of plumes has been found there so far.

Therefore, by using the latest available planned trajectory for the JUICE spacecraft, we searched for the relatively narrow time windows in which MAJIS observations are most promising for plume detection for all icy satellites. Besides phase angle constraints, other parameters are taken into account, such as spatial resolution, multiple bodies events (e.g. eclipses or transits), available time for suitable exposures, spatial coverage of plume sources on the surfaces.

Moreover, as demonstrated by [1], the presence of plumes can be associated to an excess of UV emission by exospheric oxygen. The observed OI at 130.4 and 135.6 nm is consistent with a water column density on the order of 1.8-3.3x10^{21} molecules/m^2 ([2]). From a simple model based on previous analysis of cometary H_2O emission in the near-infrared [8], the expected H_2O column density would originate an emission around 2.7 micron, due to the H_2O ν_2 fundamental band, that is detectable with MAJIS, providing an independent proof for plume activity.

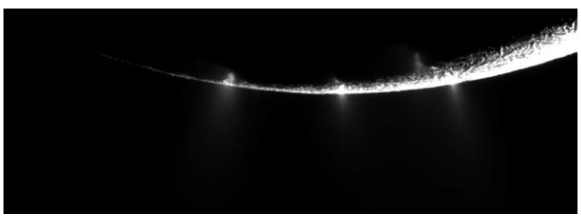

Figure 1: Enceladus' plumes observed by Cassini ISS NAC camera in 2010 near 750 nm wavelength (courtesy NASA/JPL-Caltech)

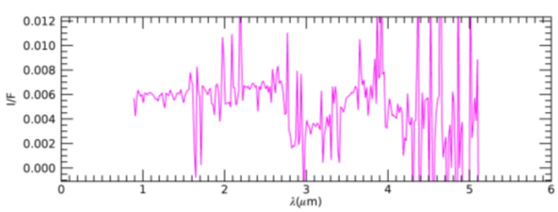

Figure 2: Example of a Enceladus plume spectrum from Cassini VIMS IR channel, showing the 3 micron water ice absorption band.

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References

[1] Roth, L., Saur, J., Retherford, K.D., Strobel, D.F., Feldman, P.D., McGrath, M.A., Nimmo, F. 2014. Transient Water Vapor at Europa's South Pole. Science, 343, 171-174. doi: 10.1126/science.1247051.

[2] Sparks, W. B., Hand, K. P., McGrath, M.A., Bergeron, E., Cracraft, M., Deustua, S. E. 2016. Probing for evidence of plumes on Europa with HST/STIS. Astrophys.Journ.,829,121.

[3] Jia, X., Kivelson, M.G., Khurana, K.K., Kurth, W.S. 2018. Evidence of a plume on Europa from Galileo magnetic and plasma wave signatures. Nature Astronomy, 2, 459–464.

[4] Grasset, O., Dougherty, M.K., Coustenis, A., Bunce, E.J., Erd, C., Titov, D., Blanc, M., Coates, A., Drossart, P., Fletcher, L.N., Hussmann, H., Jaumann, R., Krupp, N., Lebreton, J.-P., Prieto-Ballesteros, O., Tortora, P., Tosi, F., Van Hoolst, T. 2013. JUpiter ICy moons Explorer (JUICE): An ESA mission to orbit Ganymede and to characterise the Jupiter system. Planet.Sp.Sci. 78, 1–21.

[5] Piccioni, G., Langevin, Y., Filacchione, G., Poulet , F., Tosi, F., Eng, P., Dumesnil, C., Zambelli, M., Saggin, B., Fonti, S., Grassi, D., Altieri, F. 2014. MAJIS, the Moons And Jupiter Imaging Spectrometer, designed for the future ESA/JUICE mission. Geophys.Res.Abs. 16, EGU2014-10925-2, EGU General Assembly 2014.

[6] Langevin, Y., Piccioni, G., Dumesnil, C., Filacchione, G., Poulet, F., MAJIS Team 2016. MAJIS (Moons and Jupiter Imaging Spectrometer): the VIS-NIR imaging spectrometer of the JUICE mission. AAS DPS meeting #48, id.429.12.

[7] Hedman, M.M., Nicholson, P.D., Showalter, M.R., Brown, R.H., Buratti, B.J., Clark, R.N. 2009. Spectral observations of the Enceladus plume with Cassini-VIMS. ApJ, 693, 1749-1762.

[8] Migliorini A., et al., 2016, Water and carbon dioxide distribution in the 67P/Churyumov-Gerasimenko coma from VIRTIS-M infrared observations, A&A, 589.