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Oxygen in the Ganymede's surface: new laboratory measurements

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1. Introduction

Molecular oxygen has been detected on the surface of the Galilean satellites [Spencer et al., 1995; Spencer and Calvin, 2002], possibly trapped in the icy surface. Dedicated laboratory experiments showed the nature of the observed features and allowed to infer some hypothesis on the nature of O_2 in the surface matrix [Vidal et al. 1997]. The observed spectral features, centered at 577.4 nm and 627.3 nm, are indicative of double electronic transitions in adjacent O_2 molecules, following the transition:

$$a^1\Delta_g + a^1\Delta_g \; - X^3\Sigma^-_g + X^3\Sigma^-_g.$$

A better understanding and characterization of these features is necessary to constraint the properties of the Galilean moons' surfaces.

Our work aims to present new laboratory measurements of pure O_2 ice and its mixtures with H_2O, N_2, CO_2 and NH_3 in the visible spectral range, which are also interesting for the Galilean satellites. Comparison with high-resolution ground-based observation of Ganymede, showing the two spectral features diagnostic of solid O_2 is also presented. A different and new setup is used to allow ice irradiation with low energy electrons.

In addition the present work contributes to a database of spectra, which will be of basic importance to analyse spectroscopic data acquired with the MAJIS spectrometer to be included as payload in the ESA/Juice mission to the Jovian system.

2. Laboratory measurements

Laboratory measurements have been carried out using the Open University (England) portable astrochemistry vacuum chamber attached to the ultraviolet vacuum beamline of the synchrotron ASTRID 2 facility at the Aarhus University (Denmark).

The icy surfaces of the Galilean moons were simulated and studied in the 550-650 nm spectral region. The energetic processing was simulated through irradiation with 1 keV electrons [Jones et al. 2014]. Fig. 1 shows the effects of irradiation and annealing on pure O_2.

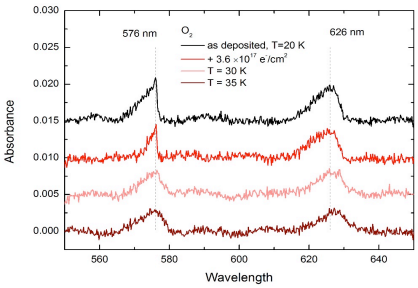

Fig. 1 O_2 spectrum, deposited at 20K (black curve) and after irradiation and anneling.

The features under investigation, centred at about 577 and 627 nm, are observed in all spectra (**Fig. 2**), although differences between pure O_2 layer and mixtures are identified. A band shift towards longer wavelengths may be due to the mixture that causes different photon excitations during optical absorption [Sack and Baragiola, 1993].

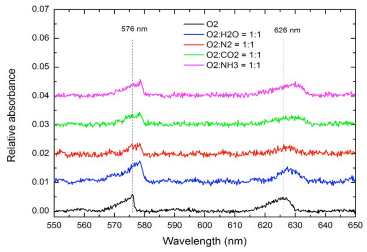

Fig. 2 Absorbance spectra of pure O_2 and its 1:1 mixtures with H_2O, N_2, CO_2 and NH_3. The two bands diagnostic of O_2 are observed in all spectra with differences in the shape and peak position.

3. Preliminary results

Our laboratory measurements are in general agreement with previous works, despite the different sample production techniques and experimental conditions.

Comparison with ground-based observations, obtained at Telescopio Nazionale Galileo (TNG) in January 2015, shows that the O_2:H_2O mixture better approximates the Ganymede's spectrum (**Fig. 3**).

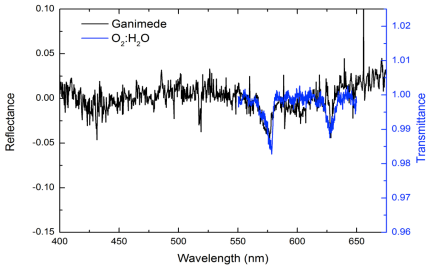

Fig. 3. Camparison between a spectrum of Ganymede obtained with the TNG telescope in January 2015 (black curve) and laboratory measurement of O_2:H_2O mixture (in blue).

Our measurements will be useful to analyse the Ganymede's data, which will be acquired with MAJIS on the Juice mission.

References

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