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Water and carbon dioxide sources on comet 67P nucleus as measured from the VIRTIS-H instrument aboard Rosetta

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Abstract

Using the high spectral-resolution channel of the Visible InfraRed Thermal Imaging Spectrometer (VIRTIS-H) onboard Rosetta, we observed the ν_3 vibrational bands of H_2O and CO_2 at 2.67 and 4.27 µm in comet 67P/Churyumov-Gerasimenko [1]. Observations were undertaken in limb viewing geometry with various line-of-sight (LOS) orientations in the body-fixed frame. A geometry tool is used to characterize the position of the LOS with respect to geomorphologic regions [6] and the illumination properties of these regions. We will present the heliocentric evolution, diurnal variations and distribution of H_2O and CO_2 production. Inhomogeneities in the CO_2/H_2O relative production rates will be discussed.

1. Introduction

Since July 2014, the Visual IR Thermal Imaging Spectrometer (VIRTIS) onboard the ESA's Rosetta spacecraft has intensively observed comet 67P/ Churyumov-Gerasimenko. First results were published in [2]. VIRTIS is composed of two channels, –M for mapping and –H for high resolution, working in the 0.25-5 µm and 2-5 µm wavelength domains, respectively [4]. In addition to nucleus mapping observations, limb observations were carried out to obtain spectra of the coma, and to detect fluorescence emissions of gas phase species. The ν_3 vibrational bands of H_2O and CO_2 at 2.67 and 4.27 µm, respectively, were detected in mid-October 2014 using VIRTIS-H, and observed regularly since then [1] including from VIRTIS-M [3].

Outgassing from cometary nuclei involves complex surface and subsurface processes that depend on the physicochemical properties of the cometary material and ice structure, as well as on current and past illumination conditions. Because they are important constituents of cometary ices, water and carbon dioxide are key species to understand cometary activity. In addition, their different volatility allows us to investigate both surface and subsurface outgassing.

2. Results at 2.5-2.9 AU from the Sun

Samples of VIRTIS-H spectra of the H_2O and CO_2 bands are shown in Figs 1 and 2.

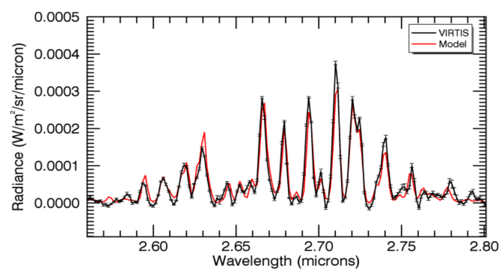

Figure 1: VIRTIS-H spectrum of the 2.7 µm band of water. Data from 4 December 2014 to 24 January 2015. In red, a fluorescence spectrum for a rotational temperature of 102 K (from [1]).

Data obtained in the time frame October 2014 - January 2015 led to the following conclusions [1]:

- Water and CO_2 productions did not evolve much from 2.9 to 2.5 AU during this period.

- High water column densities are observed for LOS above neck regions, suggesting they are the most productive in water vapour.

- Whereas water production is weak from regions with low solar illumination, CO_2 is outgassing from both illuminated and non-illuminated regions at about the same rate, which indicates that CO_2 sublimates at a depth that is below the diurnal skin depth.

- The CO_2/H_2O column density ratio varies in the range 2% to 30%. For regions into sunlight, mean values between 3 and 6% are measured, with the lowest value for regions Seth and Anuket situated in the most central parts of the body and head of the comet, respectively. The lower bound value is likely representative of the CO_2/H_2O production rate ratio from the neck regions.

- An illumination driven model, with an homogeneous surface releasing water, provides an overall agreement to VIRTIS-H data, though some mismatches, especially on the neck, are witnessing the presence of local surface inhomogeneities in water production [5].

- Rotational temperatures of 90-100 K are derived from H_2O and CO_2 averaged spectra

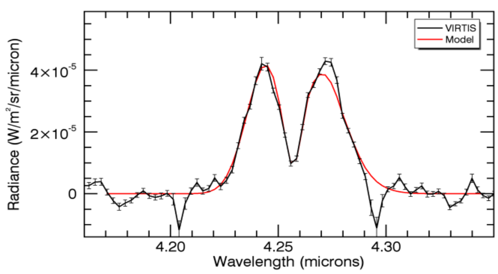

Figure 2 : VIRTIS-H spectrum of CO_2. Data from 4 December 2014 to 24 January 2015. In red, a fluorescence spectrum with a rotational temperature of 90 K (from [1]).

2. Prospects

As the comet approaches the Sun, signals are becoming stronger, allowing us to examine with fine details the outgassing of active regions and diurnal variations. We will also be able to monitor the changes of their production rates globally as 67P/C-G approaches perihelion and for different regions, in particular the southern hemisphere as it is progressively illuminated, thus providing important information to understand the source of the volatile molecules inside the nucleus and potentially retrieve their initial composition and possibly spatial heterogeneity. At the time of writing this abstract, the data have not been acquired.

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References

[1] Bockelée-Morvan, D., Debout, V., Erard, S. et al. : First observations of H_2O and CO_2 vapour in comet 67P/Churyumov-Gerasimenko with VIRTIS onboard Rosetta, A&A, submitted, 2015.

[2] Capaccioni, F. et al.: The organic-rich surface of comet 67P/Churyumov-Gerasimenko as seen by VIRTIS/Rosetta, Science 347, 2015.

[3] Capaccioni, F. et al.: Distribution of H_2O and CO_2 in the inner coma of 67P/CG as observed by VIRTIS-M onboard Rosetta, EPSC, this conference 2015.

[4] Coradini, A., Capaccioni, F., Drossart, P., et al.: An Imaging Spectrometer for the Rosetta Mission, Space Science Reviews, 128, 529, 2007.

[5] DeSanctis et al. EPSC, this conference 2015.

[6] Thomas, N., Sierks, H., Barbieri, C., et al.: The morphological diversity of comet 67P/Churyumov-Gerasimenko. Science, 347, aaa0440, 2015.