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Temporal and compositional variation of jets activity in comet Hartley 2 as observed by Deep Impact

S. Besse (1), M. A'Hearn (1), L. Feaga (1), M. Sunshine (1), S. Protopapa (1), M.J.S. Belton (2), D. Bodewits (1), T. Farnham (1), O. Groussin (3), M. Kelley (1), J-Y. Li (1), F. Merlin (4), J. Williams (1), and the DIXI-Team
(1) Astronomy Department, University of Maryland, College Park, USA, (sbesse@astro.umd.edu) (2) Belton Space Exploration Initiatives, LLc, Tucson, USA, (3) Laboratoire d'Astrophysique de Marseille, Université d'Aix-Marseille & CNRS, Marseille, France, (4) Université Paris 7, LESIA, Meudon, France

Abstract

Using the Deep Impact spacecraft observations of comet Hartley 2 [1], the production rate of H_2O and CO_2 gas are calculated at different times during the flyby. The ratio CO_2/H_2O is a constant 10%. Although the H_2O and CO_2 periods are close to the general solutions of the comet rotation [2], the H_2O period is more sensitive to the roll of the nucleus. This could explain the factor of three variation of the production rate of H_2O during the 1997 and 2010 passage. It is more likely that a different portion of the nucleus had been exposed to the Sun in 1997, a portion richer in water ice, and possibly the same region imaged on the surface of Hartley 2 during the 2010 passage by the Deep Impact flyby spacecraft [3].

1. Introduction

The Deep Impact Flyby spacecraft (DI) successfully flew by comet 103P/Hartley 2 on 4 November 2010 [1] and returned numerous observations with the High Resolution Instrument Infrared Spectrometer (HRI-IR). Early results showed that the comet activity is driven by carbon dioxide (CO_2) sublimation with a coma rich in water vapor (H_2O) and water ice particles, probably dragged from within the nucleus by the CO_2 jets [1,4,5]. The heterogeneities of gas concentrations in the nucleus are more likely related to the formation of the comet rather than evolutionary processes. If so, it provides information about the early history of the protoplanetary disk.

Production rates of H_2O obtained from various measurements are compiled in [6] (except the spacecraft results), they range between 0.65 x 10^{28} to 1.9 x 10^{28} molecules.s^{-1} around closest approach (CA). [7] reported a production rate three times higher during the 1997 passage of the comet.

In this work, the time variation of the H_2O and CO_2 gas of the coma are investigated using the observations from DI.

2. Data reduction and Methodology

The observations of HRI-IR preliminarily delivered to PDS in 2011 are not used because of inadequate dark correction. In-scene darks are used in this study by employing, as often as possible, the last frame of every scans. The surface brightness of the coma is calculated by averaging the flux in various aperture sizes. The production rates are determined using the same methodology as [8] for H_2O and CO_2 emission.

Observations at CA have a strong nucleus signal, which complicates the process. Observations before CA have a low signal-to-noise ratio (SNR); and the sampling of the coma is less frequent. Consequently, the coma is studied from DOY 311 to 316 with good SNR and appropriate sampling. DOY 311 corresponds to 2 days after CA and 7 days after perihelion (Fig 1).

3. Results

The production rate of CO_2 varies between 0.3 x 10^{27} and 1.8 x 10^{27} molecules.s^{-1}, at the maximum and minimum of the light curve. For H_2O, the variation is between 0.3 x 10^{28} to 1.75 x 10^{28} molecules.s^{-1}. The ratio CO_2/H_2O is a constant 10%. The CO_2 periodogram shows three strong lines at 54.43h, 36.19h, and 18.17h. These periods are essentially the same as the one obtained from dust observations [2]. The H_2O periodogram is more complex and shows strong lines at 54.92h, 36.56h, and 18.19h, very close to that of the CO_2. The H_2O also exhibits two weaker lines at 24.14h and 8.05h, which we associated with the roll along the long axis [2].

4. Conclusion

The gaseous species show no variation in CO_2/H_2O ratio during 5 days, ≈ 10%. Although we know about heterogeneities of the nucleus [1], they are not seen in the lightcurves because of the elongated shape of the nucleus making the small lobe (i.e., richer in CO_2) always illuminated. From the analysis of the periodogram, it is found that H_2O lags CO_2 by ~ 1h. This is consistent with a secondary source for H_2O (e.g., icy grains in the coma). The correlation of the H_2O light curve with the roll period of the nucleus suggests that the 1997 passage was in a different configuration with a H_2O-rich region exposed to the Sun, which would explain the factor of three variation between 1997 and 2010. This H_2O-rich region could be the one from [3], which does not see much sunlight during the 2010 passage.

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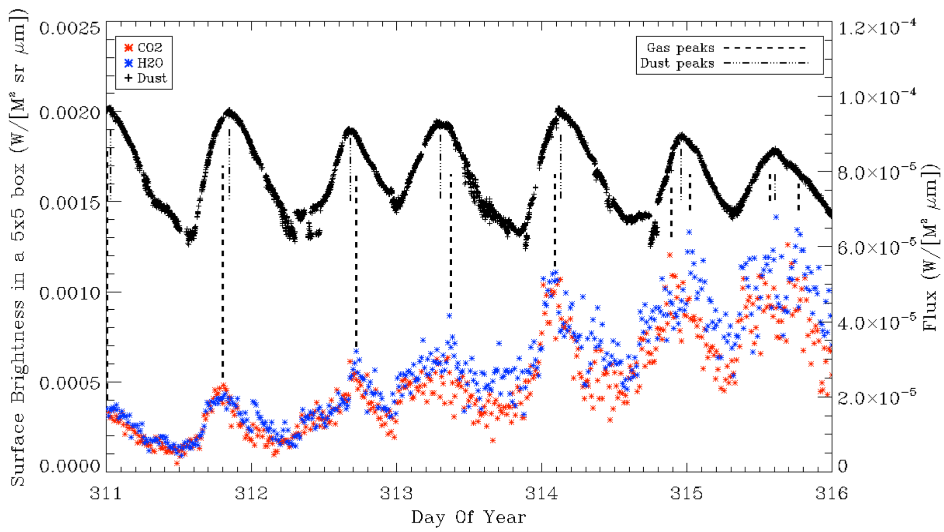

Figure 1: Surface brightness of the CO_2 and H_2O species as observed by the Deep Impact spacecraft from 2 days to 7 days after CA. The dust light curve is extracted from the Medium Resolution Instrument (MRI) and its units correspond to the right axis, while the surface brightness is on the left axis. Dashed lines correspond to the estimated position of the peak of gaseous emission while dashed-dotted lines correspond to the peak of the dust.