

Herschel PACS and SPIRE observations of comet 103P/Hartley 2

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Abstract

The ESA Herschel Space Observatory [8] used its full complement of state-of-the-art instruments to observe the far-infrared and submillimetre spectrum and to image the thermal dust radiation of the Jupiter family comet 103P/Hartley 2 in the 70–672 μm spectral range. The observations were carried out in the period 24 October to 17 November 2010, as part of the Herschel Guaranteed Time Key program "Water and related chemistry in the Solar System" (HssO) [6]. We present here observations of H_2O lines and of the dust coma made with the Photodetector Array and Camera (PACS) [9] and the Spectral and Photometric Imaging Receiver (SPIRE) [5].

1 Observations

PACS and SPIRE observations consisted both in the acquisition of coma images and spectra. Images in Blue (60–85 μm), Green (85–130 μm), and Red (130–210 μm) filters were acquired with PACS on Oct. 25, Nov. 4, and 11. Imaging photometry with SPIRE 250, 350 and 500 μm filters was carried out on 24 Oct.

The PACS spectroscopic observations consisted in dedicated line searches (water rotational lines on Nov. 4, 11, 16 and the forsterite 69 μm line on Nov. 16) and a spectral survey of the 51–220 μm range obtained with the SED observing mode (Nov. 11). Spectra acquired on Nov. 9 with the SPIRE Fourier Transform Spectrometer (FTS) cover the spectral range 447–1550 GHz. Both PACS and SPIRE spectrometers have imaging capabilities (25 pixels for PACS, 19 and 37 detectors for the short and long wavelength modules of SPIRE FTS). Hence, spectra cover both the central

and outer parts of the coma of 103P/Hartley 2.

PACS measurements were carried out on Nov. 4 to support the EPOXI flyby [1]. The imaging data were acquired 2.5 hours before the encounter. The $3_{22} - 2_{11}$ (89.9 μm), $2_{12} - 1_{01}$ (179.5 μm), and $2_{21} - 2_{12}$ (180.5 μm) water lines were observed at the time of closest approach.

2 Water lines

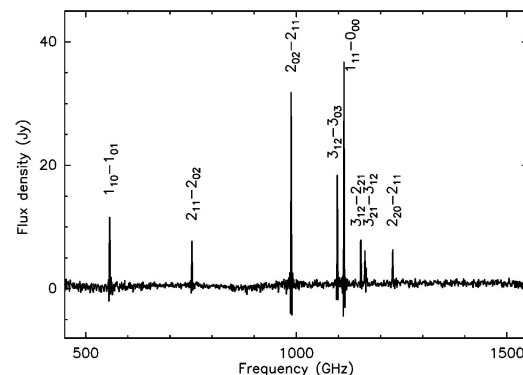


Figure 1: Spectrum of 103P/Hartley 2 obtained with SPIRE on-nucleus on Nov. 9, 2010. Identified water lines are indicated.

Figures 1 and 2 show spectra obtained with PACS and SPIRE. About 30 rotational lines of water were detected in PACS spectra, and 8 water lines in SPIRE spectra. OH rotational lines are detected in PACS spectra [4] (Fig. 1). Most H_2O lines are optically

thick. The water production rate at the time of EPOXI closest approach deduced from the analysis of the 89.9, 179.5 and 180.5 μm H_2O lines, is estimated to $\sim 1.2 \times 10^{28} \text{ s}^{-1}$ [7], using detailed modeling of water excitation and radiation transfer [2]. Approximately the same water production rate is deduced from the analysis of the SPIRE data obtained on Nov. 9.

Water maps show excess emission westward in the tail direction. For illustration, we show in Fig. 3 the brightness distribution of the 180.5 μm line obtained on Nov. 4 with PACS. A similar asymmetry is observed in the SPIRE data. This asymmetry might be related to a production from large icy fragments accelerated towards the anti-solar direction by non-gravitational forces.

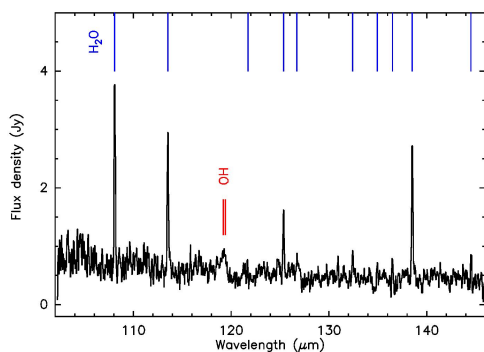


Figure 2: A spectrum of 103P/Hartley 2 obtained with PACS on Nov. 11, 2010. Identified H_2O and OH lines are indicated (blue and red ticks, respectively.)

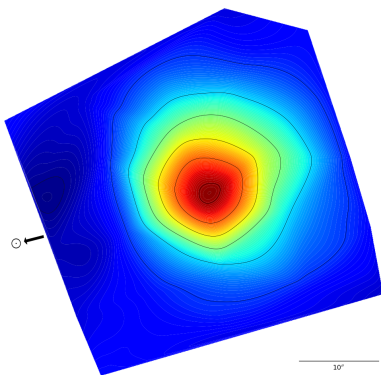


Figure 3: Map of the $2_{21} - 2_{12}$ (180.5 μm) H_2O line obtained with PACS on Nov. 4.55 UT. North is up and east is to the left. The Sun direction is given.

3. Dust coma

Images of dust thermal emission show excess emission towards the tail direction (Fig. 4). The dust production rate inferred from the PACS images is provisionally uncertain, as it depends on the dust size distribution which we expect to constrain in the future by combining PACS and SPIRE data from 70 to 500 μm . Using the dust model described in [3], we determine dust production rates in the range 250–750 kg/s for size indexes at the nucleus of 3.5–3.7, corresponding to a dust-to-gas mass production ratio of 1.5 to 2.

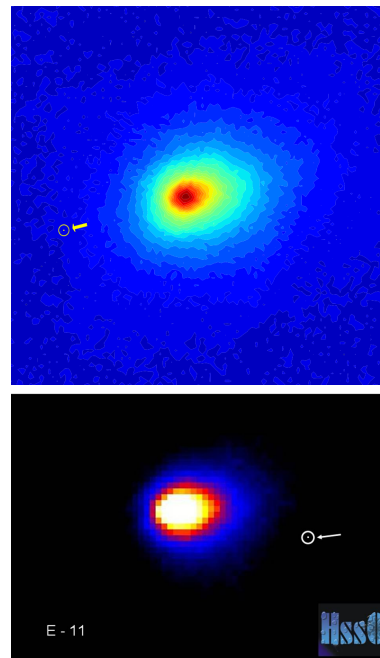


Figure 4: Top: 2×2 arcmin image of the dust coma at 70 μm obtained with the PACS instrument on Nov. 4.47 UT. Bottom: 5×8 arcmin SPIRE image at 250 μm obtained on 24 Oct. The direction of the Sun is indicated by the arrow. North is up and east is to the left.

References

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