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Parent Volatiles in Comet 103P/Hartley 2 Observed by Keck II with NIRSPEC during the 2010 Apparition

H. Kawakita (1), N. Dello Russo (2), R. J. Vervack, Jr. (2), C. M. Lisse (2), H. A. Weaver (2), H. Kobayashi (1), A. L. Cochran (3), W. M. Harris (4), A. J. McKay (5), N. Biver (6), D. Bockelée-Morvan (6) and J. Crovisier (6)
(1) Koyama Astronomical Observatory, Kyoto Sangyo University, Japan, (2) The Johns Hopkins University Applied Physics Laboratory, USA, (3)McDonald Observatory, USA, (4) University of California-Davis, USA, (5) New Mexico State University, USA, (6) LESIA, Observatoire de Paris, France, (e-mail: kawakthd@cc.kyoto-su.ac.jp / Fax: +81-75-705-1612)

Abstract

We conducted high-dispersion spectroscopic observations of comet 103P/Hartley 2 in the near-infrared wavelength region on multiple nights using the Keck II telescope with NIRSPEC. We obtained observations on four dates, with the last observations performed during the *EPOXI* closest approach. We summarize our spectroscopic observations and report gas production rates and the spatial distributions of the parent volatiles.

1. Introduction

Comet 103P/Hartley 2 (hereafter Hartley 2) is a Jupiter family comet that probably originates in the Kuiper-belt region based on its orbital elements. The 2010 apparition of the comet provided the best observing conditions for Hartley 2 to date as the comet passed within 0.12 AU of the Earth. Hartley 2 was also the target of the NASA *EPOXI* mission [1], and these favorable observing conditions allowed supporting observations from many ground-based observatories and satellites [4]. Physical and chemical properties obtained from the remote observations can be directly compared with those obtained from *in situ* measurements. Here we report our high-dispersion spectroscopic observations of parent volatiles at wavelengths near 3 microns [2].

2. Observations

We measured the volatile composition of Hartley 2 on multiple nights using the Near-Infrared Spectrometer (NIRSPEC) at the Keck II telescope on Mauna Kea, Hawaii [3]. Table 1 lists the heliocentric and geocentric distances of the comet and the velocity relative to the telescope during the observations. For our observations of Hartley 2 we used a 24 x 0.432 arcsec slit, giving a spectral resolving power of ~25,000. Our observations covered the wavelength range where many emission lines of parent volatiles (H_2O, CH_3OH, C_2H_6, C_2H_2, NH_3, HCN, and H_2CO) are present. The comet was put on the slit at different positions (A and B) and spectra were acquired using the sequence of four scans (ABBA) with an integration time of one-minute per scan. During a sequence the telescope was nodded by 12 arcsec between A- and B-positions on the slit.

Table 1: Observational conditions.

UT Date (2010)	Heliocentric distance r [AU]	Geocentric distance Δ [AU]	Δ-dot [km/s]
Sep. 16	1.20	0.28	-12
Oct. 17	1.07	0.12	-2.5
Oct. 21	1.06	0.12	+0.16
Nov. 4	1.06	0.16	+6.6

3. Results and Discussion

Echelle spectra images (Figure 1) were reduced by the usual procedures described elsewhere. For each grating setting (we used three grating settings per night), we extracted two-dimensional spectra as shown in Figure 2. Finally we obtained one-dimensional flux-calibrated spectra of the comet (Figure 3) and measured the flux for each emission line to determine the gas production rates. The spatial distributions of the molecules along the slit were also extracted. Figure 4 shows examples of asymmetric spatial profiles for C_2H_6 and H_2O along the slit, observed simultaneously on October 17. Hartley 2 showed a CN jet feature at visible wavelengths [6], and asymmetric spatial profiles obtained in our observations are probably related to such jet features of the parent volatiles.

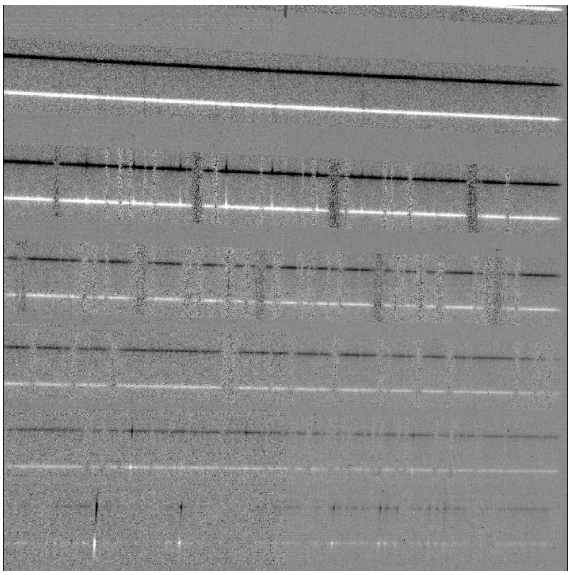

Figure 1: This is an example of a NIRSPEC echelle spectrum (taken on UT 2010 Oct 17).

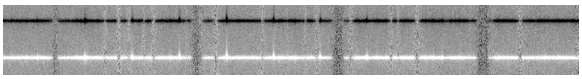

Figure 2: This is an example of a geometrically rectified spectrum from a single echelle order. Prominent emission lines from C_2H_6 are recognized.

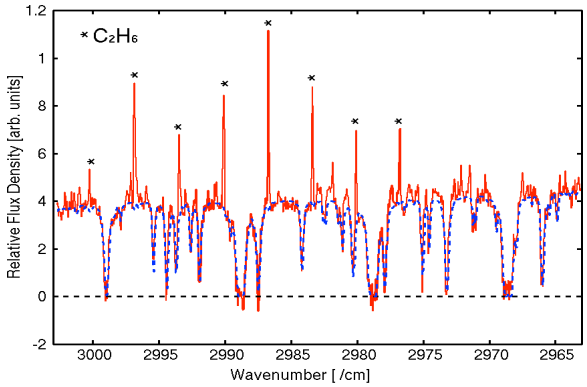

Figure 3: An example of a flux-calibrated spectrum. The "*" mark indicates emissions from C_2H_6. Other emissions are due to CH_3OH and weaker lines of C_2H_6.

On October 17, C_2H_6 and H_2O showed very asymmetric spatial profiles along the slit. Interestingly, their extensions were in opposite directions from each other. Mumma et al. (2011) also reported similar asymmetries for the molecular spatial profiles on October 19 and discussed sources for the molecules [5]. C_2H_6 and H_2O could be released from different vents on the nucleus or from extended sources like the icy grains observed *in situ* by *EPOXI*. The different spatial profiles perhaps suggest that the ice near the surface of the nucleus was probably heterogeneous in chemistry. Note that the dust continuum spatial profile was symmetric and sharper than the nominal ρ^{-1} profile, but broader than a point-spread-function (PSF) of a star. We will discuss gas production rates, mixing ratios, and spatial profiles of parent volatiles of Hartley 2 in the poster.

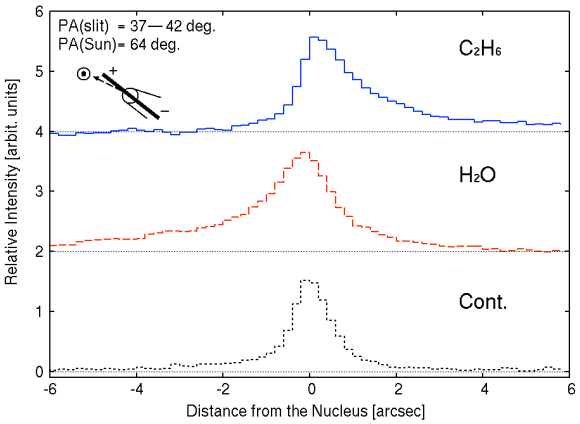

Figure 4: Spatial profiles of C_2H_6, H_2O and dust continuum. These are extracted from the observations shown in Figure 1. Positive distances correspond to approximately the Sun direction in this plot.

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