High Resolution Optical Spectroscopy of Comet 103P/ Hartley on UT Nov 4.

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Introduction

Comets can provide insights into how our solar system formed. This is due to their near pristine composition, which has been essentially unalterred since the formation of the solar system. A powerful tool for understanding the composition of a comet's nucleus is to observe the gas and dust composition of the coma.

However, coma composition alone does not directly represent the makeup of the nucleus [1]. Many species that are seen in cometary spectra at optical wavelengths represent daughter species whose presence results from the photodissociation of larger, structurally more complicated parent molecules. These parent molecules are best observed at IR and mm wavelengths. Therefore an understanding of the link between daughter and parent molecules is vital if the composition of the nucleus is to be understood. This can be accomplished most effectively by having observations of parent species in the IR or mm nearly coincident with optical observations of daughter species, as was done by Jehin et al. [2]. In this case the data are directly comparable, and correlations between daughter species and candidate parent molecules can be analyzed.

We present preliminary analysis of high spectral resolution optical spectra of comet 103P/ Hartley on UT 2010 November 4, hours before the DIXI flyby. This data set is complementary to infrared spectra obtained the same night with the NIRSPEC spectrometer on the KECK II telescope [3].

Observations

We obtained the spectra using the ARCES echelle spectrometer mounted on the Astrophysical Research Consortium 3.5-m telescope at Apache Point Observatory. ARCES has a very large spectral range (3500-10,000 Å) and a spectral resolution of R $\sim$ 31,500. Some of these observations overlap in time directly with NIRSPEC observations, facilitating a direct comparison of daughter species observed in the optical with candidate parent molecules observed in the IR.

We obtained observations on the optocenter of the comet. We also obtained spectra at offset positions $\sim$ 1000 km east and west of the optocenter, which correspond roughly to the solar and antisolar directions, respectively. This was necessary in order to extract spatial information from our spectra, since the 3.2" $\times$ 1.6" slit was too small for spatial information to be extracted within the slit. The projected area of the slit for 103P's geocentric distance at the time of the observations was about 350 $\times$ 175 km.

Results

We present the detection of CN, CH, C_3, C_2, and NH_2 in the spectra of 103P/ Hartley. Regions of the spectrum corresponding to spectral lines attributed to these molecules are shown in Figure 1. For each region two spectra are overplotted. The solid line represents the spectrum of the antisolar (western) offset position, and the dotted line the spectrum from the solar (eastern) off-

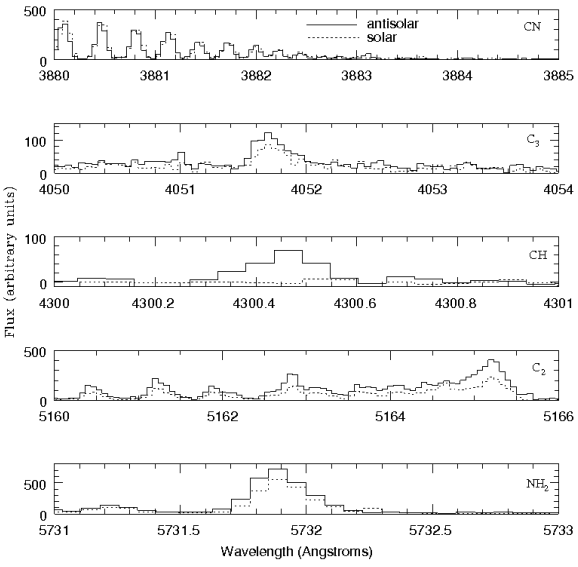

Figure 1: Regions of the spectra corresponding to, from top to bottom, CN, C_3, CH, C_2, and NH_2. Spectra in the antisolar direction (west) are plotted with a solid line and spectra in the solar direction (east) with a dotted line. Note the difference between the emission in the solar and antisolar directions for C_2, CH, C_3, and NH_2, while CN shows no discernible difference.

set position. We find evidence for possible asymmetries in the spatial distributions of C_2, CH, C_3, and NH_2 in the coma of 103P. Emission from CH is completely absent in the solar direction. The C_2 emission seems to be a factor of two larger in the antisolar than in the solar direction. The C_3 emission also shows stronger emission in the antisolar direction, but not the factor of two seen with C_2. The NH_2 emission seems to show an asymmetry similar in nature to that of C_3. No asymmetry is present in the CN emission. We will also present preliminary production rates of the observed species.

Future Work

These observations represent one night in a series of nights where we obtained high resolution optical spectroscopy of 103P/ Hartley, covering a time period from early September 2010 to late November 2010 (with another night in mid-January 2011 planned). This includes observations both pre-perihelion and post-perihelion. A full analysis of this data will allow us to look for variations in the production rate of CN, CH, C_2, C_3, and NH_2 throughout the orbit due to changing heliocentric distance and possibly seasonal effects. In addition to the Nov. 4, 2010 data set, we also have several other observations that are nearly coincident with NIRSPEC data. These data sets will be compared to clarify the parent-daughter molecule relationship in 103P.

Acknowledgements

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References

[1] R. Schulz. Compositional coma investigations: Gas and dust production rates in comets. In L. Daniela, M. Sylvio Ferraz, & F. J. Angel, editor, *Asteroids, Comets, Meteors*, volume 229 of *IAU Symposium*, pages 413–423, 2006. doi: 10.1017/S1743921305006885.

[2] E. Jehin, D. Bockelée-Morvan, N. Dello Russo, J. Manfroid, D. Hutsemékers, H. Kawakita, H. Kobayashi, R. Schulz, A. Smette, J. Stüwe, M. Weiler, C. Arpigny, N. Biver, A. Cochran, J. Crovisier, P. Magain, H. Rauer, H. Sana, R. J. Vervack, H. Weaver, and J.-M. Zucconi. A Multi-Wavelength Simultaneous Study of the Composition of the Halley Family Comet 8P/Tuttle. *Earth Moon and Planets*, 105:343–349, September 2009. doi: 10.1007/s11038-009-9317-8.

[3] N. Dello Russo, R.A. Vervack, H.A. Weaver, C.M. Lisse, H. Kawakita, H. Kobayashi, A.L. Cochran, W.M. Harris, A.J. McKay, and M.A. DiSanti. this meeting. 2011.