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Volatile Compositions of Short Period Comets 2P/Encke and 21P/Giacobini-Zinner Across Apparitions

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Abstract

The new iSHELL [5,6] spectrograph at the NASA Infrared Telescope Facility on Maunakea, HI is enabling detailed near-infrared compositional studies of more comets than ever before. The highly favorable apparitions of ecliptic comets 2P/Encke in 2017 and 21P/Giacobini-Zinner in 2018 allowed the first comprehensive comparisons of primary volatile abundances in comets across multiple apparitions. This enabled us to address pressing questions in cometary science, including investigating heliocentric distance and/or evolutionary effects on volatile production, sampling the hypervolatiles CO and CH_4 in short period comets, and measuring volatile release at small R_h. We characterized the volatile composition of 2P/Encke on three post-perihelion dates, detecting fluorescent emission from nine primary volatiles (H_2O, CO, C_2H_6, CH_3OH, CH_4, H_2CO, NH_3, OCS, and HCN), and obtained a sensitive upper limit for C_2H_2. 21P/Giacobini-Zinner was observed on four pre-perihelion dates, two dates near perihelion (coinciding with closest approach to Earth), and one post-perihelion date. We report detections of CO, C_2H_6, and CH_4 simultaneously with H_2O on multiple dates. We report rotational temperatures, production rates, and abundances relative to H_2O.

1. Introduction

Comets are among the most primitive remnants of solar system formation and their volatile composition is thought to reflect the conditions (composition and temperature) in the regions in which they formed. However, short period comets, which experience repeated heating due to multiple close perihelion passages, may display variations that could be due to evolutionary or seasonal effects. New instrumentation, coupled with a number of excellent apparitions by short period comets between 2016 and 2018, has allowed us to begin to test these possible effects.

2. Results

With three iSHELL settings, we can sample nine primary volatiles. A sample spectrum showing CO and H_2O in 21P is shown in Figure 1. Secure measurements of CO and CH_4 in Jupiter Family comets are particularly sparse because they are often faint and observed near closest approach to Earth when the geocentric velocity is insufficient to shift them out of their opaque telluric counterparts. As the most volatile molecules systematically observed in comets, their abundances may be particularly sensitive to both natal conditions and post-formative evolution.

We will present spectra and best fit models from which we derive production rates and abundances for both comets. Compared to mean abundances in comets observed to date in the near-infrared, mixing ratios of trace gases in 2P/Encke were depleted for all species except H_2CO and NH_3, which were "normal." 21P is also low in CO relative to all comets, but was found to be consistent with the average for CH_4.

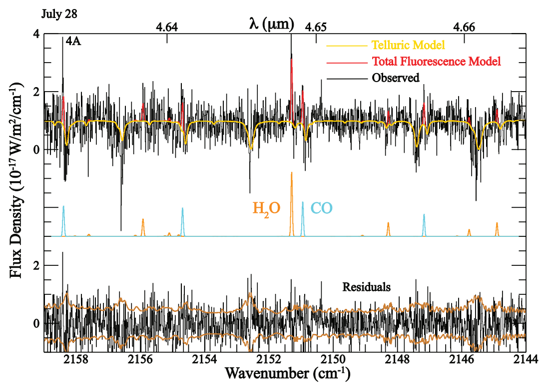

Figure 1: Extracted iSHELL spectrum showing detections of CO and H_2O in 21P on UT 2018 July 29. The telluric model is shown in yellow, the total fluorescence model in red, with fluorescence models for water (orange) and CO (blue) shown offset for clarity (from Roth et al. in prep).

Of particular interest is that significant differences in primary volatile composition were found for both comets, particularly for Encke, compared to published results for prior apparitions (see Figure 2). We discuss possible mechanisms for these differences and discuss these results in the context of findings from the Rosetta mission and ground-based studies of comets.

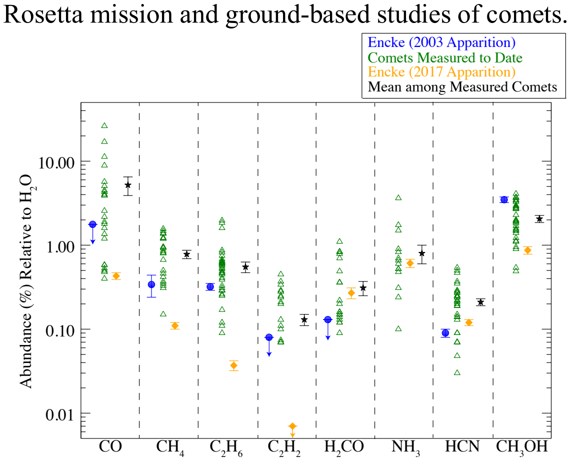

Figure 2: Comparison of mixing ratios (%, relative to H_2O) of primary volatiles sampled in Encke during 2003 (blue [4]) and 2017 (orange [7]). The range of measurements of each volatile is shown in green [1,3] and the mean value is in black. Downward arrows indicate 3σ upper limits.

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References

[1] Dello Russo, N. et al.: Emerging trends and a comet taxonomy based on the volatile chemistry measured in thirty comets with high-resolution infrared spectroscopy between 1997 and 2013, Icarus, 278, 301, 2016.

[2] Dello Russo, N. et al.: Post-perihelion volatile production and release from Jupiter-family comet 45P/Honda-Mrkos-Pajdušáková, Icarus, submitted

[3] DiSanti, M. A., et al.: Hypervolatiles in a Jupiter-family Comet: Observations of 45P/Honda-Mrkos-Pajdušáková Using iSHELL at the NASA-IRTF, Astron. J., 154, 264, 2017.

[4] Radeva, Y., et al.: High-resolution infrared spectroscopic measurements of Comet 2P/Encke: Unusual organic composition and low rotational temperatures, Icarus, 223, 298 2013

[5] Rayner, J., et al.: iSHELL: a 1-5 micron cross-dispersed R=70,000 immersion grating spectrograph for IRTF, Proc. SPIE 8446, 84462C, 12 pp., 2012.

[6] Rayner, J., et al.: iSHELL: a construction, assembly and testing, Proc. SPIE 9908, 990884, 17 pp., 2016.

[7] Roth, N. X., et al.: A Tale of "Two Comets: The Primary Volatile Composition of Comet 2P/Encke Across Apparitions and Implications for Cometary Science, Astron. J, 156, 251, 2018.