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Hypervolatiles in Jupiter Family Comet 46P/Wirtanen Observed with IRTF iSHELL

Adam McKay(1,2), Michael DiSanti (1), Boncho Bonev(2), Neil Dello Russo(3), Ronald Vervack Jr.(3), Erika Gibb(4), Nathan Roth(4), Mohammad Saki(4), Hideyo Kawakita (5)
(1) NASA Goddard Space Flight Center, Maryland, USA, (2) American University, D.C., USA, (3) Johns Hopkins Applied Physics Laboratory, Maryland, USA, (4) University of Missouri St. Louis, Missouri, USA, (5) Kyoto Sangyo University, Japan

1. Introduction

Comets have a primitive volatile composition that likely reflects the physics and chemistry operating in the region of the protosolar disk where they formed. For this reason studies of volatile material in comets have been considered important for understanding the formation of volatiles during the Solar System's infancy as well as the subsequent incorporation of volatiles into planetary bodies. However, close passages to the Sun during their most recent history means that evolution could also influence the volatile composition of comets we observe today, in particular abundances of extremely volatile species (so-called "hypervolatiles") such as CO and CH_4. This is potentially important for Jupiter Family Comets (JFC's), which likely have dynamical origins in the Scattered Disk and have undergone more close passages to the Sun.

Ground-based high spectral resolution IR spectroscopy has proven to be an effective way of determining the volatile composition of comets, especially hypervolatiles like CO and CH_4[1,2, and references therein]. However, observations of CO and CH_4 at IR wavelengths require both a comet of sufficient brightness and large enough Doppler shift (i.e. large enough geocentric velocity) so as to shift cometary CO and CH_4 emissions away from the absorptions of their telluric counterparts into areas of higher atmospheric transmission. This is rarely achieved for JFC's, which often have low geocentric velocity even when they are bright enough for IR high resolution spectroscopy, making observations of CO and CH_4 vary rare for JFC's.

Comet 46P/Wirtanen provided a rare opportunity to observe hypervolatiles in a JFC during its historic 2018-2019 apparition. While closest approach (and the focus of most of the ground-based observing campaign) was in mid-December, at this time the Doppler shift was not sufficient for studies of CO and CH_4. Here we present observations from January and February 2019 obtained with the iSHELL instrument on IRTF, with a particular focus on CO and CH_4.

2. Observations

We obtained IR spectroscopy of 46P in mid-January and early February, when the comet possessed sufficient Doppler shift for studies of CO and CH_4 but was also still bright enough for IR studies of its volatile composition. We observed in three spectral settings, Lp1 (sensitive to CH_4, C_2H_6, H_2CO, CH_3OH, and OH prompt emission), L_{custom} (sensitive to HCN, C_2H_2, NH_3, and H_2O), and M2 (sensitive to CO, H_2O, and OCS). Details of our observations are given in Table 1. We obtained very long on-source integration times: Lp1 had 280 minutes on-source in January and 140 minutes on-source in February, M2 had 324 minutes on-source in January and 78 minutes on-source in February, and Lcustom had 156 minutes on-source in January (not observed in February). We will present results from our analysis of these spectra, with a focus on the hypervolatiles CO and CH_4.

Table 1: Log of Observations

UT Date	R_h (AU)	Δ (AU)	$\dot{\Delta}$ (km/s)
Jan 11, 2019	1.128	0.179	+10.1
Jan 12, 2019	1.133	0.185	+10.3
Jan 13, 2019	1.138	0.191	+10.4
Feb 4, 2019	1.271	0.339	+13.2
Feb 5, 2019	1.278	0.346	+13.3

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