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Testing the cosmogonic origin of Jupiter-Family-Comets (JFCs): The case of 46P and 21P

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Abstract

We investigate the origin and evolution of Jupiter-Family-Comets (JFCs) by performing a detailed characterization of several key cosmogonic indicators in 46P and 21P as measured with iSHELL/NASA-IRTF, and by comparing these markers to other JFCs. Specifically, we quantified their chemical composition (e.g., HCN, NH_3, CO, C_2H_2, C_2H_6, CH_4, CH_3OH, H_2CO), derived spin-temperatures of several species (e.g., H_2O, CH_3OH, C_2H_6), performed sensitive tests to their isotopic (e.g., D/H), and searched for the signatures of ammoniated salts in their IR spectra. The results of these two recently observed JFC comets will be presented in the context of our extensive database of molecular inventory, with the ultimate goal of establishing new constraints on the origin and evolution of JFCs.

1. Introduction

Knowledge of the elemental, chemical and isotopic compositions of comets and planetary atmospheres is essential for the following open issues: (i) testing models of Solar System formation and evolution, (ii) assessing cometary delivery of organic compounds to the inner planets, and (iii) addressing the puzzling origin of water on Earth. Our knowledge about infant stages of our planetary system is still fragmentary and cometary nuclei retain the least processed material from that era. Investigation of comets composition, based on cosmogonic indicators (i.e., elemental and isotopic ratios, molecular abundances and isomeric ratios), is essential for testing models of Solar System formation and evolution, for assessing cometary delivery of organic compounds to the early Earth, and for addressing the origin of water on Earth [1].

In this talk, we will present and compare the volatile composition of two comets studied recently with high accuracy using iSHELL/NASA-IRTF: 21P/Giacobini-Zinner (the archetype of comets depleted in C_2 relative to CN), and the ecliptic comet 46P/Wirtanen (Faggi et al. 2019, in prep.).

2. High-resolution IR spectroscopy

High resolution spectroscopy with long-slit echelle spectrometers is a powerful method for ground-based IR surveys. In the infrared spectral region of about (3–5 um), trace volatiles (primary and product, including CO, H_2CO, CH_3OH, CH_4, C_2H_2, C_2H_6, HCN, NH_3, and OCS) are sampled simultaneously with H_2O (the dominant primary volatile, see Figure 1) [2,3,4].

Symmetric species (CH_4, C_2H_2, C_2H_6, C_2H_4, etc.) lack a permanent dipole moment and so are not active in pure rotational emission (radio, submillimeter), and their excited electronic states are usually pre-dissociated. Thus, they are uniquely sensed through their vibrational emissions at IR wavelengths, usually excited by solar fluorescence [4,5,6].

Today, advances in sensitive high-resolution spectrometers and analytical spectroscopic tools continue to open new paths in the exploration of comets and planetary atmospheres. In particular, high-resolution infrared echelle-spectrometers now permit exploration of solid and gaseous compositions for a broad range of planetary sources with unprecedented precision.

By providing major increases in spectral resolving power, spectral grasp, and instrumental sensitivity, the emergence of a new class of high-resolution IR echelle spectrometers offers the next advances in this field. The new capabilities of iSHELL provided unique results. In the two comets we will present, we detected fluorescent emission from organic gases (HCN, NH_3, CO, C_2H_2, C_2H_6, CH_4, CH_3OH, H_2CO) and water, and emission features of solid phase materials. Using our latest fluorescence models and analytical methods, we derived accurate mixing ratios, determined spin temperatures for several of these species, and obtained sensitive tests for isotopic enrichements.

The individual iSHELL settings cover a very wide spectral range with very high accuracy, eliminating many sources of systematic errors when retrieving molecular abundances; future comparisons amongst comets will clarify the nature and meaning of cosmogonic indicators based on composition.

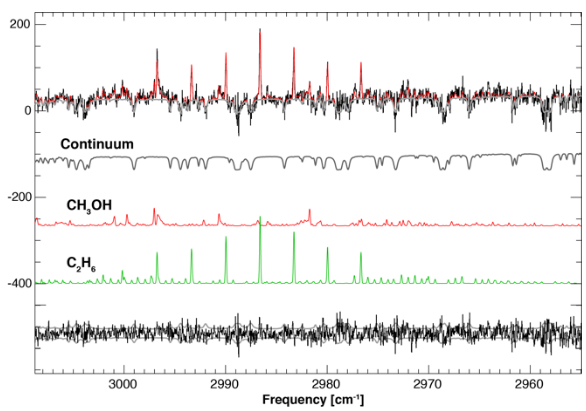

Figure 1. Spectra of 46P as observed with iSHELL/NASA-IRTF, showing strong detections of ethane (C_2H_6) and methanol (CH_3OH), and permitting also to quantify their spin temperatures.

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References

[1] Mumma & Charnley, *Ann Rev. Astron. Astrophys.* **49**, 471–524 (2011)

[2] Mumma, *et al. Adv. Space Res*. **31**, 2563-2575 (2003)

[3] DiSanti & Mumma *Space Sci. Rev*. **138,** 127-145 (2008)

[4] DiSanti *et al. Astrophys. J.* **650**:470-483 (2006)

[5] Villanueva *et al. Astrophys. J.* **747**, 1–11 (2012b).

[6] Villanueva *et al. J. Quant. Spectrosc. Radiat. Transfer* **113,** 202–220 (2012a).