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Analysis of H_2O rotational lines in comets with the *Herschel* PACS observations

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1. Introduction

Comets are among the best preserved specimens of the primitive solar nebula. Analyzing molecular components in comets could thereby provide information on the formation and evolution of our Solar System [1]. It is important to study the molecules in comets of various origins as they might come from various parts of the accretion disk and the species might have been formed under various chemical and physical conditions. Water constitutes usually 80% of cometary ices. Studying this molecule is thus essential to determine the nature of comets and characterize the molecular composition of them.

2. Observations and analysis of water lines

An accurate measurement of H_2O in comets from observations of its rotational lines is not easy because H_2O lines are often optically thick. The *Herschel Space Observatory* and its Photodetector Array Camera and Spectrometer (PACS) are well suited to search and analyze the water lines. We report observations carried out as a part of the "Water and related chemistry in the Solar System" guaranteed time key program for *Herschel* [2]. The PACS spectroscopic observations cover the spectrum between 55 and 220μm in four scans: two using the blue detector array (50-70μm and 70-100μm) and two using the red dectector array (100-150μm and 130-220μm).

We analyzed the PACS data of the comets 10P/Tempel 2, 103P/Hartley 2, 45P/Honda-Mrkos-Pajdusakova and C/2009 P1 (Garradd) in order to study the H_2O lines and search for $H_2^{18}O$ lines. Our data sample is really interesting because it contains not only Oort Cloud comets (OCC) but also Jupiter Family comets (JFC) and all the spectra were acquired with the same instrumentation. An example of a reduced spectrum obtained with PACS is presented in

Figure 1.

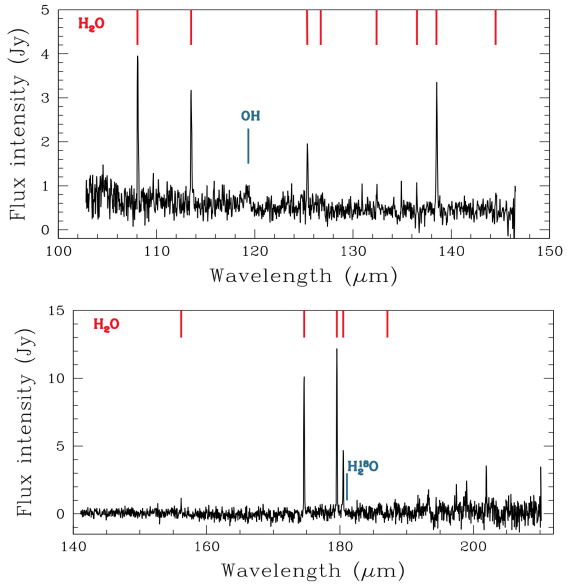

Figure 1: Two wavelength ranges of a spectrum of 103P/Hartley 2 obtained on 11 Nov 2010 with PACS instrument. Identified H_2O lines are indicated with red ticks. Bottom: Detected $H_2^{18}O$ line is pointed with a blue tick.

This work is based on excitation and radiation transfer models of H_2O and $H_2^{18}O$ provided by Biver et al. [3] but a preliminary examination of the relative intensities of lines at 179.5 and 180.5 μm and their brightness distribution suggest that these models need to be improved. We thus made a joint analysis of fifty observed water lines in order to identify the sources of disagreements. The interpretation of the spectral data also required to carefully take into account the PACS point spread function (PSF). Since the radiative transfer models include physical processes affecting the excitation of molecules, one of the main goals

of this analysis aims in a better understanding of the excitation mechanisms of water. Refining the models could then better constrain the water distribution and the water production rate in comets.

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