NUMERICAL SIMULATIONS OF WATER SPECTRA OBTAINED WITH THE MICROWAVE INSTRUMENT FOR THE ROSETTA ORBITER (MIRO) FROM COMET 67P/CHURYUMOV-GERASIMENKO.

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The European Space Agency Rosetta Spacecraft was launched on March 2, 2004 toward comet 67P/Churyumov-Gerasimenko. One of the scientific instruments on the Rosetta orbiter is a millimeter/submillimeter radiometer and spectrometer named MIRO (Microwave Instrument for the Rosetta Orbiter). This instrument will be used to study the evolution of four volatile species – CO, CH_3OH, NH_3 and three isotopologues of water, $H_2^{16}O$, $H_2^{17}O$ and $H_2^{18}O$ in comet 67P as a function of heliocentric distance. The MIRO experiment will use these species as probes of the physical conditions within the coma. The basic quantities measured by MIRO are the sub-surface temperature, gas production rates and relative abundances, and velocity and excitation temperature of each species, along with their spatial and temporal variability. This information will be used to infer coma structure and outgassing processes, including the nature of the nucleus/coma interface.

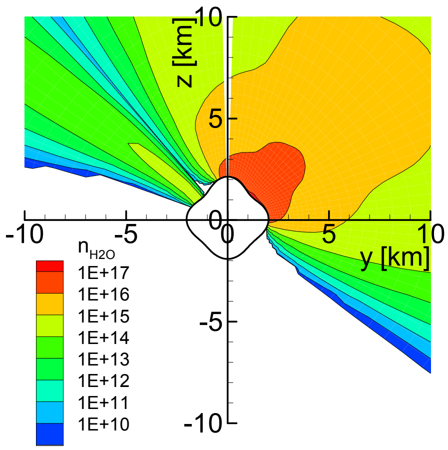

Fig. 1 Distribution of water density (m^{-3}) in the (y,z) plane in the vicinity of the nucleus [1]. The direction of the Sun is (0.5, 0.5, 0.707) in (x,y,z) coordinates.

We present the results of numerical simulations of the emergent line profiles (the synthetic line profiles) of the fundamental rotational line 1_{10}-1_{01} of water, $H_2^{17}O$ and $H_2^{18}O$ that could be obtained by MIRO during the approach of comet 67P. Simulations were provided for several spacecraft-nucleus surface distances for nadir and limb viewing.

The distributions of water density and velocity in the coma were taken from gas dynamical 3-D calculations performed for 67P at 3 AU from the Sun for a mixture of CO and H_2O with total gas production rate $\sim10^{27}$ s^{-1} and the "starfish" nucleus analytical shape (Fig. 1) [1]. For the computation of the line profiles we assume that the excitation state of the water molecules corresponds to the local thermodynamical equilibrium distribution.

Simulations show that the signal-to-noise ratio is very high over a wide range of spacecraft-nucleus distances. The observed spectral lines are optically thick for H_2O and optically thin for $H_2^{18}O$ and $H_2^{17}O$. The frequency resolution allows to study the gas dynamical structure of the coma from the line profiles. Examples of computed line profiles of H_2O for a spacecraft-nucleus surface distance of 10^4 km and several off-set positions along the y-axis are presented in Fig. 2 (left). Examples of computed line profiles of H_2O and $H_2^{18}O$ for nadir viewing at distance of 100 km are presented in Fig. 2 (right). In this case, the lines are seen un absorption against the nucleus continuum. The outflow velocity is easily measurable from the Doppler shift of the line frequency.

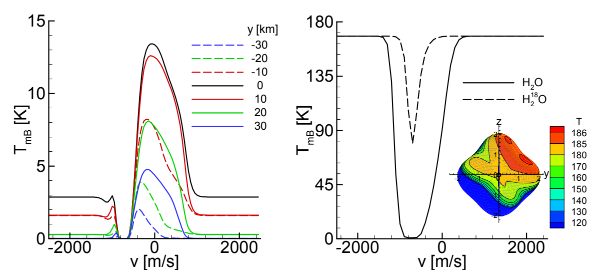

Fig. 2 Variation of line profiles versus off-set position of the beam (left) and for nadir view (right). The surface temperature map is shown. The line of sight is along the x-axis. The spacecraft-nucleus distance is 10^4 km (left) and 100 km (right.)

References: [1] Crifo J. F. et al. (2004) In The New Rosetta Targets. Observations, Simulations and Instrument Performances. Kluwer, *Astrophysics and Space Science Library*, *311*, 119-130.