Using Hydrodynamical Modeling of the CO Coma of Comet Hale-Bopp to Interpret IRAM Plateau de Bure Observations.

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Introduction: Millimeter interferometry enables to study the spatial distribution of molecules in inner cometary atmospheres. In March 1997, with the IRAM Plateau de Bure Interferometer, unique data were obtained in comet C/1995 O1 (Hale-Bopp) with angular resolutions between 1 and 3". The traditionnal (non gas dynamical) analysis of CO $J(2–1)$ observations suggested the presence of a nearly equatorial CO jet spiraling with nucleus rotation and comprising about 40% the total CO production [1]. We interpret here the same data on the basis of a physical model of the coma.

Observations: The main evidences for the existence of a CO structure in the coma are : 1) on the autocorrelation spectra the mean velocity offset evolves with time, following a sine with the rotation period of the nucleus (11.35 h, [2], see Fig. 1); 2) on successive interferometric maps (data subsets of 1 hour), the position of the brightness maximum moves along the direction perpendicular to the spin axis (Fig. 2).

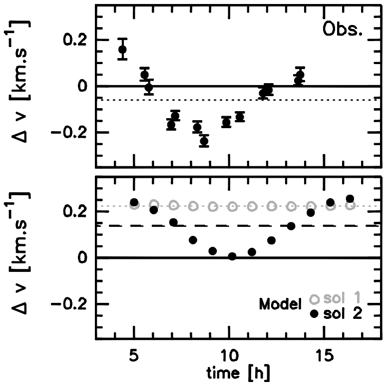

Figure 1: Time evolution of the velocity offset of the CO $J(2–1)$ line, measured on observed (upper panel) and synthesized (lower panel) single dish spectra. *Solution 1 assumes an homogeneous production of CO, Solution 2 includes a CO jet near the nucleus equator.*

Coma model: Rodionov and Crifo [3] suggested that an elongated nucleus could create strong structures in the gas coma during its rotation without any inhomogeneity in the gas production from the surface. They developed a 3-D, time dependent, gas dynamics model of a coma created by a non spherical rotating nucleus. H_2O is assumed to sublimate according to solar illumination while CO diffuses uniformly from below the surface (Solution 1). In a second step, they included on the nucleus an area with higher CO production (Solution 2). The aim was to check whether the "jet" described in [1] could survive gas dynamics effects and still reproduce the observations. Additional solutions have been computed then to assess the impact of different parameters (such as nucleus illumination or coma heating) on the coma morphology.

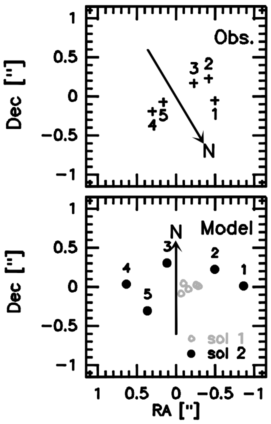

Figure 2: Position of the brightness maximum on five successive interferometric maps (1h of integration). The arrow indicates the direction of the North pole of the nucleus. Note that the orientation is not the same in the observations and the simulations. *The observations (respectively the model results) are presented in the upper (resp. lower) panels. Solution 1 assumes an homogeneous production of CO, Solution 2 includes a CO jet near the nucleus equator.*

Results: We have developed a radiative transfer model to simulate both interferometric and single dish observations of the CO $J(2–1)$ rotational line, reading hydrodynamical solutions as input. Our simulations show that the effects of the nucleus shape on the coma structure are too faint to be detectable in the observations (see Figs. 1–2). Assuming an inhomogeneous CO production from the nucleus, it is possible to reproduce the main features observed in comet Hale-Bopp with the PdBI in 1997. Some differences remain, showing that the coma structure was actually more complicated.

References : [1] Henry, F., Bockelée-Morvan, D., Crovisier, J., Wink, J. (2002), EM&P, 90, 57; [2] Jorda, L., Rembor, K., Lecacheux, J. Colom, P. et al (1999), EM&P, 77, 167; [3] Rodionov, A.V. and Crifo, J.-F. (2006), AsSpR, 38, 1923.