MILLIMETER-WAVELENGTH SPECTROSCOPY AS A TOOL FOR STUDYING THE ROTATION OF ACTIVE COMETS: THE CASE STUDY OF COMET 8P/TUTTLE. M. Drahus[1], C. Jarchow[1], P. Hartogh[1], W. Waniak[2], T. Bonev[3], G. Borisov[3], K. Czart[4], and M. Küppers[5], [1]Max-Planck-Institut für Sonnensystemforschung, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany, drahus@mps.mpg.de, [2]Astronomical Observatory of the Jagiellonian University, ul. Orla 171, 30-244 Kraków, Poland, [3]Institute of Astronomy of the Bulgarian Academy of Sciences, 72 Tsarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria, [4]Toruń Centre for Astronomy of the Nicolaus Copernicus University, ul. Gagarina 11, 87-100 Toruń, Poland, [5]European Space Astronomy Centre, 28691Villanueva de la Cañada, Madrid, P.O. Box 78, Spain.

Introduction: Active cometary nuclei are expected to manifest their rotation by diurnal variability of the outgassing rate and direction of parent molecules. A natural observing tool for detecting and investigating these effects is millimeter-wavelength spectroscopy. It is sensitive to parent molecules through their rotational transitions, and offers spectral resolution of the order of 1 million or more (0.3 km/s or better). The unique resolving power provides a detailed spectral profile (or at least a position) of an individual line, which is controlled by an instantaneous outgassing pattern of the nucleus surface, whereas the integral sum of the line is a good indicator of an instantaneous total production rate. A critical condition for a successful detection of these effects is to restrict the observation to the molecules emitted at similar moments in time, which requires small beam sizes and short exposures. So far, such effects have been detected only for comet Hale-Bopp [1], [2], Tempel 1 [3], and recently Schwassmann-Wachmann 3 [4].

Comet 8P/Tuttle approached the Earth at a distance of only 0.25 AU in Dec. 2007 and Jan. 2008, providing a natural opportunity to investigate the effects related with the rotation of its nucleus. It is a Halley family comet with an orbital period of 13.6 years. Due to the very unfavorable geometric conditions around its previous perihelion passage in 1994, the last time it was widely observed was only during its return in 1980/1981.

Observations: Comet 8P/Tuttle was monitored through the $J(3\text{–}2)$ transition of the HCN molecule using the Arizona Radio Observatory's Submillimeter Telescope on Mount Graham. The half-power radius of the beam was 14.5 arcsec, corresponding to 2600 km at the comet, and the spectral resolution was 0.28 km/s. The monitoring covered five hours of observation on Dec. 30, 2007, three hours on Dec. 31, 2007, and five hours on Jan. 1, 2008, all under excellent weather conditions. As a result we acquired 27 spectra, each comprising a 30-min. time interval.

Results and discussion: On each night the line profile was evolving in an organized manner; in Fig. 1 we show two contrasting examples. At the same time the integral sum of the line was fairly constant. The repeatability of the spectral signatures is consistent with the rotation periods of 5.7 hr, 7.4–7.6 hr, and their multiplicities.

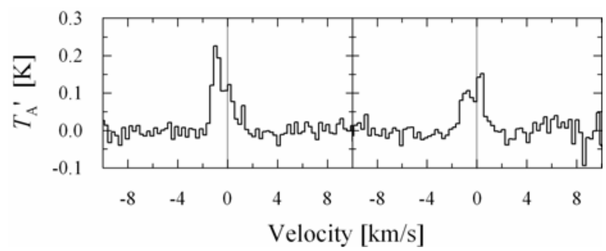

Figure 1: An example of two individual spectra.

Very similar results have been obtained before [5], [6]. We should note, however, that the period of 7.4 hr links the spectra from different nights noticeably better than does the period of 5.7 hr. Multiplicities of both base periods cannot be excluded, though they are difficult to evaluate.

Our spectra suggest a gas-expansion velocity equal to 0.8 km/s, and a mean-diurnal production rate of log Q(HCN) = 25.45. Whereas the velocity is typical for a comet around the Earth's orbit, the production rate is significantly lower from what should be expected for a nucleus with a 7.3-km radius [7].

Conclusions and future work: We demonstrated that the millimeter-wavelength spectroscopy of parent molecules can be an effective tool for studying the rotation of active comets. As by-products of such observations, the gas-expansion velocity and the mean-diurnal production rate of the observed molecule can be easily retrieved. Furthermore, we will attempt to model the observed line profiles all together in order to obtain some constraints on the spin axis orientation and the location of active source(s).

References:

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