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Comet 10P/Tempel 2 outgassing observed with Herschel

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1. Introduction

Comet 10P/Tempel 1 was observed with the Herschel Space Observatory, in the framework of the *Herschel* guaranteed time key project "Water and related chemistry in the Solar System" [3]. One of the main goals of the project is studying water emission and excitation processes in cometary comae The observations of Comet Tempel 2 covered the period from June 15 to July 29, 2010. The comet was at a distance ~1.43 AU from the Sun and at a distance ~1.9 - 1.7 AU from Herschel. Long and short-term monitoring was performed. Herschel/HIFI provided detection of several water transitions: 1_{10}–1_{01} (557 GHz), 2_{02}-1_{11} (987 GHz), 1_{11}–0_{00} (1113 GHz), 2_{12}–1_{01} (1669 GHz). In addition, the cometary coma was mapped at 557 and 987 GHz on June 15, July 7, July 19 and July 29. Three OTF maps of water are shown in Fig. 1. The ammonia transition NH3(1-0) was detected for the first time in a Jupiter-Family comet [1]. Water lines were also detected with Herschel/PACS and Herschel/SPIRE.

Comet Tempel 2 is a well-known member of the Jupiter-family comets that was observed in many apparitions since its discovery in 1873. It passed last perihelion on July 4.9 UT, 2010 at heliocentric distance of 1.42 AU.

2. Data analysis

The excitation model includes collisions with water and electrons in the inner coma. Model calculations are performed with a constant gas temperature T= 28 K, $x_{\_ne}$=0.2 (electron density factor), expansion velocity in the coma, v_{exp} = 0.9 km/s. The density distribution model assumes contribution from one or more active regions. Sekanina [6] derived the spin axis orientation of Comet Tempel 2 as well as locations of three active regions (vents) on the surface of its non-spherical nucleus. Equatorial coor-

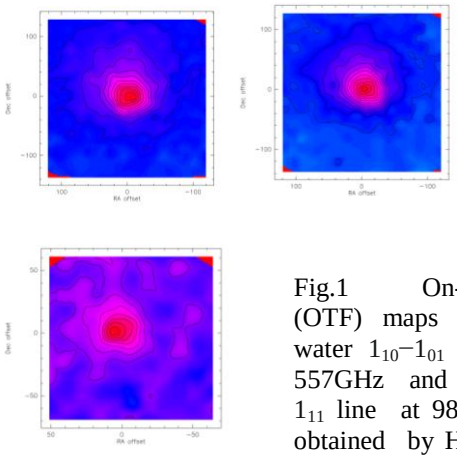

Fig.1 On-the-fly (OTF) maps of the water 1_{10}–1_{01} line at 557GHz and of 2_{02}-1_{11} line at 987 GHz obtained by HIFI on July 19, July 29, and of July 7 (bottom), respectively. North is up, East is to the left. The Sun is to the NE, closer to the East . The jet is directed to the NE but closer to the North. The gas emission is towards the observer.

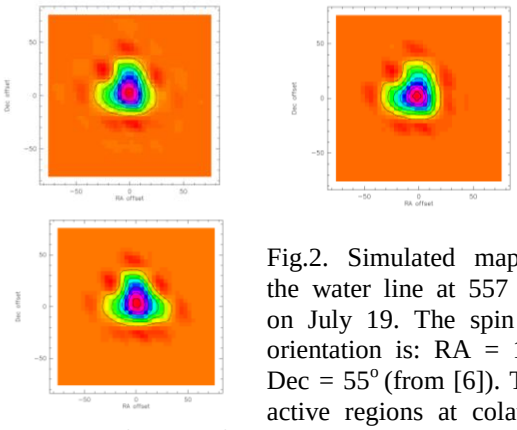

Fig.2. Simulated maps of the water line at 557 GHz on July 19. The spin axis orientation is: RA = 150 ^{o} Dec = 55^{o} (from [6]). Three active regions at colatitide between 10^{o} and 40^{o} (two upper maps), one active region at colatitude 30^{o}(bottom map).

dinates of the northern rotation pole of the nucleus is: RA = 150°, Dec = 55°. Then the spin axis is directed to the NE towards *Herschel*. The three active spots or one active spot located at the northern hemisphere of the nucleus is assumed. Different locations of the active regions are studied. In all considered cases the gas emission are directed towards the observer over large intervals of the rotational period. In consequence the lines (optically thin) are strongly blueshifted. However, the self-absorption effects essentially change the optically thick line profiles of water. Examples of the preliminary model maps are shown in Fig. 2. Rotation period of the comet is P= 8.95 h. Sekanina's orientation of the spin axis seems to be confirmed by the Herschel observations. However the location of the active spots is under discussion

3. Activity of Comet 10P/Tempel 2

The pattern of activity of Comet Tempel 2 indicates a strong anisotropic emission from its nucleus. The temporal variation of the production of water is in a good agreement with the light curve derived from visual observations (e.g. [4]). Both the light curve and production rate from the previous apparitions and the last apparition exhibit a strong asymmetry with respect to perihelion; a rapid brightness increase before the maximum, followed by a slow decrease after it. The outgassing peaks about 10-20 days after perihelion. The production rate measurements from the 1987 and 2010 apparitions are shown in Fig. 1. The anisotropic emission may be explained by a non-uniform distribution of active region over the nucleus surface. Other evidences for localized activity of Comet Tempel 2 are also provided by Herschel observations: the shapes of the water lines, the maps of the coma.

4. Summary

Comet 10P/Tempel 2 was the target of Herschel Space Observatory. It was observed close to its perihelion passage on July, 2010. A water production rate ~$3\cdot10^{28}$ s^{-1} was derived. The high-resolution spectra of Herschel/HIFI allowed to detect several rotational water lines. The line shapes and the OTF maps suggest an anisotropic outgassing due to localized active spots.

[4] Roettger, E.E. and Feldman, P.D., Icarus 86, 100-114, 1990

[5] Osip et. el., Icarus 98, 115-124,1992

[6] Sekanina, Z., AJ 102, 350-389, 1991

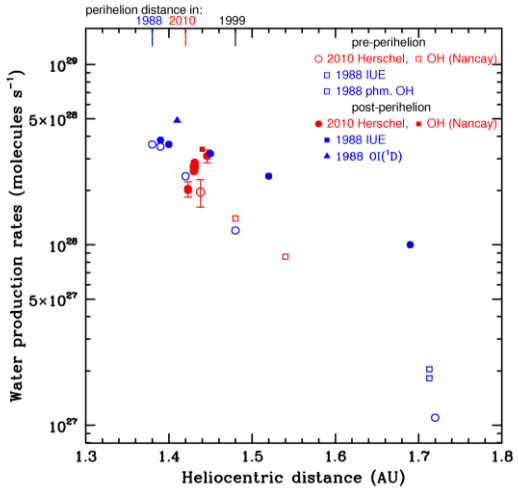

Fig.3 The water production rate is higher post-perihelion. The perihelion distance, q, increased after the 1988 apparition. In consequence the peak of production rate at the 2010 apparition decreased. Open and full symbols show production rates pre- and post-perihelion from [1], [2], [4], [5], and Herschel/HIFI. The water production rates based on Herschel-HIFI observations are ~$2\cdot10^{28}$ s^{-1} and ~$3\cdot10^{28}$ s^{-1} close to perihelion and 30 days post-perihelion, respectively.

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References

[1] Biver, N. et al., in preparation

[2] Fink, U., Icarus 201, 311-334, 2009

[3] Hartogh, P., Lellouch, E., Crovisier, J., et al., Planet. Space Scie., 57, 1596–1606