Radio Observations of the OH Radical in Comets 46P/Wirtanen and 81P/Wild 2

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Comets 46P/Wirtanen and 81P/Wild 2 are the targets of the Rosetta and the Stardust missions, respectively. In order to constrain the gas production rates of these ill-known comets, their OH 18 cm lines were sought with the Nanąay radio telescope during their 1997 apparitions. 46P/Wirtanen was not detected within an upper limit of $Q_{[OH]} < 1.5\times10^{28}$ s^{-1} at $r = 1.12$ AU from the Sun. For 81P/Wild 2, $Q_{[OH]}$ was measured to be $0.8\pm0.2\times10^{28}$ s^{-1} at $r = 1.74$ AU.

1. Introduction

Two important missions will explore comets in the near future: ESA's Rosetta and NASA's Stardust. Both are targeted at Jupiter-family comets: 46P/Wirtanen for Rosetta and 81P/Wild 2 for Stardust. These comets were selected on the basis of their accessibility to spacecraft within a reasonable schedule. However, they are faint objects for which little information is available. In particular, they have never been subjected to spectroscopic investigations.

To prepare for these missions, supporting observations by all available means were advocated (Schulz & Schwehm, 1996). We took part in this effort by making radio observations of the comets' OH 18 cm lines. The OH radical, a decomposition product of water, is a direct tracer of the gaseous output of comets. It has been found with the Nançay radio telescope in about 50 comets so far (Bockelée-Morvan et al., 1994; Gérard et al., 1998 and references therein), resulting in the monitoring of their water production rates and in the study of the kinematics of their atmospheres.

In early 1995, 15P/Finlay was observed without success while it was a Rosetta backup target. In mid-1995, OH observations of Comet 73P/Schwassmann-Wachmann 3, a former Rosetta candidate, revealed an unexpected outburst, which was related to a splitting of the nucleus (Crovisier et al., 1996). The observations of 46P/Wirtanen and 81P/Wild 2 at their 1997 returns are presented here.

The observations were made using the same instrumentation and protocol as the previous cometary observations at Nançay (Bockelée-Morvan et al., 1990; 1994; Gérard et al., 1998). The reduction and the conversion of the observed signals into OH production rates were made using the same model as before. The modelling of the quenching of the cometary OH maser by collisions (Gérard et al., 1998) on the basis of observations of C/1996 B2 (Hyakutake) and C/1995 O1 (Hale-Bopp) is being refined, but this improvement is of no consequence for the small comets studied here.

2. 46P/Wirtanen

46P/Wirtanen passed perihelion on 1997 Mar 14 at 1.06 AU from the Sun. The observing conditions were highly unfavourable, the comet being at small solar elongation and never closer than 1.5 AU from the Earth. It was observed from Nançay for about 1 h daily during two periods, pre- and post-perihelion, when the inversion

Table 1. Summary of the observations and the derived OH production rates.

Date	*Δ (AU)*	*r (AU)*	*inversion*	*line area (mJy km s^{-1})*	*$Q_{[OH]}$ (10^{28} s^{-1})*
46P/Wirtanen					
1997 Feb 04-Mar 05	1.58	1.12	–0.29	–5±4	< 1.5
1997 Apr 19-May 09	1.63	1.23	–0.17	2±6	< 2.4
81P/Wild 2					
1997 Jan 21-Mar 23	0.88	1.74	–0.30	–17±4	0.8±0.2

Δ: average distance to Earth; *r*: average distance to Sun; 'inversion': expected inversion of the OH maser; observed line area; *Q*: OH production rate or its 3σ upper limit

of the OH maser was predicted to be high. However, the OH lines were not detected. The observing conditions (distances to Sun and Earth, OH maser inversion) were almost constant during these two periods, so the spectra were averaged over each period of observation. The observation parameters and the resulting limits are listed in Table 1. $Q_{[OH]} < 1.5\times10^{28}$ s^{-1} was derived for between the beginning of February and the beginning of March, and $Q_{[OH]} < 2.4\times10^{28}$ s^{-1} for between the end of April and the beginning of May.

From the light curves of previous returns, Jorda & Rickman (1995) and Rickman & Jorda (1998) evaluated the water production rate of 46P/Wirtanen to be 1.5-6×10^{28} s^{-1} at perihelion. A'Hearn et al. (1995) measured $Q_{[OH]} \sim 1.1\times10^{28}$ s^{-1} close to the perihelion of the 1991 return. As discussed by Rickman & Jorda (1998), this evaluation might be an underestimate because of the use of inappropriate parameters in the Haser model describing the OH distribution.

During the 1997 return, optical observations could be performed only pre-perihelion because of the unfavourable viewing conditions. Using the Faint Object Spectrograph on the Hubble Space Telescope on Jan 15 (comet r = 1.3 AU from the Sun) to measure the OH band in the UV, Stern et al. (1998) reported a water production rate ~0.6×10^{28} s^{-1}. From measurements of the Lyman-α line with the SWAN instrument aboard the Soho observatory, Bertaux (1997) estimated $Q_{[H_2O]} = 0.7\times10^{28}$ s^{-1} on Feb 10 (r = 1.15 AU). Farnham & Schleicher (1997) measured $Q_{[OH]} = 0.8\times10^{28}$ s^{-1} from narrowband photometry at Lowell Observatory on Mar 05 (r = 1.07 AU).

These results and the Nançay limits cannot be directly compared because the production rates were not always derived with the same Haser model parameters for OH. However, the non-detections at Nançay appear to be consistent with the low production rates derived from the UV observations.

3. 81P/Wild 2

81P/Wild 2 passed perihelion on 1997 May 06 at 1.58 AU from the Sun. It was observed at Nançay almost daily from the end of January to the end of March, during the period of best observing conditions. The observations were more sensitive than those of Comet 46P/Wirtanen because of the closer approach to Earth. The comet was detected from the average of all the observations (Table 1 and Fig. 1). The line is relatively narrow, with a width comparable to those observed for comets with small gas production rates (Bockelée-Morvan et al., 1990). The production rate is $Q_{[OH]} = 0.8\pm0.2\times10^{28}$ s^{-1}. This is to be compared with the $Q_{[OH]} = 4\times10^{27}$ s^{-1} determined from narrowband photometry at Lowell Observatory during the 1978 return, when the comet was at 2.24 AU (pre-perihelion) from the Sun (A'Hearn et al., 1995).

These observations clearly show the limits of OH observations of faints comets at

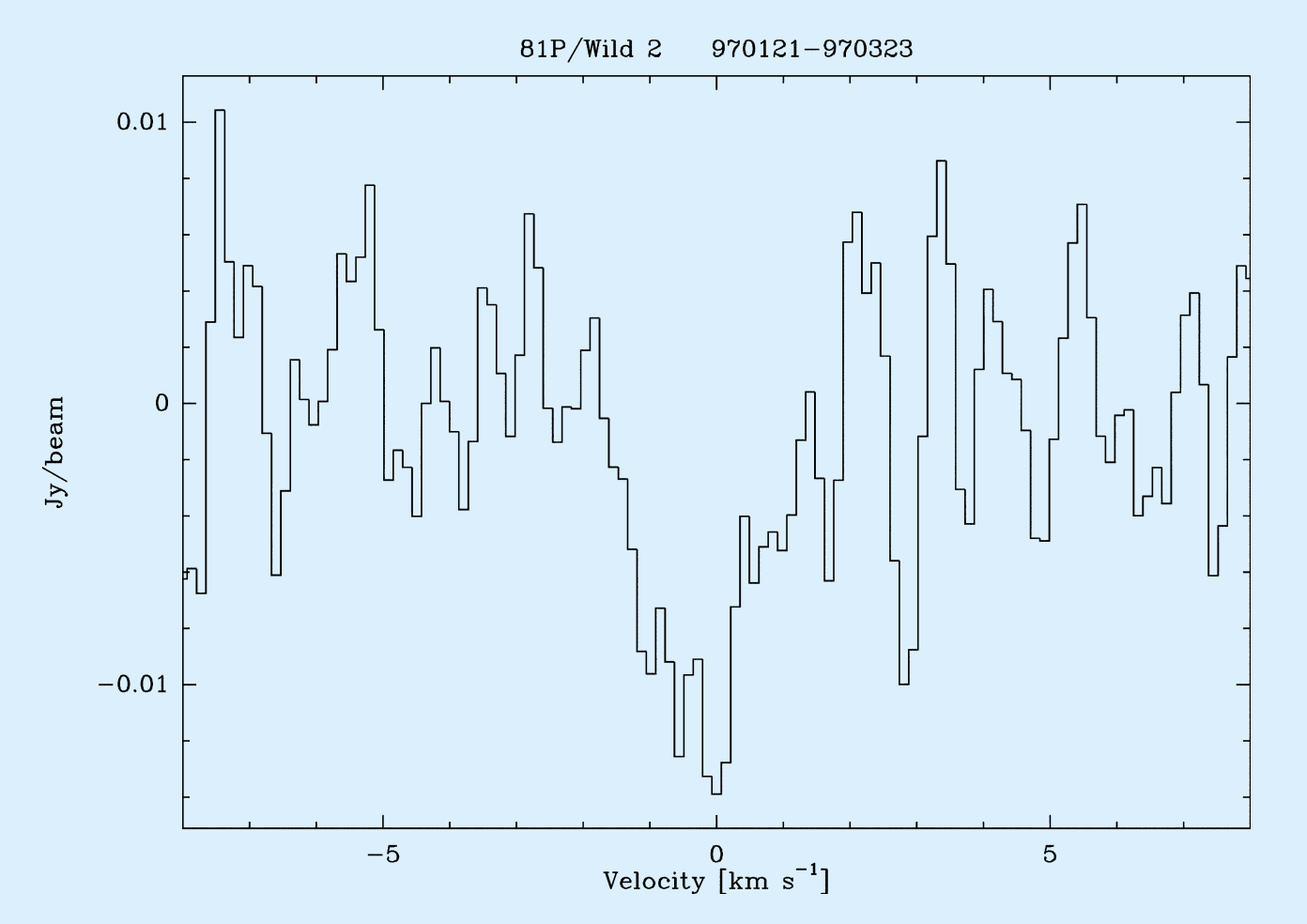

Fig. 1. The 18 cm OH spectrum of 81P/Wild 2. Average from 1997 Jan 21 to 1997 Mar 23 of the left and right circular polarisations of the 1667 MHz line.

Nançay. An upgrading of the radio telescope is now in progress, from which a gain of a factor of 2 in sensitivity is expected. This will permit a better study of Jupiter-family comets.

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