# ON THE FIRST SOUTHERN-SKY $H_2O$ MASERS OBSERVED AT ITAPETINGA, BRAZIL

PIERRE KAUFMANN, W. G. FOGARTY, E. SCALISE, JR., and R. E. SCHAAL
*Centro de Rádio-Astronomia e Astrofísica, Universidade Mackenzie, São Paulo, Brazil*

**Abstract.** The first spectra of southern $H_2O$ masers obtained with the 14-m Itapetinga radio telescope are described. A new $H_2O$ source was found in H2-3 (G345.4 − 0.9).

The first southern-sky $H_2O$-maser spectra were obtained at Itapetinga Radio Observatory, Atibaia, São Paulo, Brazil, in the middle of 1973, with a 45-ft radome-enclosed radio telescope. A preliminary description of the instrument was given by Kaufmann and D'Amato (1973). Based on measurements of Jupiter at 22.2 GHz, the antenna has an aperture efficiency of 60% for the dish alone (without radome), and thus for point sources 1 K of corrected antenna temperature corresponds to 31 Jy. A load at 330 K served as a calibration source for the observations. The relative pointing and tracking accuracies of the radio telescope were 4″ rms. The absolute accuracies were not yet completely determined, but an upper limit of less than 20″ is known for the repeatability – negligible in comparison to the antenna HPBW at K-band.

A simplified spectrometer was used during these first experiments. The IF output from a dual beam front end was fed into a spectrum analyzer which scans in frequency. After synchronous detection the measurements were stored and averaged by an on-line digital integrator. The integration time corresponding to a multichannel system was $T = N\Delta t(\Delta f/\Delta F)$ seconds, where $N$ is the number of sample scans, $\Delta t$ the duration of each scan, $\Delta f$ the filter bandwidth and $\Delta F$ the frequency interval analyzed. Most of the measurements were taken with $\Delta f = 43$ kHz, $\Delta F = 2$ MHz and $\Delta t = 1$ s. The actual integration times, $N\Delta t$, of thousands of seconds corresponded to relatively small $T$. These first spectra were somewhat noisy but repeatable with respect to intensities and structures found.

Antenna temperatures were carefully corrected for atmospheric and radome attenuation, following the relation

$$T_a = T_a^* \exp(\tau \sec z)/\eta_r,$$

where $T_a$ is the corrected antenna temperature, $T_a^*$ the measured antenna temperature, $\tau$ the optical depth of the troposphere, $z$ the zenith angle, and $\eta_r$ the radome transmission at K-band. During the period of observation, $\tau$ ranged from 0.1 to 0.2 and was frequently measured.

The main results can be summarized as follows:

(a) Well known sources measured by northern hemisphere observatories were observed. The spectrum of the Orion A $H_2O$ maser is shown in Figure 1 for comparison purposes, since it is well known in position and typical strength of the lines (Hills *et al.*, 1972).

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(b) Southern hemisphere $H_2O$ sources discovered by Johnston *et al.* (1971) using the 9-m Carnavon antenna in Australia and by Johnston *et al.* (1972) using the Parkes telescope (with its inner reflector resurfaced) were then observed and confirmed at Itapetinga. Among these sources we should comment that G285.3 − 0.1,

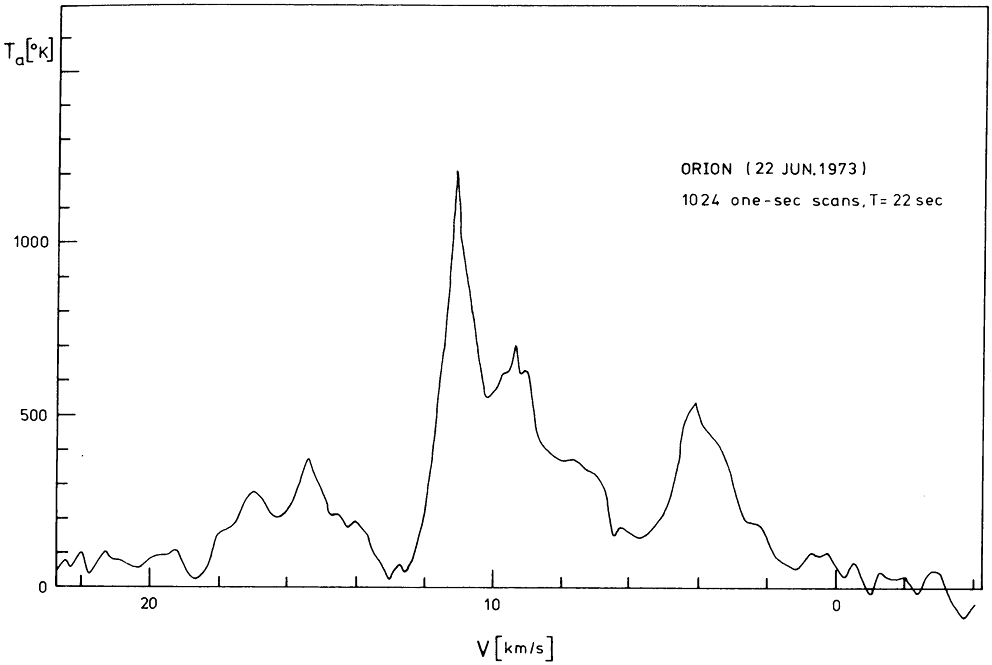


Fig. 1. The principal $H_2O$ lines observed in Orion, centered on $+10$ km s$^{-1}$.

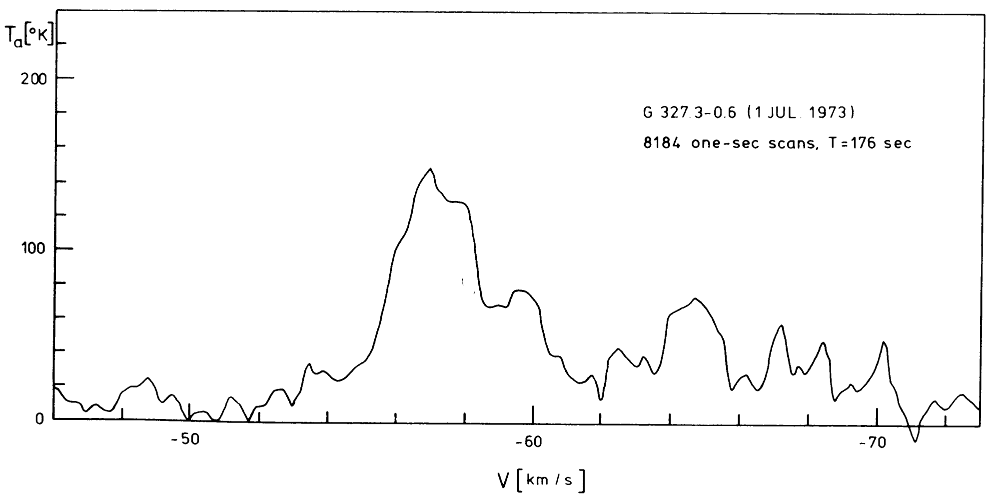


Fig. 2. A more complex spectrum of water vapour lines from the galactic source G327.3 − 0.6.

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G327.3 − 0.6, G331.5 − 0.1, G333.6 − 0.2 and G345.7 − 0.1 have shown stronger lines, with some changes in their original structures, and gave antenna temperatures ranging from 150 K to 950 K. The source G327.3 − 0.6 is shown in Figure 2 with an additional line appearing at $-65$ km s$^{-1}$. The source G331.5 − 0.1 is shown in Figure 3, and it is the strongest so far known in this series of new $H_2O$ masers. It shows a $-97$ km s$^{-1}$ line that is much stronger and well resolved than the broader emission between $-86$ km s$^{-1}$ and $-94$ km s$^{-1}$.

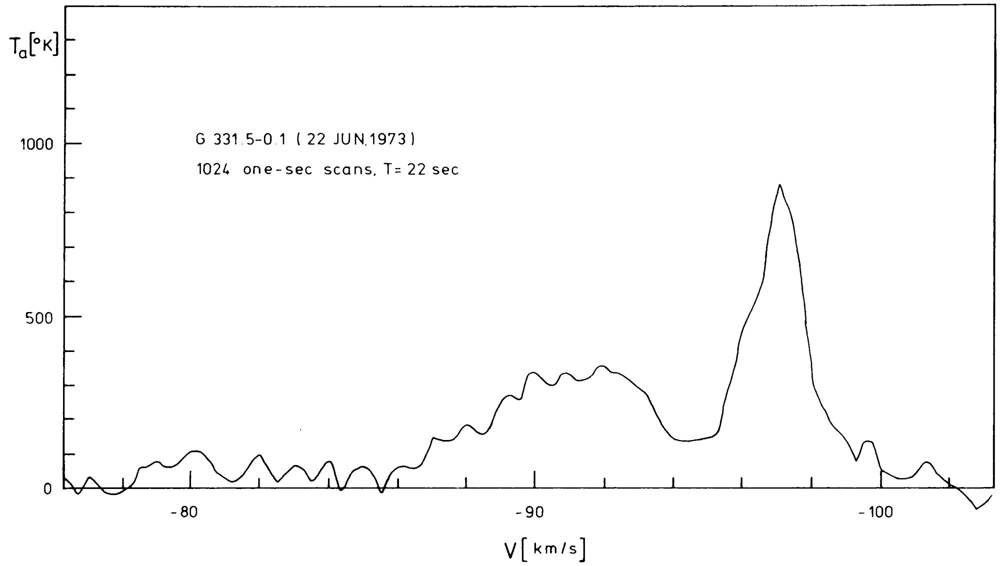


Fig. 3. This source, G331.5 − 0.1, is the strongest from the new series of $H_2O$ sources discovered by Johnston *et al.* (1972) and has shown line intensity variations.

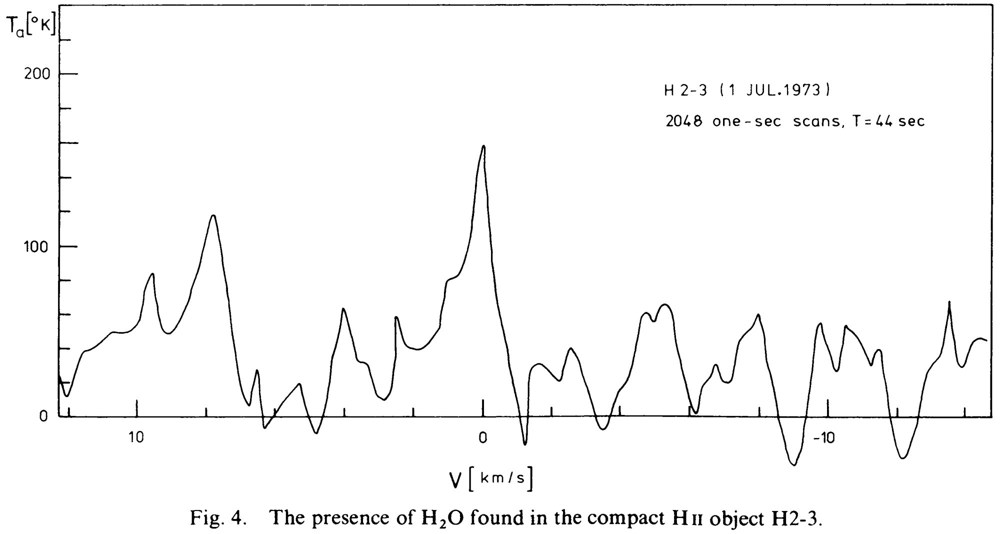


Fig. 4. The presence of $H_2O$ found in the compact H II object H2-3.

For all these sources, including Orion A, the Itapetinga results in antenna temperature are bigger than Parkes' by a factor of about ten. Although it is known that $H_2O$ sources show important time variations in intensity, this does not seem to be the case for all the sources observed in this study. It is then suggested that the sources discovered by Johnston *et al.* (1972) typically present lines with flux densities of about ten times larger than previously reported.

(c) Quite surprisingly VY CMa was probably 'off' during the epoch of the observations (end of June 1973) with an upper limit in antenna temperature of 35 K rms, suggesting that drastic variability might be happening in that well known and usually strong source.

(d) A new $H_2O$ source was found in the compact H II object H2-3 (also G345.4−0.9), as shown in Figure 4, with one line close to 0 km $s^{-1}$ and possibly another weaker one at +8 km $s^{-1}$. OH in absorption was known for H2-3 at −14 km $s^{-1}$ and +20 km $s^{-1}$, as well as a H109α recombination line at −23 km $s^{-1}$ (Turner, 1970; Rubin and Turner, 1971). The presence of an $H_2O$ maser in H2-3 favours the discussion of Rubin and Turner (1971) on the non-planetary nebula nature of this object and supports the possibility that it is more likely a young compact H II object like the well studied nebulosity K3-50.

## Acknowledgements

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Pierre Kaufmann
W. G. Fogarty
E. Scalise, Jr.
R. E. Schaal
*Centro de Rádio-Astronomia e Astrofísica,*
*Universidade Mackenzie,*
*São Paulo, Brasil*

## DISCUSSION

*Robinson:* It is most surprising that for all sources the *antenna temperatures* measured with the Universidade Mackenzie 14-m dish are a factor of 10 higher than measured in 1971 at Parkes using a 34-m dish. The ratio of flux densities would then be more than 20. Water vapor sources are very variable, but it is most unlikely that the flux from *all* sources would have increased by 20 times.

The published Parkes measurements were made with the NRL 25-m dish (using Jupiter as a flux calibrator). The Parkes observations of W49, Orion A and YV CMa agreed to within a factor of 2 with earlier NRL measurements; the factor of 2 uncertainty arises from the variability of the $H_2O$ sources.

*Kaufmann:* We are interested in cooperating in order to understand why Parkes values for $H_2O$ sources were so low, since we do not see any factor that could change Itapetinga values by $\pm 10$ to 20%. Our values are just compatible with the antenna performance.

*Johnston:* After seeing your antenna temperatures, I would estimate the discrepancy to be about a factor of 3.

**Note added in proof** *(Kaufmann):* The $H_2O$ sources shown in this paper were again measured in November 1973 and April 1974. A negative feedback in the radiometer has been found and eliminated, and the Moon has also been used for calibration, and this reduced the originally quoted antenna temperatures by a factor of 2. The discrepancy discussed in the paper reduces to a factor of 5. On the other hand, another set of measurements of $H_2O$ southern masers by Caswell, Batchelor, Haynes, and Huchtmeier (*Australian J. Phys.*, in press, 1974) with the Parkes telescope, taken in the same period as the results shown in this paper but with higher resolution (15.6 kHz per channel), shows smaller discrepancies on the stronger sources.