Proc. ASA **3** (1) September 1976

line-to-continuum ratio are 0.003, 0.005 and 0.006. For G291.3-0.7 the line-to-continuum ratio for the J = 5/2, F = 3→3 transition is 0.017. From an analysis similar to that used by Gardner and Whiteoak (1975), the excitation temperature representative of the J = 5/2 and J = 7/2 states is below 45 K if the transition temperatures defining the population distributions within the two states are equal. This limit does not contradict the value of 38 K derived from absorption due to transitions of the J = 3/2 and J = 5/2 states.

In their survey of several sources, Turner *et al.* (1970) detected J = 7/2, F = 4→4 emission only from W3OH. Despite our additional detections, this emission is still the strongest that has been observed — the flux density is more than five times greater than for any source in Table I.

The narrow-band F = 4→4 emission indicates the presence of high-gain maser amplification. This is not the case for the F = 3→3 transition, which has not been detected in any source. Because G347.6+0.2 and Sgr B2 are the weakest emitters of all the observed sources with J = 5/2 emission, the negative results for the J = 7/2 transitions do not contradict the general characteristic that inversion of the J = 7/2 state accompanies that of the J = 5/2 state. The excitation conditions must be somewhat different for each state because the J = 7/2 spectra do not always agree in detail with the J = 5/2 spectra (e.g. the results for OH 309.9+0.5). There are features in the J = 5/2 spectra of some sources that are stronger than the J = 3/2 ground-state features (Knowles *et al.* 1976). Because all J = 7/2 features are weaker than the corresponding J = 5/2 features this is an indication, assuming all states are inverted, that the excitation energy spectrum peaks at energies lower than the 202 cm^{-1} required to excite the J = 7/2 transition.

Burdyazha, V. V., and Varshalovich, D. A., *Sov. Astron.*, **16**, 980 (1973).
Gardner, F. F., and Whiteoak, J. B., *Mon. Not. R. Astron. Soc.*, **172**, 9P (1975).
Knowles, S. H., Caswell, J. L., and Goss, W. M., *Mon. Not. R. Astron. Soc.*, (in press) (1976).
Rickard, L. J., Zuckerman, B., and Palmer, P., *Astrophys. J.*, **200**, 6 (1975).
Turner, B. E., Palmer, P., and Zuckerman, B., *Astrophys. J.*, **160**, L125 (1970).

22 GHz Observations with the Resurfaced Central 17 m of the Parkes Radio Telescope

J. L. Caswell, R. A. Batchelor, W. M. Goss, R. F. Haynes, S. H. Knowles*, K. J. Wellington, D. E. Yabsley and M. Balister† *Division of Radiophysics, CSIRO, Sydney.*

At the centre of the Parkes 64-m radio telescope a region of diameter 17 m has recently been resurfaced to improve its efficiency at high frequencies. The first measurements using this section have been made at 22 GHz, in observations of both continuum sources and water vapour masers. For these observations the receiver front-end used a mixer cooled in liquid nitrogen, followed by a 5 GHz cryogenic parametric amplifier as a second stage. The option of switching against an offset horn was available and the total system noise temperature was ~ 750 K.

Dish Evaluation

Prior to the resurfacing, the aperture efficiency of the welded-steel 17-m central section of the Parkes telescope at 22 GHz was approximately 15%, comparable with that of the whole 37-m central section (Caswell *et al.* 1974). The new surface, consisting of aluminium plates fixed above the steel with height adjusters at intervals of approximately 20 cm, was designed by the Division of Radiophysics and the National Measurement Laboratory and was installed in October 1975.

In the current measurements the 2HE conical feed horn used at the focus gave a rapid cut-off of illumination at the rim of the 17-m surface. The beamwidth to half-power was ~ 2′.9 arc, measured from scans across the strong water vapour maser W49.

We used Jupiter as our calibration source and assumed its disk temperature to be 140 K. The resulting ratio of flux density to antenna temperature was measured as 23.5 Jy K^{-1}.* The corresponding overall efficiency of the 17-m reflector is ~ 50%, with no appreciable dependence on zenith angle. These values have been corrected for atmospheric attenuation (determined from the measured variation of the atmospheric temperature contribution as a function of zenith angle), which was typically 12% at the zenith throughout the period of the observations (late November to early December 1975). The generally good observing conditions at frequencies up to 22 GHz were consistent with previous experience at the Parkes site.

Pointing calibration of the telescope was investigated using observations of Jupiter, the H_2O masers in W49 and the star VY CMa, the southern QSO, PKS 0637-75 and two

*On leave from the U.S. Naval Research Laboratory, Washington, D.C., U.S.A.
†On leave from the National Radio Astronomy Observatory, Charlottesville, Virginia, U.S.A.

*1 Jy (jansky) = 10^{-26} W m^{-2} Hz^{-1}.

HII regions with positions accurately known from Fleurs synthesis telescope (FST) measurements (see Table I) at 1415 MHz. After applying corrections derived from these observations, the residual errors in the telescope pointing were approximately 15″ arc (r.m.s.).

Flux densities for several continuum sources were determined relative to Jupiter and are listed in Table I. The HII regions will be useful secondary calibrators in subsequent observations. The QSO has a quite flat spectrum between 1.4 and 22 GHz and its flux density is quite likely to vary with time, as is common with flat-spectrum QSOs.

Spectral-Line Observations of Known H_2O Sources

The 1024-channel digital autocorrelator was used to observe most previously known southern H_2O masers; these measurements yielded positions in good agreement with those given by Caswell *et al.* (1974). The larger beam size relative to previous Parkes observations also facilitated investigation of some H_2O masers whose positions were previously only poorly known. Our newly determined positions for these are listed in Table II. We have quoted the galactic names to greater accuracy than usual since this is necessary to distinguish components of close pairs of sources.

The following points are of special interest.

(a) H_2O 305.36+0.15 and H_2O 305.37+0.21 are two distinct sources with similar velocity ranges (-30 to -40 km s^{-1}) but separated spatially ~ 3′ arc. In earlier measurements only one or the other has been detected at any one epoch. Emission between V = -80 and -110 km s^{-1}, considerably displaced from the main velocity range, was also detected; it appears to arise from a position close to H_2O 305.37+0.21 and so it is probably a high-velocity feature of this source.

(b) H_2O 349.1+0.0, H_2O 19.6-0.2 and H_2O 24.8+0.1 were first discovered by Turner and Rubin (1971); their positions were of low accuracy with errors of at least 1′ arc. The present observations are the first reported since their discovery and considerably improve the positional accuracy.

(c) W28(A2), W33B, M17 and W51(N) (a component displaced to the north-west of the well-known soruce W51) were first reported by Johnston *et al.* (1973), with position errors of up to 1′ arc.

Our improved position for W28(A2) agrees well with a recent new determination by Cato *et al.* (1975) and confirms the association with an unusual OH emission source while excluding any possibility of identification with IRC-20411.

In the direction of M17, Lada *et al.* (1976) have measured a position in good agreement with ours; they also detected another source displaced from it which is highly variable and

TABLE I

Continuum Observations at 22 GHz

Source name	Type	Position (1950) R.A. h m s	Position (1950) Dec. ° ′ ″	Position ref.	Peak flux density (Jy)
G327.3-0.5	HII	15 49 10.3	-54 26 28	FST	30.0
G333.6-0.2	HII	16 18 24.0	-49 59 00	FST	68.6
G345.4-0.9	HII	17 06 01.2	-41 32 16	This paper	19.5
PKS 0637-75	QSO	06 37 23.3	-75 13 38	Optical	3.6

TABLE II

New position measurements for H_2O masers

Source name	Position (1950) R.A. h m s	Position (1950) Dec. ° ′ ″	Earlier references
H_2O 305.36+0.15	13 09 19.8	-62 21 26	Caswell *et al.* (1974)
H_2O 305.37+0.21	13 09 22.2	-62 17 52	Johnston *et al.* (1972)
H_2O 349.09+0.11	17 12 58.2	-37 56 29	Turner and Rubin (1971)
H_2O 5.89-0.40 (W28A2)	17 57 28.7	-24 03 53	Johnston *et al.* (1973)
H_2O 12.68-0.18 (W33B)	18 10 58.3	-18 02 43	Johnston *et al.* (1973)
H_2O 15.02-0.67 (M17)	18 17 27.4	-16 13 20	Johnston *et al.* (1973)
H_2O 19.60-0.23	18 24 48.4	-11 58 45	Turner and Rubin (1971)
H_2O 24.79+0.08	18 33 30.9	-07 14 27	Turner and Rubin (1971)
H_2O 49.49-0.39 (W51, main)	19 21 27.5	+14 24 53	Hills *et al.* (1972)
H_2O 49.49-0.37 (W51N)*	19 21 24.0	+14 25 18	Johnston *et al.* (1973)

*Position quoted is derived from the V = +33.5 km s^{-1} feature.

was not detectable at the epoch of our observations.

In W51, positions were measured for the main source, for a high-velocity feature at $V = +33.5$ km s^{-1}, and for a feature at $V = +60$ km s^{-1}. Greater errors were present for the +60 km s^{-1} feature (W51N), owing to blending with the main source, but it appears to be coincident with the high-velocity feature, the position of which is given in Table II. Although our position for the main source differs from the presumably more accurate interferometer position (Hills *et al.* 1972) by ~ 15″ arc, our relative positions for the two features are expected to be more accurate than this.

Discovery of Four New H_2O Masers

Four new H_2O sources were detected. Two were in the directions of the OH masers OH 330.9-0.4 and OH 337.9+0.3 but further H_2O measurements are needed to check the positions.

Another source, H_2O 337.40-0.41, (1950 position R.A. $16^h35^m08^s.1$, Dec. -47°22′23″) coincides with an unusual OH maser which we recently discovered at Parkes; it seems to be a star, a similar to W28(A2), which previously appeared to be unique. The H_2O source shows a main feature at $V = -43.5$ km s^{-1} and a weak feature at $V = -39.5$ km s^{-1}.

The remaining new source H_2O 30.81-0.06 (1950 position R.A. $18^h45^m10^s.1$, Dec. -01°58′00″) was found near the peak of W43; two other distinct H_2O masers have been found recently nearby (Cato *et al.* 1975) so that the present source brings this number to three, all within a radius of 4′ arc. Several OH masers are in the vicinity, but all are at least 1′ arc from any H_2O source and thus a large number of independent centres of activity are present. The new H_2O source shows a number of features in the velocity range +80 to +110 km s^{-1}.

Conclusion

We finally summarize several important points emerging from the observations:

(i) The new dish surface appears to be good enough to permit much higher frequency operation – probably to at least 50 GHz.

(ii) Near 22 GHz the improved efficiency will facilitate observations of extended low-surface-brightness molecular sources such as ammonia.

(iii) The efficiency increase is sufficiently great that much improved performance of the whole 37-m section will result; preliminary measurements indicate a flux-density/antenna-temperature ratio of ~ 10 Jy K^{-1}, as expected. The only radio astronomy antenna shown to have significantly better performance to date is the Bonn 100-m radio telescope.

(iv) The pointing characteristics of the 17-m section differ from those of the dish as a whole and the current pointing investigation provides a preliminary guide for observations made at higher frequencies where pointing calibration sources are scarce.

Caswell, J. L., Batchelor, R. A., Haynes, R. F., and Huchtmeier, W. K., *Aust. J. Phys.*, 27, 417 (1974).
Cato, B. T., Romnang, B. O., Lewin, P. T., Rydbeck, O. E. H., Yngvesson, K. S., Cardiasnos, A. G., and Shanley, J. F., Res. Rep. No. 123, Research Laboratory of Electronics and Onsala Space Observatory, Chalmers University of Technology, Gothenburg (1975).
Hills, R., Janssen, M. A., Thornton, D. D., and Welch, W. J., *Astrophys. J.*, **175**, L59 (1972).
Johnston, K. J., Sloanaker, R. M., and Bologna, J. M., *Astrophys. J.*, **182**, 67 (1973).
Johnston, K. J., Robinson, B. J., Caswell, J. L., and Batchelor, R. A., *Astrophys. Lett.*, **10**, 93 (1972).
Lada, C. J., Dickinson, D. F., Gottlieb, C. A., and Wright, E. L., *Astrophys. J.*, (in press) (1976).
Turner, B. E., and Rubin, R. H., *Astrophys. J.*, **170**, L113 (1971).

Spectral-Line Observations of NGC 5128 at Centimetre Wavelengths

F. F. Gardner and J. B. Whiteoak *Division of Radiophysics, CSIRO, Sydney*

One of the unusual features of the lenticular galaxy NGC 5128 is the presence of HI absorption (Roberts 1970; Whiteoak and Gardner 1971) and H_2CO absorption (Gardner and Whiteoak 1976) against the radio source located near the nucleus. Using the Parkes 64-m radio telescope we have made HI and H_2CO observations with improved resolution, and have also detected OH absorption in this galaxy. For the OH and H_2CO observations, the equipment and observing procedure have already been described (e.g. Whiteoak and Gardner 1973; Gardner and Whiteoak 1976); for the HI observations they will be described in a forthcoming paper (Whiteoak and Gardner, to be submitted to *Aust. J. Phys.*).

HI Observations

The HI profile obtained with the 14′.8 arc beam directed at the centre of NGC 5128 is shown in Figure 1; the effective

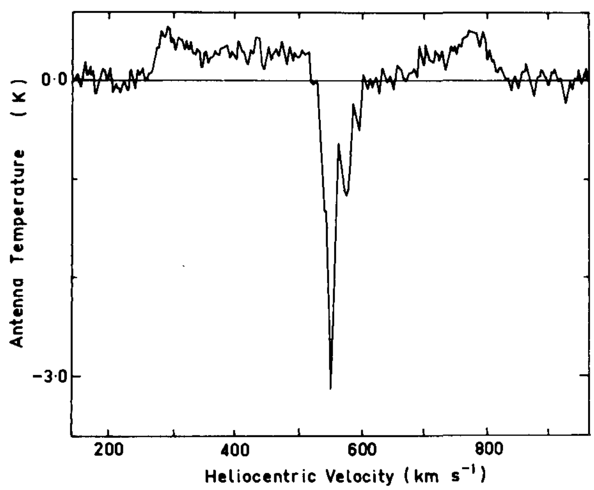

Figure 1. HI spectrum in the direction of NGC 5128. The effective resolution is 4 km s^{-1}.