SHORT COMMUNICATIONS

AUSTRALIAN EAST–WEST BASELINE INTERFEROMETER OBSERVATIONS AT 2·3 GHz*

By J. S. Gubbay,† A. J. Legg,† and D. S. Robertson†

In 1967 the two Australian stations of the NASA–JPL Deep Space Network, DSS41 at Island Lagoon near Woomera and DSS42 at Tidbinbilla near Canberra, were operated as an intensity interferometer (Gubbay and Robertson 1967). At the operating frequency of 2·3 GHz, the baseline is 9×10^6 wavelengths in extent and runs 15° south of east from DSS41. In the work reported by Gubbay and Robertson, the flux from the radio source 3C 273 was found to be partially correlated. This note concerns later measurement over the same baseline using an intermediate interferometer (Clark 1968).

Each Australian DSN station has a 26 m antenna and a maser amplifier giving a system temperature of 20–40 K. The intermediate interferometer system had the following characteristics: (1) a bandwidth of 14 kHz double sideband; (2) a sampling rate of 48 kHz (single bit samples); (3) a single observation time of 660 s (one tape of data); (4) a coherence length of 10 s, to match the stability of the rubidium vapour frequency standards; (5) a detection threshold of 1·1 f.u.‡

At least one of the two Australian antennas is usually in operation and it is difficult to gain access to the pair. Nevertheless occasions do arise when this is possible. On two such occasions, namely 16 October and 5 December 1969, we observed several radio sources, paying particular attention to southern ones. The sources were chosen from the Parkes catalogue (Shimmins *et al.* 1968; Gardner, Morris, and Whiteoak 1969) on the basis of strength and small angular size.

The 1969 results are shown in Table 1, 16 October being epoch 1 and 5 December epoch 2. The errors were calculated as follows. For weak signals the greatest source of error is statistical or noise, while for strong signals the noise contribution diminishes and the greatest sources of error are in tracking and in the measurement of the system temperature. During the experiment, two consecutive runs were made on each source. The difference between the two runs was plotted against their mean flux density, for 40 such dual runs. The envelope of the differences represented a maximum error function for a population of that size. It was found that the envelope could be approximated by adding the variation due to statistical noise, corresponding to the 2σ limits, to a contribution from system temperature reading error, amounting to 4% of the mean flux density. These limits represent the internal error limits for

* Manuscript received 19 November 1971.

† Space Research Group, Weapons Research Establishment, Department of Supply, G.P.O. Box 1424H, Adelaide, S.A. 5001.

‡ 1 flux unit (f.u.) = $10^{-26}\,\mathrm{W\,m^{-2}\,Hz^{-1}}$.

Aust. J. Phys., 1972, **25**, 461–3

TABLE 1

RESULTS FROM INTERFEROMETER OBSERVATIONS

Source	Epoch	G.M. Time (hr)	Base-line ($10^6\lambda$)	Baseline orientation (deg from N.)	Fringe amplitude (f.u.)	Total flux density (f.u.)
PKS 0237−23	1	11·48	4·90	86·9	$5{\cdot}13^{+0{\cdot}31}_{-0{\cdot}33}$	5·47
	1	14·12	9·07	104·8	$4{\cdot}98^{+0{\cdot}31}_{-0{\cdot}32}$	
3C 120	1	13·57	7·77	115·4	$4{\cdot}29^{+0{\cdot}31}_{-0{\cdot}33}$	6·4 (0·2)
PKS 0440−00	1	15·33	8·95	108·6	$3{\cdot}14^{+0{\cdot}29}_{-0{\cdot}32}$	3·02 (0·1)
PKS 0521−36	1	12·56	4·46	58·1	$1{\cdot}55^{+0{\cdot}42}_{-0{\cdot}61}$	
	1	13·42	5·58	70·0	$1{\cdot}55^{+0{\cdot}41}_{-0{\cdot}60}$	
	1	14·28	6·65	79·6	$1{\cdot}85^{+0{\cdot}35}_{-0{\cdot}45}$	
	1	15·17	7·66	88·9	$1{\cdot}44^{+0{\cdot}39}_{-0{\cdot}47}$	
PKS 0637−75	1	15·02	8·07	41·9	$2{\cdot}97^{+0{\cdot}30}_{-0{\cdot}34}$	
3C 273	2	01·03	5·18	119·6	$17{\cdot}25^{+0{\cdot}75}_{-0{\cdot}76}$	37·5 (0·7)
3C 279	2	01·12	6·21	124·9	$8{\cdot}66^{+0{\cdot}42}_{-0{\cdot}43}$	13·6 (0·2)
PKS 1510−08	2	02·36	9·17	109·7	$2{\cdot}63^{+0{\cdot}40}_{-0{\cdot}48}$	3·2 (0·2)
PKS 1549−79	2	02·19	9·02	119·4	$1{\cdot}36^{+0{\cdot}44}_{-0{\cdot}72}$	
	2	03·30	9·11	136·7	$1{\cdot}86^{+0{\cdot}38}_{-0{\cdot}50}$	
	2	04·50	9·16	156·0	$1{\cdot}94^{+0{\cdot}39}_{-0{\cdot}50}$	
	2	06·10	9·18	175·2	$2{\cdot}18^{+0{\cdot}36}_{-0{\cdot}44}$	
NRAO 530	2	02·54	9·20	110·1	$1{\cdot}91^{+0{\cdot}38}_{-0{\cdot}49}$	3·95 (0·15)
PKS 1814−63	1	10·01	9·23	149·9	< 1·1*	
	2	01·30	8·36	78·9	< 1·1	
	2	03·50	9·11	110·1	< 1·1	
	2	05·30	9·25	132·2	< 1·1	
	2	07·50	9·18	164·6	< 1·1	
PKS 1934−63	1	10·18	9·26	134·8	$4{\cdot}17^{+0{\cdot}30}_{-0{\cdot}32}$	12·7 (0·2)
	1	12·19	9·18	162·8	< 1·1	
	2	01·50	7·87	64·3	$1{\cdot}96^{+0{\cdot}39}_{-0{\cdot}51}$	
	2	03·10	8·50	83·7	$4{\cdot}61^{+0{\cdot}33}_{-0{\cdot}35}$	
	2	04·30	8·96	101·5	$5{\cdot}73^{+0{\cdot}35}_{-0{\cdot}36}$	
	2	05·50	9·20	119·3	$2{\cdot}76^{+0{\cdot}37}_{-0{\cdot}44}$	
	2	07·10	9·25	136·8	$4{\cdot}86^{+0{\cdot}33}_{-0{\cdot}35}$	
	2	08·30	9·21	155·2	$5{\cdot}50^{+0{\cdot}34}_{-0{\cdot}36}$	
	2	09·50	9·16	174·6	$5{\cdot}52^{+0{\cdot}34}_{-0{\cdot}36}$	
PKS 2134+004	1	10·55	8·68	109·0	$5{\cdot}48^{+0{\cdot}31}_{-0{\cdot}33}$	5·94 (0·1)
PKS 2203−18	1	11·18	9·06	113·9	$1{\cdot}22^{+0{\cdot}42}_{-0{\cdot}70}$	
	1	13·26	8·99	114·7	< 1·1	
	1	14·44	6·07	152·5	< 1·1	
3C 446	1	11·33	8·89	110·3	$1{\cdot}27^{+0{\cdot}46}_{-0{\cdot}85}$	5·3 (0·1)
PKS 2230+11	1	12·03	8·27	104·4	$2{\cdot}65^{+0{\cdot}40}_{-0{\cdot}51}$	4·9 (0·1)
3C 454·3	1	13·12	7·23	100·5	$10{\cdot}52^{+0{\cdot}51}_{-0{\cdot}52}$	14·3 (0·3)
	2	05·18	8·42	118·9	$7{\cdot}78^{+0{\cdot}43}_{-0{\cdot}46}$	14·1 (0·3)
	2	06·30	9·15	111·7	$7{\cdot}80^{+0{\cdot}40}_{-0{\cdot}42}$	

* Below threshold.

the observations. The interferometer was calibrated by using three Californian stations: DSS11 and 12 which have 26 m antennas and DSS14 which has a 64 m antenna. The fringe amplitudes are accurate to better than $\pm 10\%$ (Gubbay *et al.* 1971).

Of the 17 sources listed in Table 1, only PKS 0237–23, 0440−00, and 2134+004 are completely unresolved. For these three sources, the fringe amplitude is approximately equal to the total flux. This shows that the sources are less than 0·02 sec arc in angular size. Shimmins *et al.* (1968) have shown that the spectral peaks of PKS 0237−23, 1934−63, and 2134+004 occur at anomolously high frequencies so that one would expect to find components of small angular size in these sources.

The partially resolved sources are 3C 120, 273, 279, PKS 1510−08, NRAO 530, PKS 1934−63, 3C 446, PKS 2230+11, and 3C 454·3. Unfortunately, no total flux values were available at our frequency in December 1969 for PKS 0521−36, 0637−75, 1549−79, or 1814−63. These results have been included because one can determine whether sources are complex or not by observing how the fringe amplitude varies with changing baseline orientation and length. However, without appropriate total flux information, nothing can be said about their angular sizes. PKS 0637−75 was only observed once but it gave strong fringes and deserves further study.

The sources that show variable fringe amplitude with baseline are PKS 1549−79, 1934−63, and possibly 2203−18. These sources therefore have structure at our resolution level of 0·02 sec arc. The variation of fringe amplitude with baseline is particularly striking for PKS 1934−63. It is possible that PKS 1814−63 is completely resolved, but one cannot be certain without appropriate total flux information.

The epoch 1 observations of 3C 454·3 are significantly different from those of epoch 2. Trans-Pacific observations bracketing the period 1969·5 and 1970·0 show a marked reduction in a component of angular size $\leqslant 0 \cdot 002$ sec arc over that period. However, the Australian-based observations will have to be repeated to determine whether a complex structure is evident at an angular scale of $\sim 0 \cdot 02$ sec arc.

The values of total flux density given in the final column of Table 1 were provided by G. Nicolson from his continuous survey at DSS51 near Johannesburg and by D. Shaffer who measured total fluxes during a trans-Pacific experiment on 21 December 1969. All measurements were made at 2·3 GHz. The errors shown in parentheses are less than 10%.

Acknowledgments

We wish to thank the staffs at DSS41 and DSS42 for cooperating in the experiment. The use of the Deep Space Network facilities was by kind permission of the National Aeronautics and Space Administration and the Jet Propulsion Laboratory.

References

Clark, B. G. (1968).—*IEEE Trans. Antennas Propag.* **18**, 143–4.

Gardner, F. F., Morris, D., and Whiteoak, J. B. (1969).—*Aust. J. Phys.* **22**, 79–106.

Gubbay, J. S., Legg, A. J., Robertson, D. S., Craske, N., and Nicolson, G. D. (1971).—*Astr. J.* **76**, 965–9.

Gubbay, J. S., and Robertson, D. S. (1967).—*Nature, Lond.* **215**, 1157–8.

Shimmins, A. J., Searle, L., Andrew, B. H., and Brandie, G. W. (1968).—*Astrophys. Lett.* **1**, 167–9.