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THE ANGULAR DIAMETER OF DISCRETE RADIO SOURCES

H. P. PALMER

Jodrell Bank Experimental Station, University of Manchester, England

An interferometer of readily varied resolving power has been constructed at Jodrell Bank, and since 1953 it has been used to measure the angular diameters of all but the faintest of the discrete sources reported in the survey of Brown and Hazard [1].

1. EQUIPMENT

The equipment, which has been fully described by Brown, Palmer and Thompson [2], operates at a wave-length of 1·9 metres. The two aerials used are the 218′ transit radio telescope, which has a pencil beam of 2° at this wave-length, and a small broadside array with an aperture of 36 m.^{2}. The small aerial has been moved to several remote sites to permit observations at different aerial spacings. The two sections of the equipment were connected by a co-axial cable, or, at aerial spacings greater than 1 Km., by a radio link.

The interferometer was designed on the rotating lobe principle, which permits control of the period of the fringe pattern of the recorder. A long recorder time-constant can therefore be used even when there is a large spacing of the aerials. Without this facility the measurements of high resolving power could not have been carried out, and observations of faint sources, using these aerials, would be restricted to a resolving power of about $\frac{1}{2}°$.

Discrete sources of intensity greater than 30×10^{-26} w.m.$^{-2}$ (c./s.)$^{-1}$ can be identified on individual records. This also represented the limit of sensitivity, for successive records of this type cannot be averaged readily because the phase of the output signal varies in a random manner from one transit to the next.

2. THE DISCRETE SOURCES OBSERVED

This experiment was designed to obtain diameter measurements for some of the fainter sources revealed by the well-known survey of Brown and Hazard. They detected twenty-three discrete sources in this survey using the same transit radio telescope, with a field of view between declinations $+38^\circ$ and $+68^\circ$. Fifteen of these sources are sufficiently intense to be detected by the interferometer; the remainder, some of which were detected in the original survey only by averaging several records, were invisible.

The sources detected include the intense sources Cassiopeia A and Cygnus A (nos. 19 and 22), the diameters of which were measured by Brown, Jennison and Das Gupta [3, 4], while the source in Andromeda (no. 2, identified with M31) and also the source Cygnus X (no. 20) were reported to be extended sources.* (Diameter $>2^\circ$.)

Sources nos. 1 and 22 are too close to Cassiopeia A for interferometer measurements. The remaining eleven sources have been observed with the interferometer, and all but three of them have been resolved. These eleven sources fall clearly into the classes I and II suggested by Mills. The six class I sources are all relatively intense ($>60 \times 10^{26}$); they all lie within 5° of the galactic plane, and were all found to have large angular diameters, greater than 1°. The five class II sources were less intense, were more than 10° from the galactic plane, and were found to have angular diameters of a few minutes of arc.

3. THE CLASS I SOURCES

The measurements on the sources near the galactic plane have been reported previously [5]. All were resolved at aerial spacings $<\lambda 50$. One of these sources, in Auriga, has been tentatively identified by Minkowski with a faint nebulosity having a filamentary structure, which was photographed with the 48-inch Schmidt at Mount Palomar.

4. THE CLASS II SOURCES

The area of the field of view away from the galactic plane contained five faint sources which could be detected with this interferometer. They were all found to be of much smaller angular diameter, and are being studied in a second series of observations, using much larger aerial spacings,

* The reference numbers quoted here are those given in Brown and Hazard's catalogue[1].

extending, so far, to $\lambda 6720$. The sensitivity of the equipment deteriorates slightly when a radio link is used, and these faint sources are then close to the limit of sensitivity. The results are given in Fig. 1 and in Table 1. The intensities in the table have been quoted from reference 1; the apparent surface temperature has been calculated from it, assuming uniform disks of the diameter quoted.

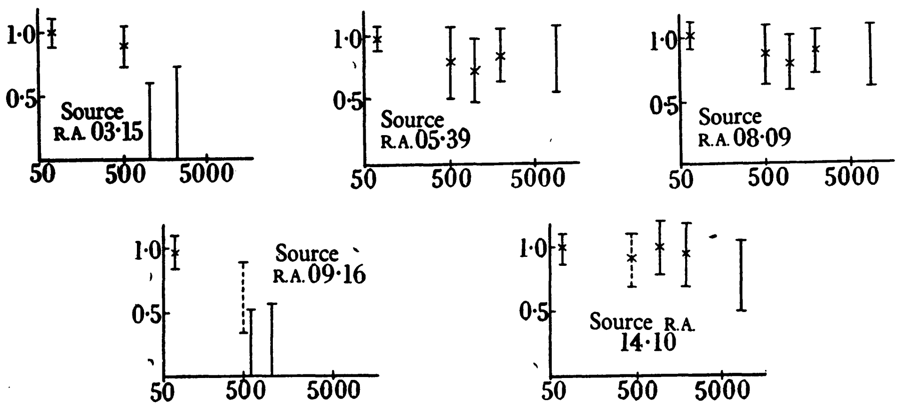

Fig. 1. Fringe visibility of five discrete sources as a function of aerial spacing in wave-lengths. |—×—| aerials spaced E.-W. |---×---| aerials spaced N.-S. |——| aerials spaced N.W.-S.E. (provisional results).

Table 1. *Preliminary results of observations with large aerial spacings*

No.	Source I.A.U. no.	R.A.	Galactic co-ordinates (lat.)	(long.)	Intensity w m.$^{-2}$ (c./s.)$^{-1}$ $\times 10^{-26}$	Apparent temperature (° K.)	Angular diameter	Remarks
6	03N4A	03·15	−12·4	118·3	65	$2{\cdot}2 . 10^5$	$2'{\cdot}4 \pm 0'{\cdot}5$	NGC 1275
10	—	05·39	+11·4	129·4	50	$> 5{\cdot}5 . 10^6$	$< 25''$	Unidentified
11	08N4A	08·09	+34·3	138·8	40	$> 4{\cdot}5 . 10^6$	$< 25''$	Unidentified
12	09N4A	09·16	+45·8	142·7	30	$3{\cdot}6 . 10^4$	$4'{\cdot}0 \pm 1'{\cdot}0$	Unidentified
18	14N5A	14·10	+61·2	61·1	40	$> 4{\cdot}5 . 10^6$	$< 25''$	Unidentified

Two of the sources of class II, at R.A. 03·15 (no. 6) and at R.A. 09·16 (no. 12) appear to have been resolved. The observations of R.A. 09·16 were difficult because it is the faintest source studied, and it may have been lost through the deterioration in sensitivity, rather than resolved.

The other three of the sources, at R.A. 05·39, 08·90, 14·10 (nos. 10, 11 and 18) were still detected at the largest aerial spacing. Because the observations are so close to noise it is only possible to say that the fringe visibility is greater than 50 % at an aerial spacing of $\lambda 6720$. If these sources are assumed to be spherical their angular diameter must be less than 25″, and their apparent surface temperatures, at 158 Mc./s., of the order of 10^7 °K. This is less than the apparent surface temperature of Cygnus A by only one order of magnitude. This experiment is being continued in a further attempt to resolve these three sources.

REFERENCES

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[5] Hanbury Brown, R., Palmer, H. P. and Thompson, A. R. *Nature*, **173**, 945, 1954.