I

SURVEYS OF RADIO SOURCES, SOURCE COUNTS AND ANISOTROPIES

https://doi.org/10.1017/S0074180900015977 Published online by Cambridge University Press

THE 6C SURVEY

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A new survey of radio sources at 151 MHz, which has not been described previously, is in progress at Cambridge. There are several of us working on it including Warner, Kenderdine, Waggett, Masson and Mayer. The results of the first observations are at present in a preliminary state but we hope that in time they will form the first part of the 6C survey. The purpose of the survey is not to reach the faintest sources detected so far in aperture synthesis observations but to study moderately faint sources at a low observing frequency and to cover a large part of the northern sky rapidly. The deepest survey made so far at a low frequency is that of Ryle and Neville (1962) at 178 MHz over a region of 50 square degrees near the north celestial pole. The faintest sources detected had flux densities of 0.25 Jy, corresponding to a source density of 10^4 sr^{-1}. It is already 15 years since that survey, which was the first trial of aperture synthesis using the earth's rotation, and much more is now technically possible. One of the most interesting features of a low frequency survey is its ability to detect preferentially sources with steep radio spectra and to be sensitive to sources of very low surface brightness. We know that in many cases these two properties go together and are associated with old radio sources, or at least with those parts of sources which are old. Many of the weak radio galaxies in nearby clusters are obvious examples of this type of source while the final, and so far unidentified, stages of the development of the most powerful double sources may be exciting candidates for discovery.

The telescope on which the survey is based is an east-west earth rotation synthesis instrument. It differs from other telescopes of this type in the low observing frequency, the large number of interferometer spacings and the simultaneous coverage of all baselines. The main characteristics are summarised in Table 1.

D. L. Jauncey (ed.), Radio Astronomy and Cosmology, 3-7.

Table 1

Observing frequency	151.5 MHz
Bandwidth	800 kHz
Maximum baseline	1.37 km
Number of interferometer spacings	446
Smallest spacing	6λ
Angular resolution	$3'.7 \times 3'.7$ cosec δ
Primary beam	$17^\circ \times 17^\circ$

Desirable characteristics of telescopes are cheapness, speed and sensitivity. In this telescope the fifty elements of the interferometer are simple arrays each comprising four Yagi aerials, resulting in a rather low total cost of £3 x 10^4 in 1973-5. The speed of observing was an important feature of the design, the aim being to cover the sky north of $\delta = +20^\circ$ in about two years. Fig. 1 shows profiles of a map of an area of sky about $15^\circ \times 15^\circ$ centred on the north celestial pole, obtained by averaging 10 separate 12-hour observations. This averaging procedure was a necessary feature of the design for the following reason. Fig. 1 illustrates the large dynamic range, and hence good sidelobe level, which is needed in the maps.

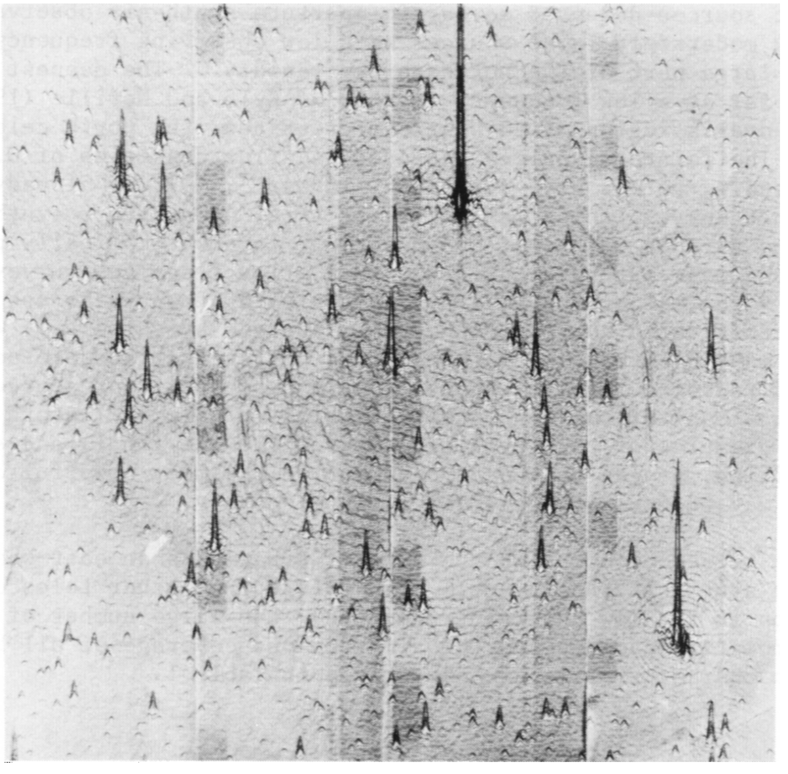

Fig. 1. Profiles of the first 151 MHz map centred on the north celestial pole.

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The brightest source has a flux density of 30 Jy, the faintest visible about 0.3 Jy and even fainter ones, not seen in this mode of presentation, about 0.05 Jy. At 151 MHz the effects of ionospheric fluctuations on the interferometer phase are important in determining the sidelobe level. So the size of the elements of the interferometer was chosen to be quite small so that, in a single 12-hour observation, the rms noise and the rms sidelobe levels on the map were roughly equal. The field of view is then large and enables averaging of many days observations to be carried out without seriously affecting the speed of the survey.

Near the lower left hand corner is an extended source which is shown again as a contour map in Fig. 2 together with a map with closely similar angular resolution at 1419 MHz made by Waggett with the Half Mile telescope. This source is of interest intrinsically for its very

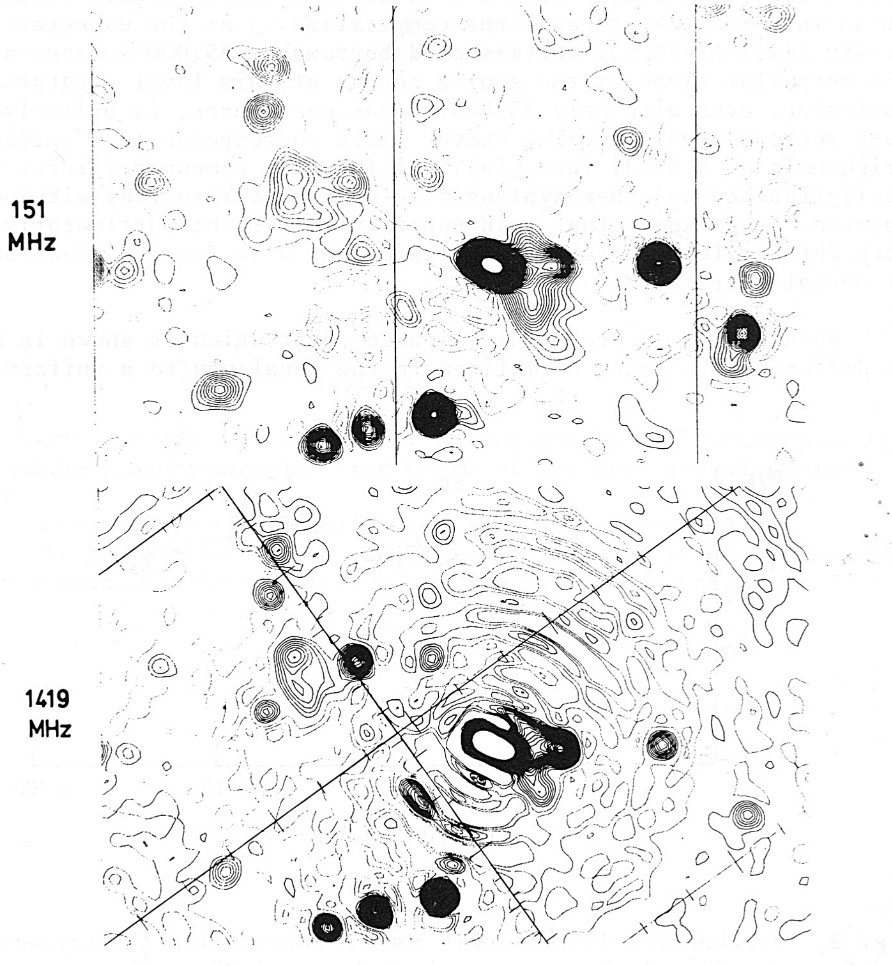

Fig. 2. Comparison of maps at 151 MHz and 1419 MHz of a small region.

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large size and low surface brightness but the map is presented here only to illustrate the faintest sources on the 151 MHz map which are believed to be real. The contour interval at 151 MHz corresponds to 30 mJy for a point source at the centre of the primary beam of the telescope and the contour interval at 1419 MHz has been chosen to give a similar appearance for a source of average spectrum. In places, sources of about 60 mJy are seen to be confirmed by the 1419 MHz map. The latter map has not been corrected for the primary beam attenuation so that an apparent absence of sources in the outer parts is to be expected. 50 mJy was the design limit of the 151 MHz survey. At present it appears that such sources can be detected on the maps but satisfactory measurements of them cannot yet be made. Fig. 1 shows the presence of intruding features, such as imperfectly removed grating rings and interference, whose effects can be, and in some cases have been, improved by further work. For instance, the parallel ridges across the field centre were due to undersampling of part of the data at an intermediate stage of the computation. At the expected sensitivity limit of 50 mJy there should be roughly 35,000 sources sr^{-1}. The very flat slope of the source counts at this level suggests that confusion, even with only 25 beam areas per source, is unlikely to be a very serious problem. The survey limit corresponds to a surface brightness of 3.5 mJy $(arc\ min)^{-2}$ at 151 MHz, somewhat fainter than is easily reached by other synthesis telescopes for sources with normal spectra. We expect that this sensitivity will be particularly useful both for studies of old radio galaxies and also for the disks and haloes of normal spirals.

We have made a preliminary source count which is shown in Fig. 3 as differential counts normalized in the usual way to a uniform static

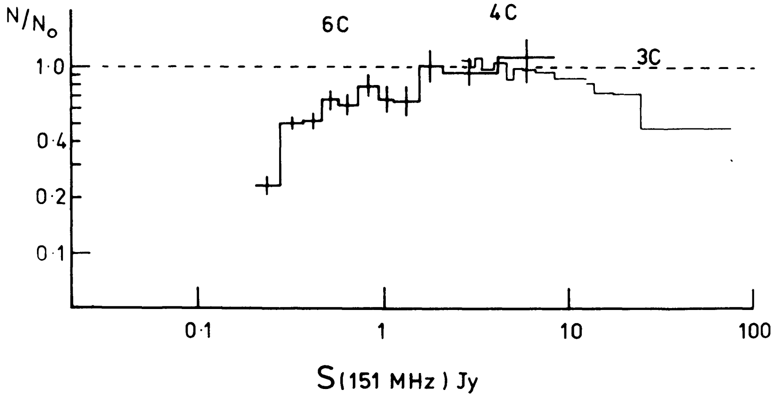

Fig. 3. Preliminary differential source counts from the present survey and from the 3C and 4C surveys adjusted to 151 MHz. The counts are normalised to 2400 sr^{-1} for S > 1 Jy.

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Euclidean model. The differential counts from the 3C and 4C surveys at 178 MHz, as presented by Longair (1974), have been incorporated in the diagram after multiplying the 178 MHz flux densities by 1.13 to allow for a mean spectral index of 0.77. The normalisation corresponds to a source density of 2400 sr^{-1} for $S > 1$ Jy at 151 MHz. The 6C values are based on a very conservative search within 7^{o} of the celestial pole for sources having $S \geqslant 200$ mJy, omitting small areas near the two bright 3C sources in the field. The convergence in the source counts looks rather dramatic at the last value plotted but at this level there is no question about the completeness of the survey. Problems arise connected with the angular size of sources and especially over the question, common to many surveys, of whether two particular sources are individuals or components of a double source. With that proviso, the counts shown in Fig. 3, although preliminary, are unlikely to be amended very much. The changes we can anticipate are an improvement by a factor of four in the limiting flux density which we hope to obtain quite soon and on eventual improvement by a factor of 80 in the statistics when the survey is complete. We do not dare to predict a date for that.

REFERENCES

Longair, M.S., 1974, IAU Symp. 63. Confrontation of Cosmological Theories with Observational Data. p.93.

Ryle, M. & Neville, A.C., 1962, Monthly Notices R. astr. Soc., 125, 39.

DISCUSSION

van der Laan: Do you use, or intend to use any "clean" techniques for dynamic range enhancement, or just to avoid the area around strong sources?

Baldwin: At present we exclude areas around the two strongest sources. We don't intend, at the moment, to use any "clean" techniques.

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