A 2650 Mc/s SURVEY OF AN AREA IN THE CONSTELLATION OF NORMA

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Summary

The 2650 Mc/s isophotes of an area of approximately 6 sq degrees centred at $l^{II} = 332°$, $b^{II} = 0°$, are presented. The aerial beamwidth was $7' \cdot 5$ between half-power points. Comparison of the isophotes with those of an earlier survey at 1410 Mc/s and with optical plates taken at Mt. Stromlo has led to the identification of several sources; one is coincident with a filamentary structure previously suggested as a possible supernova remnant. All data processing including the drawing of the isophotes was carried out on a computer.

I. Introduction

On the basis of an earlier survey of the Southern Milky Way at 1410 Mc/s (Hill 1964), an area of approximately 6 sq degrees centred at $l^{II} = 332°$ was selected for resurveying at a frequency of 2650 Mc/s. This area contains one of the four prominent groups of strong sources found in the earlier survey.

The observations were carried out in July 1963. The receiver output was digitized and recorded on paper tape so that the data could be fed directly into a computer. Programs developed by E. R. Hill and the author enabled the data to be completely processed to the final drawing of isophotes in galactic coordinates. Comparison of this survey with the earlier 1410 Mc/s survey provides data on the spectra of the discrete sources in the region; several of these sources have been identified on plates taken at the Mt. Stromlo Observatory.

II. Equipment

The Parkes telescope and the 2650 Mc/s receiver used have been described by Bowen and Minnett (1963) and by Cooper, Cousins, and Gruner (1964).

The 210 ft reflector was fed from a waveguide horn that could be rotated to any desired position angle. The beamwidth was $7 \cdot 5$ min of arc. The parametric receiver had a bandwidth of 50 Mc/s, which, with an overall system noise of 180°K and a time constant of 1 s, gave a noise fluctuation of about $0 \cdot 4$ degK peak-to-peak. This amplitude was reduced to approximately $0 \cdot 15$ degK by subsequent digital filtering.

The receiver output was recorded on a chart recorder and also fed into an analogue-to-digital converter. The output of the converter, consisting of 12 bits

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representing three decimal digits in binary tetrad form, was punched together with parity bits in three rows per reading. Each block of scan data was preceded by a heading block containing the scan serial number, date, initial declination, right ascension, zenith angle, sidereal time, and analogue-to-digital converter calibrations. The complete blocks of scan information, heading and data, were separated by a special character consisting of a hole in the seventh column.

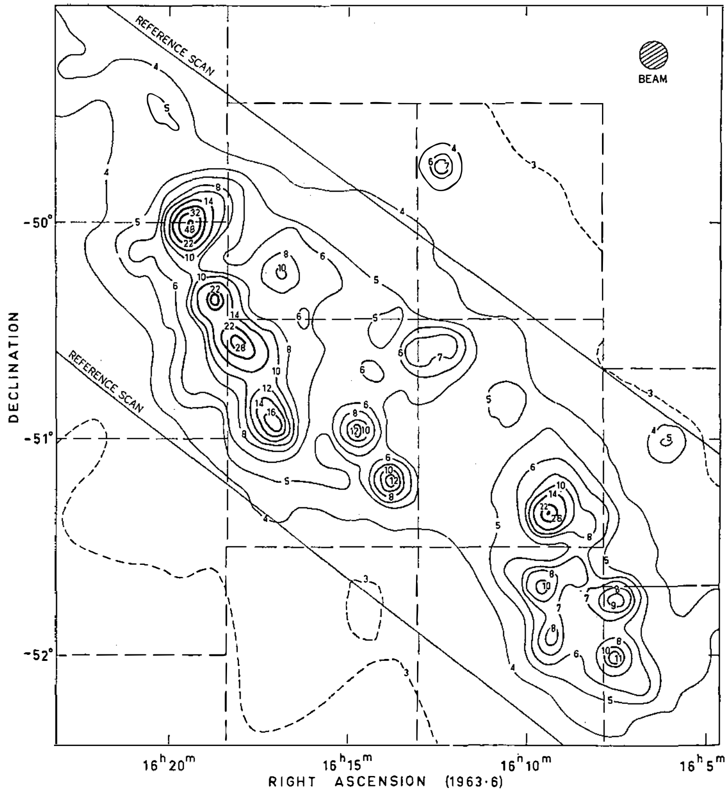

Fig. 1.—The 2650 Mc/s isophotes of an area in the constellation of Norma. Aerial beamwidth 7′·5 at half-power points. One contour unit equals 1·45 degK brightness temperature.

III. Observing Procedure

The area concerned was covered by a series of declination scans, at fixed right ascension, at a rate of $\frac{1}{2}$°/min. The receiver output was sampled and punched at declination intervals of 0·25 min. At the end of each scan the right ascension was increased by approximately 12 s and a declination scan was made in the reverse direction. For each scan the feed angle was set so that the mean position angle of the electric vector during the scan was equal to zero. In this area and at the frequency concerned, the dominant contribution to galactic radiation is from thermal sources that are unpolarized. The isophotes are therefore unlikely to be affected by the failure to consider both polarizations.

During each of the three successive nights of the survey, frequent gain calibrations were made by recording the output of a nominal 5°K noise source, which was itself checked by calibration against the reference source. The reference source (Hercules A) was scanned in right ascension and declination with the feed at two position angles 90° apart.

The parameters necessary for the computer correction of receiver non-linearity were measured each night and the mean value for the series was used in the final calculation. At 2650 Mc/s the effect of ground radiation in the main beam changes the receiver output by approximately 5 degK with a change in zenith angle from 0° to 60°. This effect was determined by scanning in declination from the south celestial pole to the zenith across a cold part of the sky.

The scan reduction program required that the temperatures of at least two points in each scan be specified. These were obtained by scanning across the normal declination scans near the northern and southern limits of the survey area. After correcting for the zenith angle effect, the temperatures of the points of intersection were calculated on the basis that *the temperature at the south celestial pole is zero.* Several of these reference scans were made during the series of observations and a mean was used to fix the temperatures required. The approximate position of the scans is shown in Figure 1.

IV. Computer Programs

It is proposed to describe both the digital equipment facilities and the computer programs in a separate paper, so only a brief statement of the steps in the reduction programs is given below.

(1) The paper tape record was transferred to magnetic tape with a 1 : 1 correspondence.

(2) Any punching or reading errors were corrected and additional heading information was added to the magnetic tape.

(3) The scan data were filtered and converted to aerial temperatures, making allowance for receiver non-linearity, time constant, and drift.

(4) Contour coordinates in terms of right ascension and declination were derived for specified contour levels. This section of the program permits the matrix of the data from which the contour points are derived to be convolved in order to simulate observations at a different resolution.

(5) Precession to the epoch 1950·0 and coordinate conversion were applied to produce a final contour map in galactic coordinates.

V. Results

The output of the first contour reduction, in equatorial coordinates, is shown in Figure 1. The complete area was built up from 11 separate smaller areas, which have been outlined in the figure. The size of each of these areas was determined by the need to provide a sufficient number of points for the contour plotting, and in some cases by the need to fit into the boundaries of the survey.

Table 1

LIST OF SOURCES

Catalogue Number	Position (1950·0) R.A. h	m	s	Dec. °	′	Galactic Coordinates l^{II}	b^{II}	Integrated Flux Density $(10^{-26}\,\mathrm{W\,m^{-2}\,(c/s)^{-1}})$	Spectral Index α $T_b = f^{-\alpha}$	Class	Remarks
1606−50	16	6	1	−50	59·0	331·37	+0·52	<2			Source not included in comparison with optical plates
1606−51·7	16	6	22	−51	42·5	331·03	−0·17	15			
1606−51·9	16	6	28	−51	58·4	330·83	−0·37	22	2·0	Th.	No visible counterpart on Schmidt plate
1608−49	16	8	15	−49	53·1	331·13	−0·48	10			
1608−51·3	16	8	19	−51	18·5	331·53	−0·07	47	2·0	Th.	Indication of some very weak and ill-defined nebulosity
1608−51·6	16	8	33	−51	39·0	331·33	−0·35	17			No visible counterpart
1611−49	16	11	17	−49	42·3	332·97	+0·78	5			A weak nebulosity about 1′ in diam. at the centre
1611−50	16	11	58	−50	33·5	332·45	+0·08	14	2·9	Non-th.	Source not included in comparison with optical plates
1612−51	16	12	47	−51	9·3	332·15	−0·43	12			A weak nebulosity with a few knots; size about 3′ × 1′. There is no obvious connection with 1613−50
1613−50	16	13	38	−50	55·4	332·40	−0·37	15	2·6	Non-th.	Stromlo No. 103* (Rodgers, Campbell, and Whiteoak 1960)
1615−50	16	15	51	−50	12·1	333·15	−0·08	4			No visible counterpart
1616−50	16	16	1	−50	53·3	332·70	−0·60	52	2·2	Th.	Extensive HII region. It appears likely that this source, 1617−50·5, and 1617−50·3 are all in Stromlo No. 106
1617−50·5	16	17	4	−50	31·3	333·07	−0·45	52	2·1	Th.	Extensive HII region
1617−50·3	16	17	43	−50	19·3	333·28	−0·38	60			Weak emission
1618−49	16	18	23	−49	58·3	333·60	−0·20	122	1·8	Th.	

* The maximum dimensions of 1613−50 are about 7′ × 7′. On the 74 in. plate a filamentary structure is obvious with two main arcs running parallel in a NE.–SW. direction. The arcs are about 7′ × 2′ and 3′ × 1′, and are quite bright. No exciting star can be seen; the star apparently in the centre of the source is of type M3. Optical spectra of the brightest parts indicate collisional excitation. There is excellent agreement between the radio position and the optical position of the centre of the arcs.

The final on-line plot with precession to the 1950·0 epoch and conversion to new galactic coordinates is shown in Figure 2. One contour unit is equal to 1 degK in aerial temperature or 1·45 degK in brightness temperature.

A list of sources and their integrated flux densities is given in Table 1. The flux density of the reference source Hercules A was taken as 25×10^{-26} W m^{-2} (c/s)$^{-1}$.

Selected areas were convolved to simulate observation at a resolution corresponding to that of the 1410 Mc/s survey by E. R. Hill. A comparison between the convolved contours and the lower frequency survey enabled an estimate to be made of the spectral index of some of the sources. These estimates are given in the table.

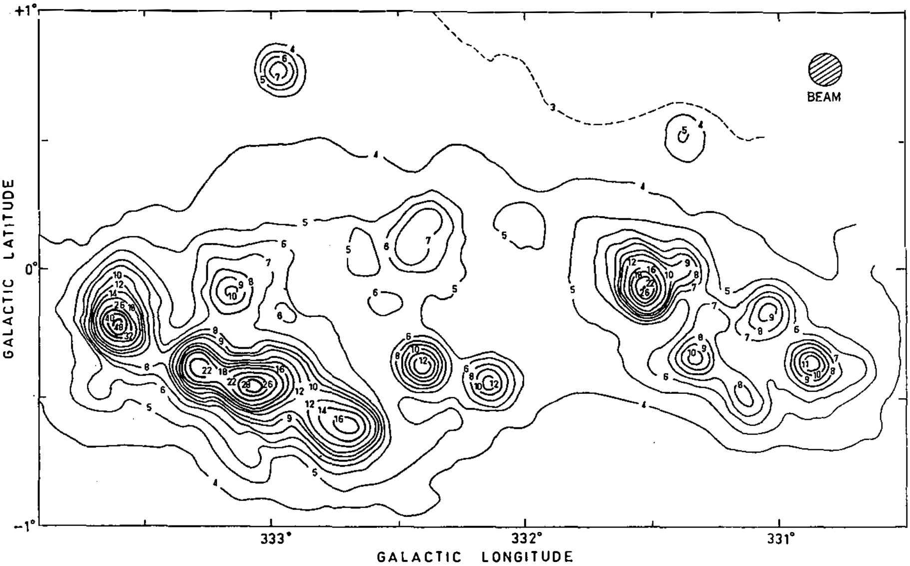

Fig. 2.—The area shown in Figure 1, converted to new galactic coordinates. One contour unit equals 1·45 degK brightness temperature.

The non-thermal spectrum of 1613—50 appears to confirm that this source is a supernova remnant as suggested by Westerlund and Mathewson (1965). A combination of source 1613—50 and the other non-thermal source 1611—50 dominates this region in the 85 Mc/s survey of Hill, Slee, and Mills (1958).

VI. Optical Identification

Dr. B. Westerlund of the Mt. Stromlo Observatory has made a comparison between the contour map and optical plates, and the comments on source identification, given in the final column of Table 1, were provided by him in a personal communication. The comments on the sources 1612—51 and 1613—50 were based on a photograph taken with the 74 in. telescope using a 146 min exposure with a Kodak 103a–E plate behind a Schott RG2 filter. For the other sources an Uppsala Schmidt plate taken with a 150 min exposure and the same filter–plate combination was available.

VII. Acknowledgments

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