THE RADIO CONTINUUM OF THE LARGE MAGELLANIC CLOUD

III.* THE SOURCES AT 11 CM WAVELENGTH

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Abstract

A catalogue is given of radio sources observed in the Large Magellanic Cloud at 11 cm wavelength. A map of the radio brightness in the 30 Doradus region is included. The observations were made with a low-noise correlation radiometer and the Parkes 64 m radio telescope.

I. Introduction

In February 1969 most of the Large Magellanic Cloud (LMC) was surveyed at a wavelength of 11 cm with a view to obtaining measurements which could be used in estimating the spectra of the individual sources. No catalogue of sources at any wavelength had previously been made although some sources are seen to be resolved in the 21 cm maps by Mathewson and Healey (1964). However, from the 6 cm maps of Part I of this series (McGee, Brooks, and Batchelor 1972, present issue pp. 581–97) it is obvious that in a number of cases several sources seen at 6 cm are blended by the telescope beam into one source at 21 cm.

After the present observations had been completed, the maps of both the LMC and SMC that are given in Part II (Broten 1972, present issue pp. 599–612) were made available. These had been constructed from earlier observations made with the same telescope. The present data have been used to form a catalogue of the 38 brightest sources in the LMC.

II. Equipment and Measuring Procedure

The observations were made with the broad band correlation radiometer described by Batchelor, Brooks, and Cooper (1968). This instrument, operating at ambient temperature, employs twin receiving channels, each with a two-stage synchronously-pumped degenerate parametric amplifier. The effective bandwidth was 200 MHz and the overall system noise temperature, including spillover and front-end losses, was approximately 80 K at 2700 MHz.

Half the observations were made by comparing the signal from the primary feed horn with that from a wide beam reference sky horn. Because of wet weather in the latter half of the survey the reference was changed to a liquid-air cooled resistive load.

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The Parkes 64 m paraboloid radio telescope with an 11 cm two-hybrid-mode corrugated horn as the primary feed (Thomas 1970) was used. From the observations of the source Hydra A the beam was found to have a half-power width of $7'\cdot7 \pm 0'\cdot1$ arc in both planes. The area under the beam out to abscissae of 20′ arc (where the response was $< 1\%$ of the maximum) was $3\cdot3\%$ greater than the area under a Gaussian curve with the same half-intensity width and cut off at the same abscissae values. Because of the use of a different feed the aperture efficiency was higher than in the observations described in Part II; the beam was more symmetric but some 5% broader.

The scales of flux density and full-beam brightness temperature were based on an assumed flux density S of 23·5 f.u.* for Hydra A. The intensity of this source was compared directly with deflections from a calibrating noise lamp. From the measured full-beam solid angle the relation between full-beam brightness temperature T_b (K) and S (f.u.) was found to be

$$S = 1\cdot28\, T_b\,. \tag{1}$$

In making the survey observations a telescope scanning rate of $1°\ \mathrm{min}^{-1}$ was used with a network having a fast-rise time constant set for 1 s (Cooper 1970). The peak to peak noise fluctuations were 0·06 K. The method of correcting for intensity and positional errors was as discussed in Part I. A positional uncertainty of 1′ arc was caused by telescope pointing errors.

III. Observations

The 11 cm survey was confined to the region between R.A. $05^h\,10^m$ and $05^h\,50^m$ and Dec. −65° to −76°. The telescope was scanned in declination along tracks of constant right ascension spaced at intervals of 40 s. Thus at the northern extremity the spacing of the scans was 4′·2 arc and at the southern extremity 2′·4 arc. Checks were made on the differences observed from track to track by taking right ascension scans at Dec. −69° 00′, −69° 10′, and −69° 50′.

Known important sources outside the survey region were observed with single scans through the positions of maximum intensity at 6 cm. Sources studied in this way included the Henize (1956) nebulae N79A, 83B, 11, and 105A.

Figure 1 is a contour diagram of the brightness temperature of the complex region near 30 Doradus. The values of T_b are marked on the contours. Since maps of the LMC at 11 cm wavelength have been given in Part II, only this map is presented here so that it may be compared with Figure 8 of Part II. Differences of approximately 12 s in right ascension and 1′ arc in declination should be allowed for because of the differing epochs (1950·0 and 1975·0). We find from a comparison of the maximum intensities of 21 of the stronger sources that the average ratio of the present values of T_b to those given in Part II is 0·98. An example of agreement just within the experimental errors (15%) can be seen in the values for the temperature of MC 74: 19·3 K (present results) and 22·4 K (Part II). Figure 1 covers exactly the same area of sky as the 6 cm map in Figure 11 of Part I. The effects of difference in angular resolution are illustrated, e.g. sources MC 61, 65, 67, 68, 69, 70, 72, 73, 84, and 86 at 6 cm can no longer be recognized here.

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

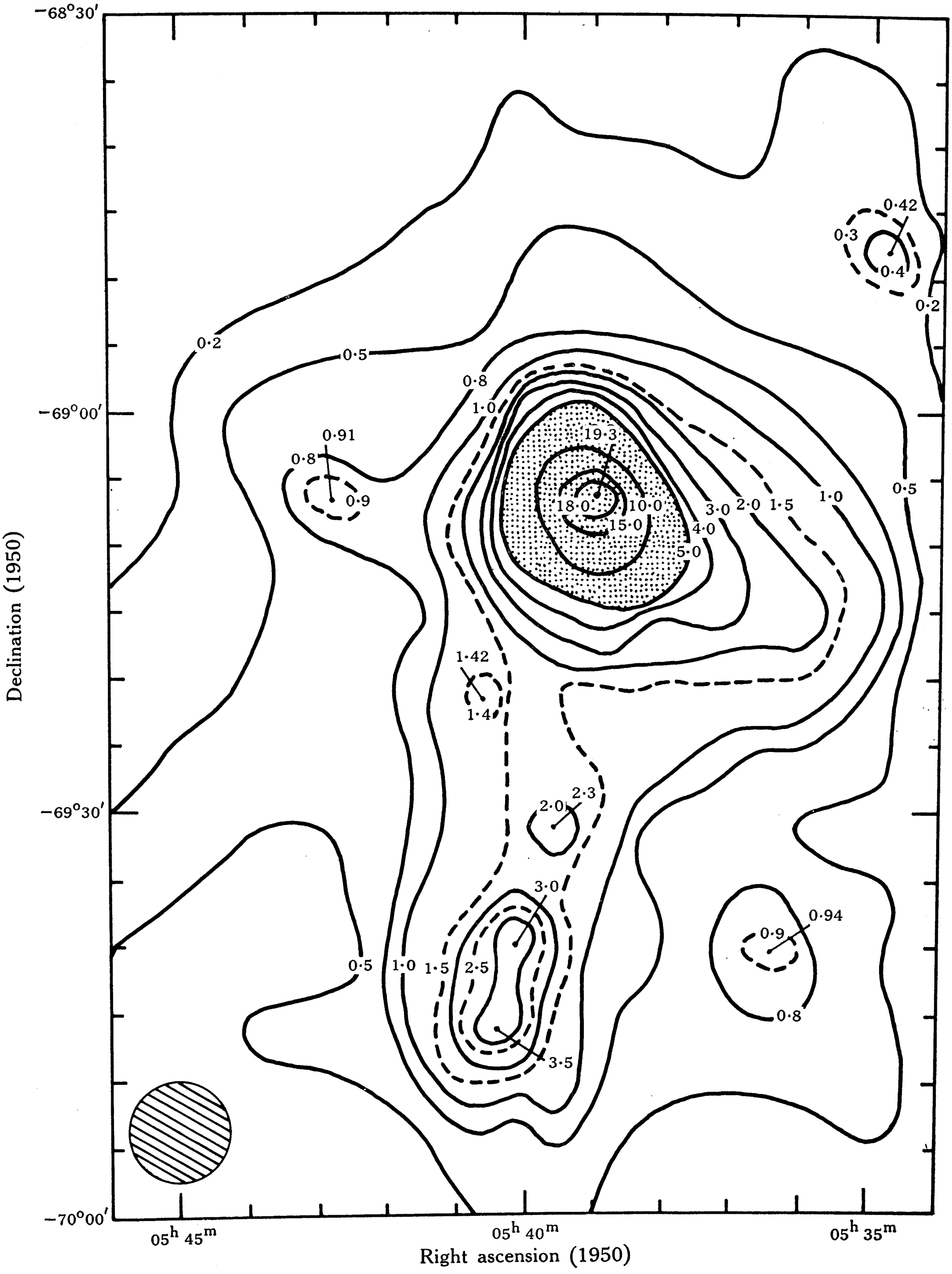

Fig. 1.—Contour map of 2700 MHz (11 cm) radio emission in the LMC near 30 Doradus. The full-beam brightness temperature in kelvins is marked on each contour and at the positions of maximum intensity. In the stippled region the contour interval has been increased to ~ 5 K. The aerial beamwidth at half-power (7′·7 arc) is shown by the hatched circle.

TABLE 1

CATALOGUE OF 11 CM SOURCES IN LMC

(1)	(2)			(3)		(4)	(5)	(6)	(7)	(8)	(9)	(10)
Source number	Position (1950·0) R.A.			Dec.		T_b(max)	Half-widths R.A.	Dec.	S_{11}	Henize number	Base-level	Notes*
	h	m	s	°	′	(K)	′	′	(f.u.)		(K)	
MC 12	04	52	53	−66	59·7	0·36	<1·0	<1·0	0·24	4A		
MC 24	05	13	40	−69	26·1	0·62	11·5	16·5	0·88	113C	0·1	
MC 26	05	16	09	−67	25·2	0·73	8·7	4·9	1·00	33		
MC 29	05	17	38	−72	39·7	0·30	<1·0	<1·0	0·38			
MC 30	05	19	00	−69	16·6	0·73	8·0	12·7	1·25	119		
MC 31	05	19	18	−69	40·1	0·84	5·4	9·5	1·43	120	0·1	
MC 32, 33	05	22	06	−67	59·9	1·12	11·3	12·5	2·86	44		
MC 37	05	24	07	−70	53·7	0·45	<1·0	9·3	0·64			
MC 39	05	25	36	−69	41·5	2·10	<1·0	<1·0	2·80	132D	0·1	
MC 40, 41	05	25	48	−66	19·7	0·70	16·6	10·6	2·14	48B	0·1	
MC 42, 43, 44	05	26	10	−66	06·8	0·84	4·5	8·9	3·62	49		
MC 47	05	26	49	−68	53·0	0·73	8·3	9·5	1·12	144A		
MC 46, 50	05	28	05	−67	28·8	0·76	4·7	14·6	1·51	51D	0·1	
MC 53	05	30	25	−72	47·0	0·36	<1·0	<1·0	0·46			
MC 54	05	31	48	−71	05·5	0·90	5·9	<1·0	1·71	206A		
MC 58	05	32	32	−66	29·3	0·30	4·5	<1·0	0·40	55		
MC 57	05	32	34	−67	42·7	0·60	7·0	4·3	1·07	57		
MC A	05	34	11	−67	27·9	0·34	13·1	8·8	0·85			1
MC B	05	34	48	−70	33·8	0·25	9·7	14·9	0·72			2
MC C	05	34	50	−68	47·7	0·42	2·8	6·1	0·65			3
MC 63	05	35	30	−66	03·8	0·78	4·9	3·6	1·64	63A		
MC 64	05	35	43	−67	35·6	1·40	5·2	1·3	1·78	59A	0·1	
MC 70, 71	05	36	25	−69	40·6	0·94	<1·0	<1·0	0·90	154A	0·4	
MC D	05	36	35	−70	45·8	0·22	<1·0	<1·0	0·28			4
MC E	05	37	57	−66	26·0	0·28	14·9	10·2	0·90			5
MC 74	05	39	02	−69	06·5	19·30	2·8	6·7	29·8	157A	1·0	
MC 75	05	39	36	−69	30·1	2·30	<1·0	<1·0	3·20	158C	1·0	
MC 76	05	40	08	−69	39·7	3·00	<1·0	<1·0	2·52	160A	1·0	
MC 77	05	40	23	−69	46·0	3·50	<1·0	<1·0	3·03	159A	1·0	
MC 78	05	40	39	−69	21·3	1·42	<1·0	<1·0	0·54	158A	1·0	
MC 80	05	42	13	−71	21·4	0·42	8·7	10·5	0·28	214C		
MC F	05	42	18	−70	30·3	0·36	<1·0	<1·0	0·29	(217)	0·1	6
MC 79, 82	05	42	47	−69	06·3	0·91	<1·0	<1·0	0·27		0·5	
MC 83	05	43	03	−73	33·3	0·73	<1·0	<1·0	0·93			
MC 89	05	47	35	−69	43·0	0·84	15·5	13·0	1·62		0·2	
MC 90, 91	05	48	56	−70	03·3	0·92	<1·0	10·4	1·03	180C	0·2	
MC G	05	48	58	−70	56·9	0·50	<1·0	<1·0	0·73			7
MC 93	06	01	06	−70	32·2	0·22	6·8	7·0	0·44			

* Notes on particular sources:

1. MC A. At 6 cm seen only as a featureless extension of MC 57 and MC 64.
2. MC B. Low-intensity feature recorded in Part II; not seen at 6 cm.
3. MC C. Low-level emission; no feature at 6 cm.
4. MC D. Not seen at 6 cm.
5. MC E. Near 6 cm extension from MC 64.
6. MC F. Not seen at 6 cm.
7. MC G. Not seen at 6 cm.

IV. SOURCE CATALOGUE

The 11 cm sources have been catalogued in Table 1 here in the same way as the 6 cm sources were in Part I. The source designation is listed in column 1, and where possible the 6 cm catalogue numbers have been retained. In some cases two of the 6 cm sources are blended into one 11 cm source. For seven sources, which are listed as MC A to MC G, no previous number appears appropriate. Comments on these are given in the notes to the table.

The positions of maximum intensity, in right ascension and declination at epoch 1950·0, are given in columns 2 and 3 while the maximum full-beam brightness temperature is given in column 4. The right ascension and declination half-power widths of the source (columns 5 and 6) have been derived from the observed half-widths on the assumption of a Gaussian brightness distribution and a Gaussian beam shape with a half-intensity width of 7′·7 arc. Sources which do not appear to have broadened the beam have been shown as having sizes $< 1'\cdot 0$ arc.

The flux densities have been measured by integrating the full-beam brightness temperature contours for each source and using the relation

$$S = (2k/\lambda^2)\int T_b \, d\Omega = 1\cdot 9\times 10^{-28}\int T_b \, d\Omega\,, \tag{2}$$

where S is now expressed in $\mathrm{W\,m^{-2}\,Hz^{-1}}$ and Ω in sq min arc. As in Part I, additional estimates of flux density were made by fitting a Gaussian to the source contours and using the relation

$$S = 1\cdot 133\,\Delta w_1\,\Delta w_2\,(2k/\lambda^2)\,T_b(\max) = 2\cdot 15\times 10^{-28}\,T_b(\max)\,\Delta w_1\,\Delta w_2\,, \tag{3}$$

where Δw_1 and Δw_2 are the apparent half-widths in minutes of arc. Weighted means of flux densities obtained from equations (2) and (3) are given in column 7. The average estimated error in the flux density measurements is 15%.

The Henize (1956) catalogue numbers of nebulae which appear to be close to the 11 cm source positions have been listed in column 8.

If a baselevel of continuum radiation was apparent under a source its maximum brightness temperature has been included in column 9. In such cases the flux densities were measured above the baselevel.

V. Acknowledgments

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VI. References

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