NEW HIGH RESOLUTION RADIO OBSERVATIONS OF 3C10, 3C58 AND PART OF THE CYGNUS LOOP.

D.A. Green and S.F. Gull
Mullard Radio Astronomy Observatory, Cavendish Laboratory, Cambridge, United Kingdom.

Introduction

We present new high resolution observations of 3C10 (Tycho's SN) and 3C58, made at 2.7 GHz with the Cambridge 5 km telescope. These observations have a resolution of $\sim$ 4 arcsec, considerably better than previous observations, giving a detailed view of the radio morphology of these two remnants. These maps have also been processed by the Maximum Entropy Method (MEM).

We also present preliminary results from observations of part of the Cygnus Loop made at 408 MHz with the Cambridge One-Mile telescope (OMT).

Reduction of 3C10 and 3C58 Observations

Table 1 presents the relevant parameters of the 5 km telescope as used for the observations of 3C10 and 3C58. It should be noted that each remnant is smaller than the grating ring radius. In each case the contributions from several background sources were removed from the observed visibilities, as these sources had grating responses that fell across the face of the remnant.

These observations have been further processed by MEM (Gull & Daniell 1979) using an algorithm by Gull & Skilling (Skilling 1982). This processing increases the dynamic range of the maps and reduces the side lobe responses, 'Clean' being inappropriate for this type of extended source. The maps presented in figs. 1 and 2 are grey-scale representations made on the Cambridge SERC Starlink computer.

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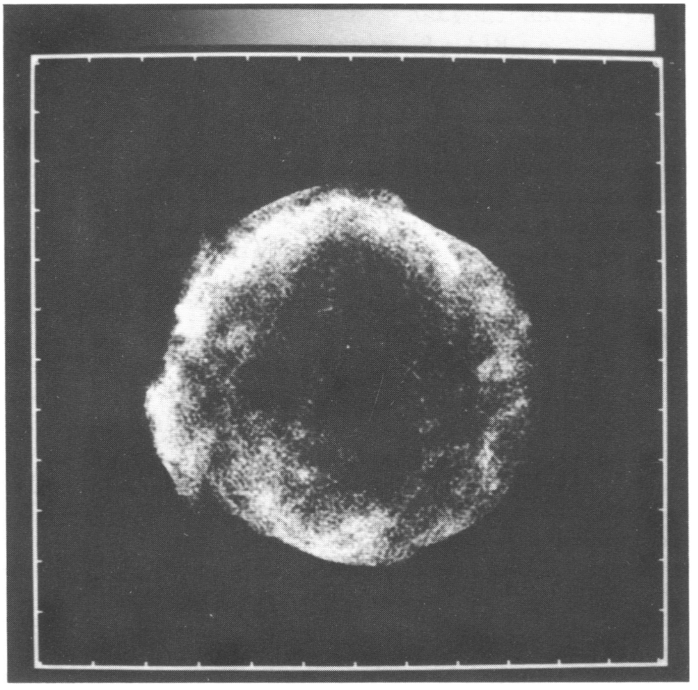

Figure 1. 3C10 at 2.7 GHz. Range, black to white, is 0.0 to 1.6 mJy/pixel, (pixel size is 2.0x2.0 arcsec). The pips on the frame are every 64 arcsec.

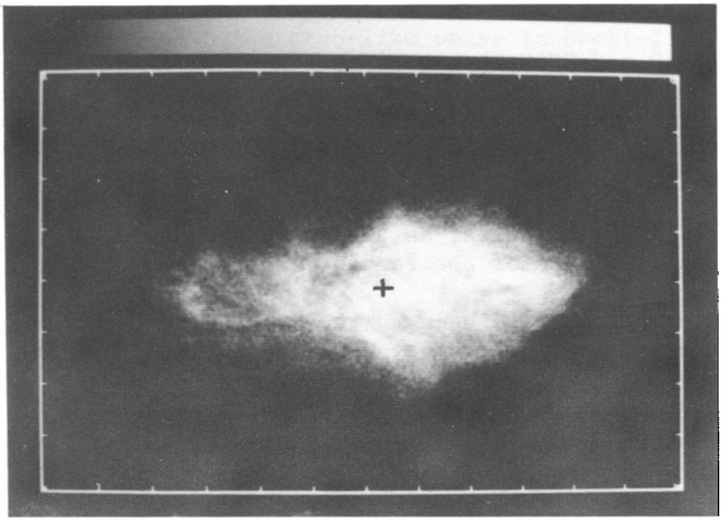

Figure 2. 3C58 at 2.7 GHz. Range, black to white, is 0.0 to 3.0 mJy/pixel, (pixel size is 2.0x2.0 arcsec). The pips on the frame are every 64 arcsec. The cross marks the position of the X-ray point source.

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Table 1: Details of the 5 km telescope as used for the observations of 3C10 and 3C58.

Frequency	2.695 MHz
Stokes parameter observed	I-Q
Number of spacings observed	128
Spacing increment	35.74 m
Grating ring radius (RA)	10.2 arcmin

	3C10	3C58
	h m s	h m s
Map centre: RA	0 22 30.0	2 1 55.0
(1950.0) Dec	$63^{\circ}52'$ 00".0	$64^{\circ}35'$ 30".0
Date of observations	Jun/Jul 1980	Oct/Nov 1981
Resolution (RA x Dec)	3.7 x 4.1 arcsec	3.7 x 4.1 arcsec
Angular size of source	8 x 8 arcmin	9 x 5 arcmin

Tycho - Discussion

The general morphology of the remnant is as seen previously (see, for example, Duin & Strom 1975, Henbest 1980), but fig. 1 shows several interesting features that have not been seen on lower resolution radio maps. The western and southern edges of the remnant are fitted very well (within 5 arcsec) by a circular arc of radius 226 arcsec, centred at $0^h22^m28^s.5$ (± $0^s.3$), 63°51'26" (± 2"). We shall take this to be the 'geometrical' centre of the remnant, which is presumably the direction to the site of SN 1572, as the arc fits the perimeter of the remnant so well. The edge of the remnant is extremely sharp over much of this arc, and shows considerable limb-brightening, especially near the southern edge.

The eastern and northern edges of the remnant generally appear more diffuse and brighter than the rest of the perimeter of the remnant. In the NE the edge is very sharp, and strongly limb-brightened (this is at a radius of 262 arcsec from the geometrical centre of the remnant, larger than the radius for most of the remnant). The bright emission in the N and NE appears to form a partial ring of diffuse emission. It is in just these regions that the optical filaments are seen (van den Bergh et al. 1973). The optical filaments align extremely well with the bright radio emission.

Comparison with the Einstein HRI X-ray observations (Becker et al. 1982) shows a very close correspondence between the X-ray emitting clumps in the middle of the remnant and clumps of radio emission. The brighter X-ray emission is in the NW rather than the NE as for the radio. The radio emission being noticeably more limb-brightened than the X-ray.

There is an unresolved source near the centre of the remnant.

This source was first reported by Gull & Pooley (1980) after the original processing of these observations. This source is at $0^h22^m31^s.21$ (± $0^s.05$), $63^\circ52'16''.8$ (± $0''.4$) 1950.0 epoch, (this is 0.4 arcsec from the originally reported position). Its 2.7 GHz flux (1980.55 epoch) is 4.0 mJy, and it is 54 arcsec from the geometrical centre of the remnant. Morbey & van den Bergh (1980) report no optical stellar image at the position originally given by Gull & Pooley.

This source could be a background radio source (the chance of finding a source of flux greater than 4 mJy within the boundary of the remnant is 0.2), or it may be the radio remnant of the SN of 1572. If this is the stellar remnant of the SN of 1572 and if the 'geometrical' centre of the remnant is the direction to the site of the SN, then the proper motion of this source is 0.13 arcsec/year. This puts a lower limit on its velocity of 1300 km s^{-1} (taking 3C10 to be at a distance of 2.3 kpc, Albinson & Gull 1982). High resolution proper motion studies will be useful to clarify the nature of this source.

3C58 - Discussion

Fig. 2 shows that 3C58 has a large extent of low brightness radio emission, with a distinct outer edge which is presumably the position of the blast-wave shock. This feature has not been so evident in previous observations, as this low brightness emission would be lost in the noise or else not easily seen on contour representations. Thus 3C58 appears larger, and relatively broader than in previous observations, being 9 x 4.7 arcmin (RA x Dec), (though Wilson & Weiler (1976) get a still larger size of 10 x 6 arcmin, which we believe is due merely to their larger beam at lower frequencies).

There is a bright region of radio emission at $2^h1^m46^s.3$ (± $0^s.3$), $64^\circ35'12''$ (± 2"), which is 20 arcsec from the X-ray point source position (Becker et al. 1982) which is marked on fig. 2. The filamentary structure of the bright emission is complex and reminiscent of that of the Crab Nebula.

Cygnus Loop

Part of the Cygnus Loop has been observed (as a full '5C' survey: 5C8) with the OMT at 408 and 1407 MHz. Preliminary results at 408 MHz are presented in Fig. 3. This map has a resolution of 80 x 160 arcsec (RA x Dec), it has been corrected for the primary response of the OMT, and several of the brighter background sources in the field have been removed from this map.

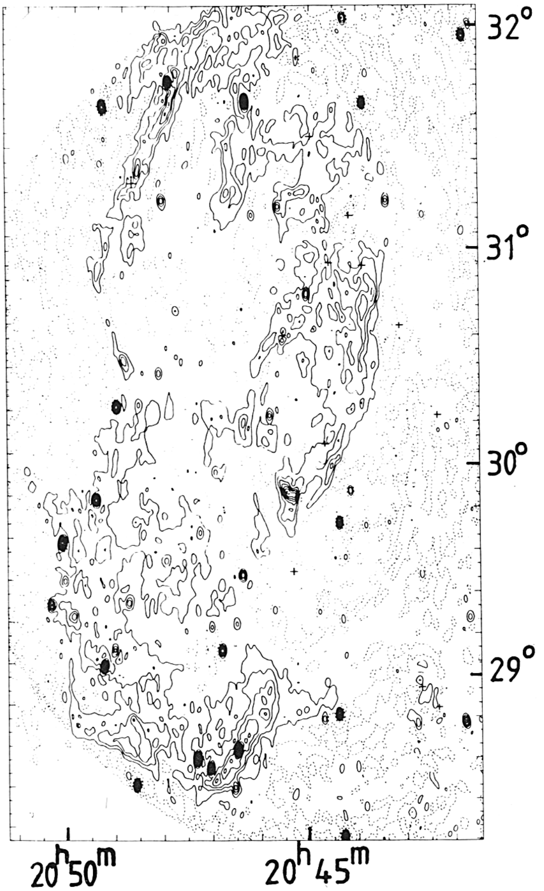

Figure 3. Part of the Cygnus Loop at 408 MHz. The first solid contour is at ∿ 0.8 K, then every ∿ 1.6 K. Point sources have been removed from the positions marked by crosses.

Acknowledgements

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References

Albinson, J.S. & Gull, S.F., 1982. In 'Regions of Recent Star Formation', (D.Reidel), eds. Roger, R.S. & Dewdney, P.E., p. 193.

Becker, R.H., Helfand, D.J. & Szymowiak, A.E.,1982. Astrophys. J., 255, 557.

Duin, R.M. & Strom, R.G., 1975. Astr. Asrtophys., 39, 33.

Gull, S.F. & Daniell, G.J., 1979. In 'Image Formation from Coherence Functions in Astronomy', (D.Reidel), ed. van Schooneveld, L., p. 219.

Gull, S.F. & Pooley, G.G., 1980. IAU Circular, No. 3502.

Henbest, S.N., 1980. Mon. Not. R. astr. Soc., 190, 833.

Morbey, C. & van den Bergh, S., 1980. IAU Circular, No. 3511.

Seward, F., Gorenstein, P. & Tucker, W., 1982. Preprint.

Skilling, J., at 'Maximum Entropy Data Analysis & Estimation Workshop', Laramie, (Wyoming, 1981).

Strom, R.G., Goss, W.M. & Shaver, P.A., 1982. Mon. Not. R. astr. Soc., 200, 473.

Wilson, A.S. & Weiler, K.W., 1976. Astr. Astrophys., 49, 357.

van den Bergh, S., Marscher, A.D. & Terzian, Y., 1973. Astophys. J. Suppl. Ser., 26, 19.