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Research Note

The Large Scale Radio Structure of NGC 1275

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Summary. New data at 1.4 GHz prove the existence of a component in NGC 1275 on a scale of $\sim 30''$ and give structural information about the previously known 5′ halo.

Key words: radiogalaxies — clusters

NGC 1275, the brightest member of the Perseus Cluster, is one of the most active galaxies known and has been the subject of extensive radio investigation. The associated radio source (Perseus A, 3 C 84) has structure on many different angular scales. At high frequencies most of the radio emission comes from a small variable core $\lesssim 0.02''$ (Barber *et al.*, 1966; Kellermann *et al.*, 1971). This core is imbedded in a 5′ halo (Ryle and Windram, 1968). In addition to the core and halo there is indirect evidence (Miley, 1968; Wilkinson, 1971, 1972) for the presence of an intermediate scale component on an angular scale of $\sim 30''$. The existence of this component was inferred from the low fringe amplitudes measured by an interferometer with a 22 km baseline.

Previous investigations of the large scale radio structure of NGC 1275 have been limited by instrumental leakage from the strong unresolved core. Such errors are minimal for measurements made with the Westerbork Synthesis Radio Telescope (WSRT) (Baars *et al.*, 1973; Högbom and Brouw, 1974) because of the excellent gain and phase stability of its receivers. We therefore mapped NGC 1275 with the WSRT at a frequency of 1415 MHz in order to confirm the reality of the 30″ component and to study the structure of the halo.

The source was observed in June 1971 for 12 h. Twenty baselines were used ranging in length from 54 m to 1422 m in equal steps of 72 m. Relevant information is listed in Table 1. The point sources 3 C 48 and 3 C 147 (assumed flux densities 15.67 f.u. and 21.25 f.u. respectively) were used as calibrators.

Figure 1 shows the resultant variation of average fringe amplitude with projected baseline for position angles of $0° \pm 15°$ and $90° \pm 15°$. The former corresponds to resolution of the telescope in the north-south direction and the latter to resolution in the east-west direction. The visibility data define three distinct scales of structure.

First, the steep decrease at projected baselines shorter than 1500 λ is caused by the 5′ *halo* component which Ryle and Windram (1968) designated as 3 C 84 A (iii) and contains about 2 to 3 f.u. at 1.4 GHz. This component is clearly more resolved in Pa 0° than in PA 90° indicating that it is extended in the north-south directions.

Secondly, the absence of any amplitude variation > 10% between a few thousand wavelengths and a million wavelengths. Barber *et al.* (1966) and Donaldson *et al.* (1971) demonstrates the existence of a *compact* component < 0.05″ containing about 7 f.u. at 1.4 GHz. This component is complex and extended by 0.006″ in P.A. ~ 174° (Legg *et al.*, 1973; Rogers *et al.*, 1974; Wittels *et al.*, 1975).

Table 1. Parameters of the observations and reduction for NGC 1275

Date of observation	5 June 1971	
Frequency	1415 MHz	
Bandwidth	4.2 MHz	
Half-power diam. of primary beam	36′	
Baseline increment	72 m (340 λ)	
Radius of first grating ring	12′ × 19′	
Maps computed	Full resolution	Low resolution (Fig. 2)
Shortest spacing	54 m	54 m
Longest spacing (25% taper)	1422 m	486 m
Half power diam. of synthesized beam	23″ × 35″	67″ × 102″
Effective rms noise per synthesized beam (f.u.)[a]	0.0012	0.002
Flux density of subtracted point source (f.u.)[a]	7.2	9.32

[a]) 1 f.u. = 10^{-26} W m^{-2} Hz^{-1}.

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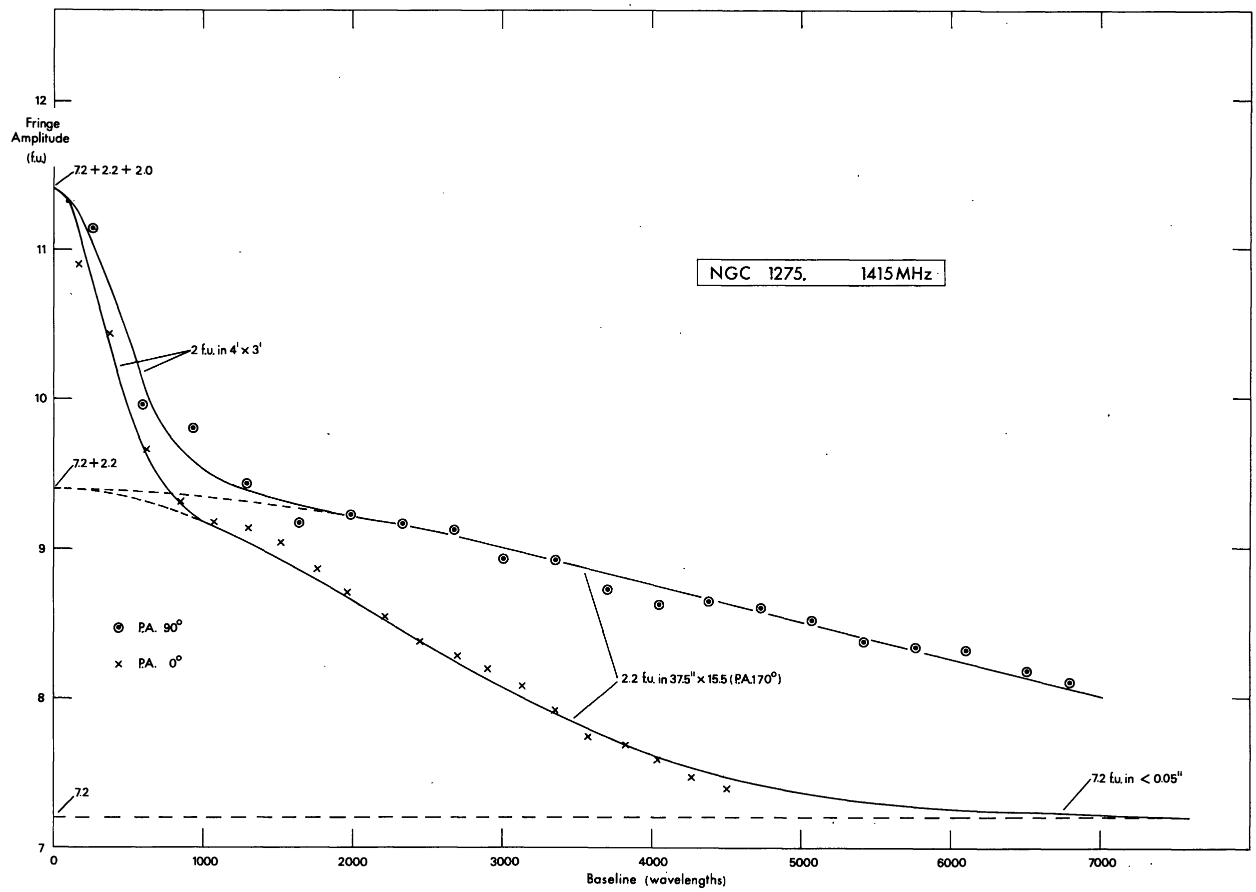

Fig. 1. Fringe amplitude as a function of baseline. The two sets of data points correspond to resolution in the east-west and north-south directions respectively. The uncertainty in each point corresponds to $\sim \pm 0.1$ f.u.

Thirdly, the gradual variation in fringe amplitude for projected baselines larger than 1500 λ shows that there is indeed an *intermediate scale* component with an extent of $\sim 30''$ which is also elongated in the north-south direction (actually P.A. $170° \pm 10°$). This component radiates about 2 f.u. at 1.4 GHz. Note that the halo, compact and intermediate scale components are all elongated in approximately the same direction.

With the present resolution it is difficult to obtain more detailed information about the structure of the intermediate scale component and its relation to that of the compact component. An equally good fit of the observed visibility amplitudes in Fig. 1 is given by models consisting of (i) a 7.2 f.u. compact core enveloped by a 2.2 f.u. elliptical ($35'' \times 12''$) gaussian halo or (ii) two unresolved components containing 8.2 and 1.1 f.u. respectively, separated by 20". In the latter case the 8.2 f.u. point would be the compact component observed at long baselines and presumably associated with the nucleus of NGC 1275.

The structure of NGC 1275 was investigated further by Fourier transforming the visibility data. The effective beam in such a synthesis map depends on both the baselines used and on the grading applied to the fringe amplitudes before transformation. Separate maps were produced with baseline coverage and grading functions chosen as optimum for studying the 5′ and 30″ component respectively. In both cases the influence of the compact "core" component was removed by point source subtraction and the grating rings from the

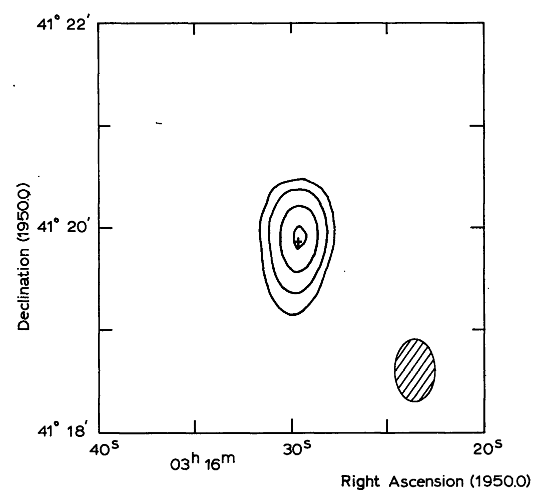

Fig. 2. The radio structure of NGC 1275 with a resolution of 23″ by 35″. The 7.2 f.u. compact core component has been subtracted from the map and the effects of grating rings from 3 C 83.1 have been removed. The cross indicates the position of the nucleus and the radio core. Contours representing flux density per synthesized beam area are shown at levels of 0.25, 0.5, 1.0 and 1.5 f.u. The half power contour of the synthesized beam is given by the shaded ellipse

nearby source 3 C 83.1 was eliminated using the "clean" techniques (Högbom, 1974). Table 1 lists some relevant parameters of the maps.

The full resolution map (Fig. 2) shows that the 30″ component is not only elongated in the north-south direction but appears to extend predominantly *southwards* from the nucleus of the galaxy and from the compact radio core.

In Fig. 3 our low resolution map is shown superimposed on an optical picture of the region. Here both the core and intermediate scale component have been subtracted in order to study the structure of the halo. Two main bodies of radio emission can be discerned. The more intense component, "*a*" is coincident with NGC 1275 and elongated in the north-south direction i.e. roughly the same direction as the smaller scale components. A second component, "*b*" is situated between NGC 1275 and the giant elliptical galaxy NGC 1272. Because of its general asymmetry with respect to NGC 1275 this two-component halo is morphologically different from the usual double radio source. In addition, some weaker features are apparent in the outskirts of the halo. Because of the large dynamic range required, further measurements are needed to confirm the reality of these features. Observations with the W.S.R.T. at a frequency of 610 MHz are at present underway which should give an unambiguous answer to this question and in addition provide spectral information. We defer discussion of the physical conditions in the halo until these observations are reduced.

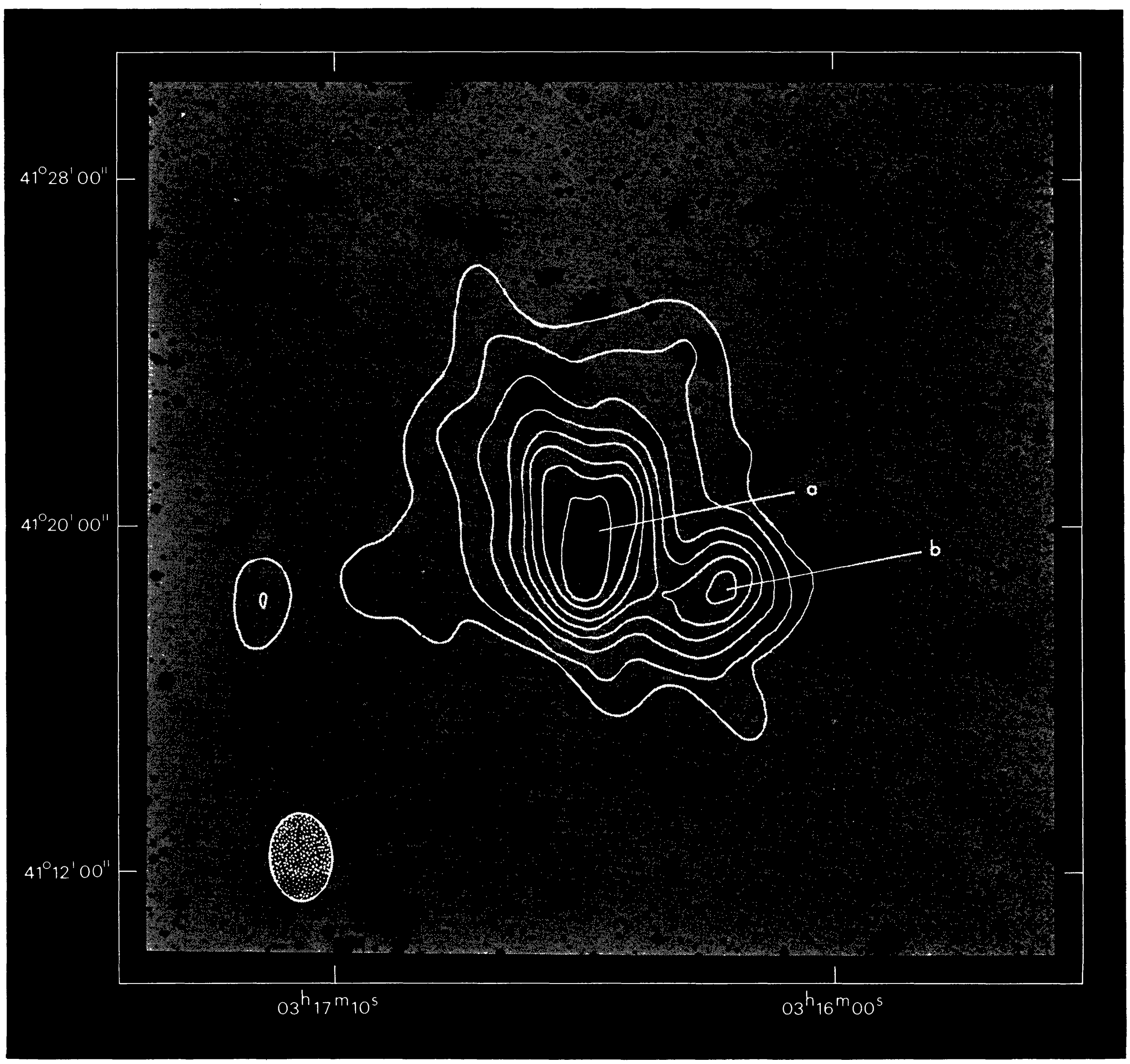

Fig. 3. The radio halo of NGC 1275 with a resolution of 67″ by 102″. A 9.4 f.u. unresolved source has been subtracted, corresponding to the core and intermediate scale components. Also the grating ring effects from 3 C 83.1 have been removed. The contours are superimposed on an optical photograph from Arp and Bertola (1971). Contours representing flux density per synthesized beam area are shown at levels of 0.02, 0.04 and thereafter at intervals of 0.04 f.u. The data is uncorrected for the effect of the 35′ diameter primary beam. The synthesized half power beam width is indicated by the shaded ellipse

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