THE NUCLEUS OF NGC1275

J.D. Romney, W. Alef, I.I.K. Pauliny-Toth, and E. Preuss
Max-Planck-Institut für Radioastronomie, Bonn, FRG

K.I. Kellermann
National Radio Astronomy Observatory, Green Bank, USA

The bright radio nucleus 3C84 of the peculiar galaxy NGC1275 was among the first sources studied by VLBI techniques sixteen years ago (Clark et al., 1968). Early observations at short centimeter wavelengths using arrays of up to four telescopes (Schilizzi et al., 1975, and references therein) demonstrated the presence of structure significantly more complex than that seen in other strong compact objects, but were insufficient to determine the brightness distribution with the relatively primitive methods then in use. By the time of the most recent international VLBI symposium (Aug. 1978, in Heidelberg, FRG), Pauliny-Toth et al. (1976) had succeeded in modelling the structure seen by a 4-station transatlantic array, revealing three distinct bright emission regions aligned in position angle -9°, and connected by non-colinear, more diffuse features. Further observations and a reanalysis of earlier data by Preuss et al. (1979) confirmed previous inferences that the three major condensations remained stationary but varied in brightness.

The predominant impression arising from these early observations at or near 2.8 cm wavelength was one of extreme, even "pathological" structural complexity, much in contrast to the relatively simpler morphology seen in other sources. More recently, the spectral index study by Unwin et al. (1982) and especially the 1.3 cm map of Readhead et al. (1983) have evinced a structural affinity between 3C84 and many other active extragalactic objects, where a compact variable flat-spectrum "core" and one or more relatively diffuse steeper-spectrum "jet" components are typical. The failure to recognize this connection in the earlier observations of 1972-76 is attributable largely to the lack of activity in the core during this period, and to the coincidentally equal intensities of the major components at 2.8 cm, the only wavelength then affording both sufficient angular resolution and acceptable calibration.

3C84 remains an unusually complex source. To some extent at least this is a selection effect arising from its very near distance, although the extreme radio luminosity and anomalous optical morphology suggest an intrinsic complexity. The recognition that 3C84 can be classified as a core-jet structure (e.g., Readhead et al.) provides an opportunity to study in detail the processes occurring in core-jet sources.

R. Fanti et al. (eds.), VLBI and Compact Radio Sources, 137–140.
© 1984 by the IAU.

https://doi.org/10.1017/S0074180900077883 Published online by Cambridge University Press

Since 1979 we have obtained 2.8 cm maps of 3C84 at three epochs using transatlantic arrays of seven (1979.1) and five (1981.1, 1982.1) stations. This observing wavelength is optimal for studies connecting the very compact and more extended structures; the major bright features are well resolved, while instrumental factors and the component spectra combine favorably to allow mapping with high dynamic range. The maps, presented in Fig. 1 together with the 1974.5 model of Pauliny-Toth et al., were derived using an adaptive calibration technique similar to that of Schwab (1980); earlier versions of the 1979.1 and 1981.1 maps were presented by Romney et al. (1982) before application of the amplitude corrections. We describe below the general structural evolution observed, and then consider in more detail the component motions so strikingly evident in Fig. 1.

The observations at epoch 1979.1 yielded by far the most complete aperture coverage, allowing a dynamic range of about 50 to be achieved. The core-jet configuration pointed out by Romney et al. is evident: the northern core component is resolved at this epoch into two intensity peaks separated by 0.9 milliarcsec (1.5 ly) along position angle $\sim 45^\circ$, the southwestern peak coinciding with a sharp, nearly right-angle bend leading into the diffuse 6 milliarcsec region which itself exhibits internal curvature. Contained within this diffuse structure are the relatively weak central component and the southern condensation which is the brightest part of the source at this epoch. There are no corresponding features to the north of the core greater than a few percent of this peak brightness.

The 1981.1 map has relatively limited dynamic range because only abbreviated tracks were observed, but the strengthening of the core is evident. This is presumably linked to the outburst seen to begin about 1980 at millimeter wavelengths (O'Dea, private communication), although the fading southern component limits the 2.8 cm flux density increase to 13% over the 1979.1 measurement. The marked increase in separation between the core and the southern feature, previously described by Romney et al., is discussed below. At epoch 1982.1 all these trends are seen to continue. The brightening core dominates the diffuse region; the southern component continues to fade as it recedes farther from the core, although it has become so extended that its location is increasingly indistinct. The double structure in the core does not appear at either of these later epochs.

In quantifying the motion of the southern component we have adopted the conventional registration in which the core is presumed stationary. The double northern component in the 1979.1 map presents an additional problem; we have identified the northeastern peak as the core, as seen in Fig. 1, on the basis of its spectral index and compactness. With this registration a linear fit yields an angular velocity of 0.24 ± 0.06 milliarcsec y^{-1}, corresponding to $v = 0.4c$ if $H_0 = 50$ km s^{-1} Mpc^{-1}. 3C84 is unique among active radio nuclei in manifesting this subluminal but finite velocity.

https://doi.org/10.1017/S0074180900077883 Published online by Cambridge University Press

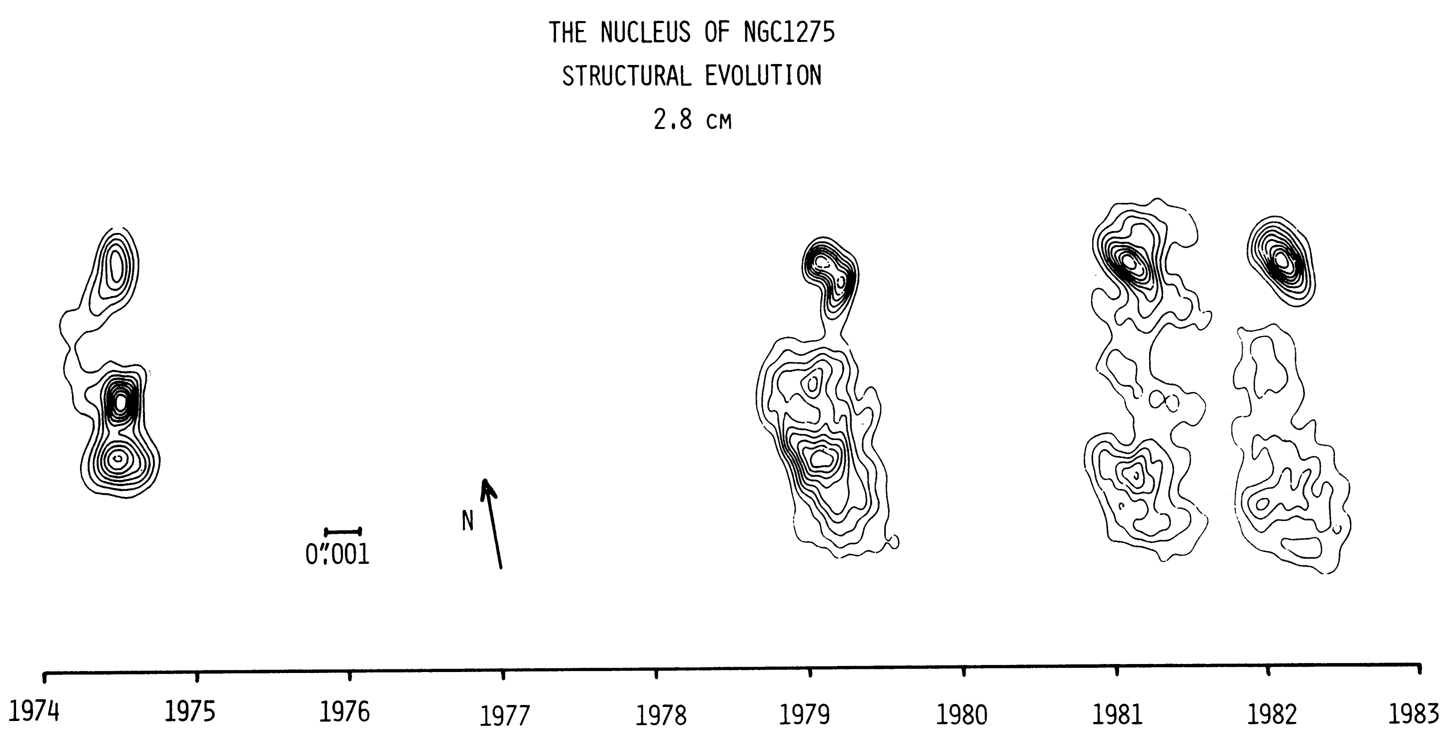

Fig. 1: Evolution of the compact structure in 3C84. The abscissa scale is observing epoch; the ordinate is angular distance along position angle -9°. Registration of the individual maps is discussed in the text. The contour unit is 10% of the peak brightness in each map. A uniform restoring beam was used, 0.85 by 0.43 milliarcsec in position angle -20°.

https://doi.org/10.1017/S0074180900077883 Published online by Cambridge University Press

It is not clear how best to interpret the central component and the earlier observations. The best fit to the southern component for the three recent epochs passes quite near the central region of the 1974.5 model, although Preuss et al. reported no measurable positional changes prior to 1978, and the southern peak in the 1979.1 map is consistent with its location at the earlier epochs. The central feature is essentially stationary over the entire 10-year interval.

Although the observed transverse velocity of the one-sided structure is subluminal, it is instructive to consider an interpretation in the context of the relativistic-beaming model commonly invoked to explain both the apparent transverse motion and the one-sided morphology in superluminal sources. An intrinsically two-sided jet is assumed, with an orientation near the line of sight and velocity such that the counter-jet is suppressed (i.e., the approaching jet enhanced) by the necessary factor of $\sim$ 50 and an apparent transverse motion at $\sim$ 0.4c is observed. This configuration can also explain naturally the sharp observed bend in the jet as a magnification of a minor intrinsic bend passing close to the line of sight; Allan (1984) has analyzed both the geometric and Doppler effects. The required values of the jet parameters offer an interesting contrast to the superluminal case: for example, at a typical inclination to the line of sight of 5°, the jet is only mildly relativistic, with Lorentz factor $\gamma \sim 2$, and a de-projected length of $\sim$ 40 pc. For a more typical superluminal $\gamma \sim 7$ the jet must lie within a few tenths of a degree of the line of sight, and is more than an order of magnitude longer. Of course in the case of 3C84 it is also possible to postulate an intrinsically one-sided jet, containing knots moving at 0.4c in or near the plane of the sky.

REFERENCES

Allan, P.: 1984, this volume, p. 195.

Clark, B.G., Kellermann, K.I., Bare, C.C., Cohen, M.H., and Jauncey, D. L.: 1968, Astrophys. J. 153, pp. 705-714.

Pauliny-Toth, I.I.K., Preuss, E., Witzel, A., Kellermann, K.I., Shaffer, D.B., Purcell, G.H., Grove, G.W., Jones, D.L., Cohen, M.H., Moffet, A.T., Romney, J.D., Schilizzi, R.T., and Rinehart, R.: 1976, Nature 259, pp. 17-20

Preuss, E., Kellermann, K.I., Pauliny-Toth, I.I.K., Witzel, A., and Shaffer, D.B.: 1979, Astron. Astrophys. 79, pp. 268-273.

Readhead, A.C.S., Hough, D.H., Ewing, M.S., Walker, R.C., and Romney, J.D.: 1983, Astrophys. J. 265, pp. 107-131.

Romney, J.D., Alef, W., Pauliny-Toth, I.I.K., Preuss, E., and Kellermann, K.I.: 1982, I.A.U. Symposium 97, "Extragalactic Radio Sources", pp. 291-292.

Schilizzi, R.T., Cohen, M.H., Romney, J.D., Shaffer, D.B., Kellermann, K.I., Swenson, G.W.Jr., Yen, J.L., and Rinehart, R.: 1975, Astrophys. J. 201, pp. 263-274.

Schwab, F.R.: 1980, Proc. Soc. Photo-Opt. Instrum. Eng. 231, pp. 18-25.

Unwin, S.C., Mutel, R.L., Phillips, R.B., and Linfield, R.P.: 1982, Astrophys. J. 256, pp. 83-91.

https://doi.org/10.1017/S0074180900077883 Published online by Cambridge University Press