WSRT OBSERVATIONS OF CORE-DOMINATED RADIO SOURCES

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A few years ago we presented evidence for large scale radio structures around most superluminal radio sources (Schilizzi and de Bruyn, 1983). The extended emission is relatively faint and, in at least two cases (3C120 and 3C345), exhibits a rather complex morphology. Although the sample was small, the conclusion seemed inescapable that the largest angular sizes (LAS) of the superluminals do not permit a large deprojection factor due to foreshortening, without making these sources exceptionally large intrinsically. That is to say, they would be exceptional within the context of the unified scheme (US) which interprets superluminal sources as favourably oriented, strongly beamed, core components of classical double radio sources. To save the US, we concluded that the ejection axes of these sources must undergo a large ($\gtrsim 30°$) change of direction in the period between the creation of the outer and inner emission regions. Superluminality would then be a temporary phase (although possibly recurrent) in the lifespan of a large fraction of the parent population of classical doubles.

In order to extend this result to a larger sample of objects we made observations with the WSRT of 14 sources generally thought to be akin to the superluminal sources. In this sample we included a variety of objects: low frequency variables, optically violent variables and BLLac type objects. The selection criteria for the sample were loosely defined: we chose strongly core-dominated radio sources with a flux density of at least 2 Jy at 6 cm and at accessible declinations ($\delta \gtrsim 15°$) in order to also obtain good resolution in the declination direction (the WSRT is an EW-interferometric array). The sources in the sample were: 0133+47(OC457), 0235+164, 0552+39(DA193), 0735+178, 0836+71, 0851+20(OJ287), 0954+55(4C55.17), 1219+28(W Coma), 1308+32, 1358+62, 1611+34(DA406), 2201+42(BL Lac), 2230+11(CTA102), 2251+16(3C454.3).

Observations of 12 hours duration were made of all objects in April and May 1983 with the digital line backend giving a sensitivity of about 0.4 mJy (r.m.s.). Recently, we reobserved three objects (0235+164, OJ287 and BLLac) with the newly constructed broad-band backend yielding a sensitivity of 0.08 mJy after 12 hours integration.

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The object OJ287 was observed for three 12 hour periods in October and November 1985 to search for rapid intra-day variability. A detailed account of the results on this object will be presented elsewhere (de Bruyn, in preparation).

The reduction of these data was carried out using standard procedures developed for redundancy observations with the WSRT (Noordam and de Bruyn, 1982). A preliminary account of some of the results was presented at IAU Symposium 110 in 1983 (de Bruyn and Schilizzi, 1984).

An important aspect of the reduction of redundancy observations with the WSRT is the production of accurate visibility curve information without recourse to a self-calibration step. The accuracy with which information on sizes and fluxes of resolved emission is derived therefore depends only on the quality of the correlator which is known (empirically) to be very good.

The general result from this work is that all sources show evidence for emission resolved by our 3".5x3".5 sinδ beam. In about half of the sources in the sample, this emission is distributed across a region several beams in diameter, at a level never exceeding 2 to 3 times the noise level. In these cases the flux densities and sizes of the extended emission were derived from simple fits to the visibility curves (averaged over 12 hours). Note that this procedure may underestimate the longest dimension if the sources are elongated.

A sample of the results is shown in Figures 1 through 4. A full description of these and the other sources not shown, will be presented elsewhere (de Bruyn and Schilizzi, in preparation). Here we will only summarize the main results:

1) there are no naked sources when observed with a dynamic range of several thousand to one,
2) the morphology of the extended emission is generally diffuse, often asymmetric, and in a few cases there are clear suggestions of double structure,
3) the median LAS is of the order of 100 kpc ($H_o = 50$ kms^{-1} Mps^{-1}, $q_o = 0.5$),
4) in many cases where this could be determined, the inner (VLBI) axis and the large scale orientation show no relation. Examples in the current sample are OJ287 and 3C454.3, but this result was also found in 3C120 and 3C345 (Schilizzi and de Bruyn, 1983).

We briefly compare these results with the expectations and predictions of the relativistic beaming and unified schemes (Blandford and Königl, 1979; Scheuer and Readhead, 1979; Orr and Browne, 1982). We can make the following inferences:

i) if the intrinsic core/lobe flux ratio is in the range 0.01-0.1, as observed in sources whose extended power is comparable to those in our sample, we need a minimum Lorentz factor between 5 and 10 in order to boost the core power to the observed levels (assuming jet motion within angles of 10°-20° to the line of sight).

ii) it is doubtful that all the sources in our sample are drawn from the same parent population. We have made comparisons with samples of lobe-dominated sources drawn from the 3CR and B2 catalogues, sources which straddle our objects in power and should be the parent population. The observed LAS distributions (expressed in linear size)

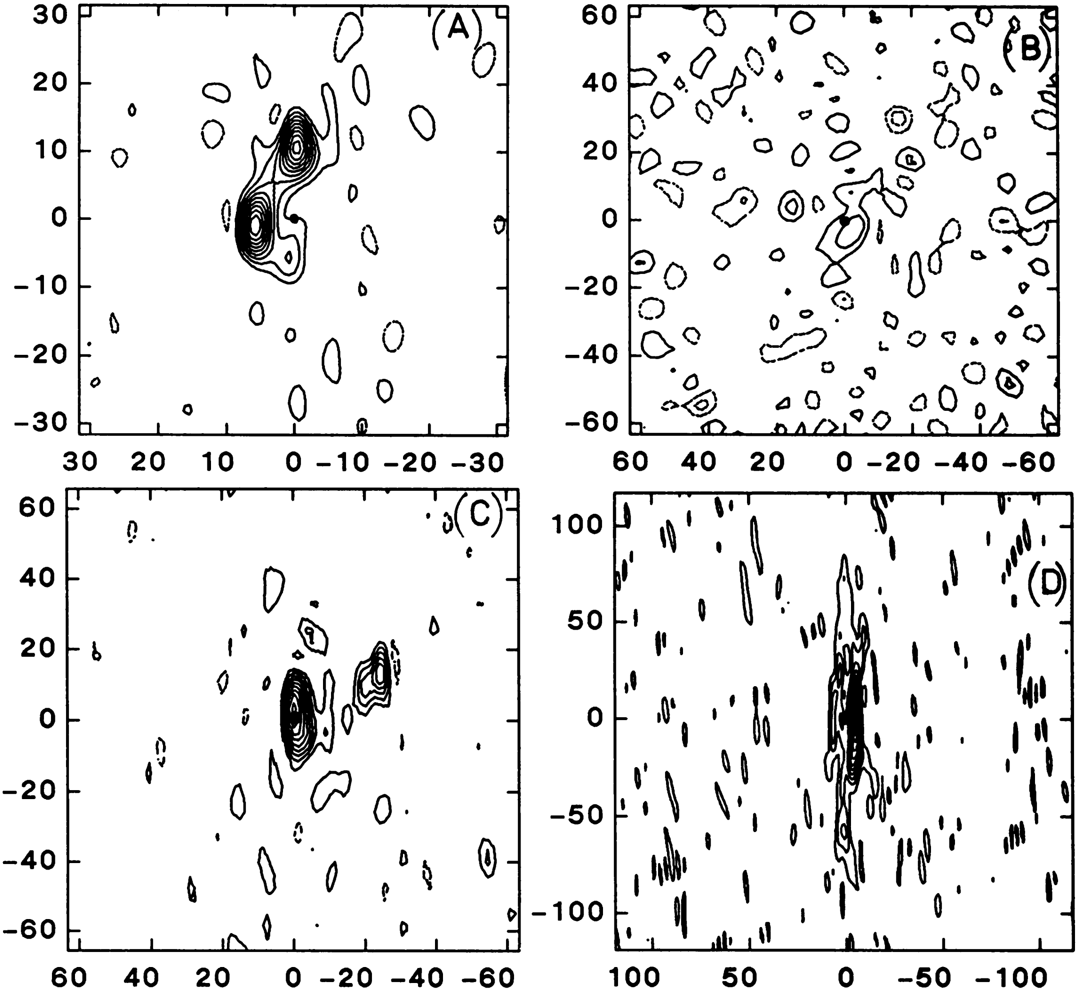

Fig. 1a, b, c, d Maps of the extended emission around four core-dominated radio sources. The axes are labelled in arcsec. In all maps the strong core was subtracted at the centre (shown as a dot). In 0836+71 and 3C454.3 the strong secondary emission within one beam area of the core was also subtracted. The full resolution beam measures 3".5x3".5/sinδ.

a) B2 1308+32: core 1.9Jy; contour levels -1, 1, 2, 3, ..., 9 mJy.
b) 0836+71: map smoothed to 7"x7"/sinδ; core 2.85 Jy; secondary (at Δα=-0".55 Δδ=-1".4) 70 mJy; contour levels -1.6, -0.8, 0.8, 1.6 mJy.
c) OJ287: average of two 12 hour syntheses; core 3.6 Jy; contour levels -0.15, 0.15, 0.30, ..., 1.35 mJy. There is probably continuous emission between the core and the "jet".
d) 3C454.3: core 14 Jy, secondary (at Δα=-3".7 Δδ=+3".6) 260 mJy. contour levels -1.25, 1.25, 2.5, ..., 16.25 mJy. The extensions to the north and south show up more reliably in smoothed maps (and unpublished 21 cm data). The appearance of the structure around the core depends on the amount subtracted at the core position.

of all three sets of objects are very similar. But within the US/beaming hypothesis, our sources should be foreshortened by some factor. How large this factor could be is difficult to say because it depends on the intrinsic morphology. For sources with clear doubles or distinct high-brightness features the foreshortening correction could be considerable (up to 5). However, many of the sources in low luminosity samples of sources are distorted to some degree and have a transverse size up to half the overall size. Clearly for such sources the foreshortening correction can be at most a factor of two.

About half of the sources in our sample could fall in this latter category. For them we can state only that their LAS, corrected for foreshortening based on a Lorentz factor of 5-10, is still consistent with them being drawn at random from a sample of randomly oriented radio galaxies and quasars. This is in agreement with the results of Antonucci and Ulvestad (1985) who observed a large sample of BLLac objects. Yet, the maps of OJ287 and 3C454.3 (Figs. 1c and d) reveal distinct features at a large projected linear distance from the core. Foreshortening corrections of 3-4 for these sources would make them exceptionally large, and difficult to fit within the unified scheme.

iii) we observe different position angles for the VLBI and large scale structures and we observe large projected angular sizes. It is not possible to reconcile both these observations within the unified scheme; either there is a large foreshortening (with consequent problems for the deprojected sizes) and a small intrinsic misalignment (in which case the observed large misalignment could be attributed to magnification effects) <u>or</u> there is little or no foreshortening but a gross (>30°) intrinsic misalignment in these sources in going from the inner to the outer structure.

If we accept the second possibility (see also Schilizzi and de Bruyn 1983), we are faced with the problem of explaining why a disproportionately large fraction of core-dominated sources (compared to the parent population) has a gross misalignment in structure. The sources exemplifying this problem are 3C120, 3C345, OJ287 and 3C454.3. The conclusion is therefore that we must modify, or radically depart from, the unified scheme. One possibility would be to assume that there is a causal relationship between the presence of relativistic motion in core dominated sources and beam wobbling and/or the formation of extremely large radio structures.

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