EXTENDED STRUCTURE AROUND SUPERLUMINAL AND OTHER CORE-DOMINATED RADIO SOURCES +

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The maps that we will show you today probably have the lowest resolution of any that you will see this week. They were made from data taken by the Westerbork Synthesis Radio Telescope (WSRT), which has a maximum baseline of 2.8 km, yielding a resolution of 3"5 (λ 6 cm), 12"5 (λ 21 cm) or 29" (λ 49 cm). Because the WSRT is an EW-array the resolution in declination is worse by a factor 1/sin δ. This is unfortunate since three interesting superluminal sources are close to the equator. For two of these, namely 3C120 and 3C273 we nevertheless have obtained some interesting results.

Since 1981 the WSRT is increasingly being used in a new observing mode whereby all 14 telescopes are correlated with one another (Noordam and de Bruyn, 1982). The large number of redundant spacings thence provided are used to determine the phase and gain errors contributed by each of the 14 telescopes as a function of time (hour-angle). In addition, tropospheric wave front distortions on scales smaller than the array are removed. The resulting data base is a time-series of perfect 1-dimensional (complex) visibility curves with only two unknowns: the absolute amplitude and the phase slope across the array (= absolute position). Because there are far more spacings (66) involved in the redundancy decomposition solution than there are unknowns to solve for (14 telescopes + 13 visibilities), a useful byproduct is the consistency of the solution, and hence the reliability of the visibilities. With the digital line backend (Bos et al., 1981) we now obtain an accuracy of 0.03-0.05% rms in amplitude and 0.02-0.03° in phase depending, among other things, on frequency and bandwidth. The new broadband continuum backend may even surpass this already excellent performance. It is therefore possible to measure flux densities of weak extended haloes around discrete sources, on scales of about 5 arcseconds and larger, with an accuracy better than 0.1%. It is important to realise that this can be done <u>without</u> knowledge of the brightness distribution in the field of view.

In order to make a two-dimensional map from the sequence of one-dimensional scans an 'aligning' routine is used, which is basically

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similar to SELFCAL (see Noordam and de Bruyn, 1982). However, an alignment scheme that uses the fact that the source centroid position and total flux are invariant under projection has been successfully used on several complex sources (e.g. 3C120). This scheme can do without a model for the source and is thus radically different from SELFCAL. Moreover, it is much less of a burden on the astronomer and the computer!

In the remaining time we will present you some results of three ongoing programmes using the WSRT in its redundancy configuration. All sources in these programmes are core-dominated.

1) Sample 1 contains 14 sources which belong to one or more of the following classes: BLLac type objects, low frequency variables and optically violently variables. Of the eight sources thus far reduced (BLLac, OJ287, 0735+17, 1308+32, 1358+62, 1219+28, CTA102 and 3C454.3) nearly all contain significant extended emission. One of the sources that comes closest to being a "perfect" point source is 1219+28 (W Coma) of which a map is shown in Fig. 1a. No extended emission with a peak intensity greater than 0.1% of the core is seen. However, on the short baselines (< 500 meter) an excess flux of about 5-10 mJy is recorded, which in a smoothed map shows up to the SW of the core. In BLLac an extended region, containing about 1% of the total flux (3.74 Jy at that time), is revealed after subtraction of an unresolved core (see Fig. 1b). The source boundaries are not well-defined since the emission fades into the noise level. However the size is at least 30" oriented roughly in position angle 20°, which is not significantly different from that of the VLBI structure (Phillips and Mutel, 1982). A third very active BLLac-type object is OJ287 which was found to contain a significant very diffuse halo. In this source the extended emission has a peak intensity of about 0.03% of the core flux (4.8 Jy at the time of the observation). If these sources are to be explained as the favourably oriented examples of normal lower luminosity elliptical radio galaxies whose core emission is relativistically boosted (Browne, 1983), then their beam Lorentz factors must lie between 4 and 8.

2) Another continuing programme is the mapping of the 'classical' superluminal sources at all three wavelengths available. Results at 6 cm for 3C120, 179, 273, 279, 345 and NRAO140 have been published (Schilizzi and de Bruyn, 1983; henceforth SB). New 21 cm observations of 3C120 have since shown that there is faint emission in addition to the east and west lobes discovered at 6 cm. A smoothed map is presented in Fig. 2. It shows a diffuse structure several arcminutes in size centered 4!5 west and 2' south of the nucleus. There is little doubt that it is associated with 3C120. The EW-size of 3C120 is therefore some 7!5. In addition, significant emission exist to the north and south of the source. Its total dimension in those directions is not well determined but certainly measures 10'; it could be as large as 20'. This revised estimate of the LAS of 3C120 puts it in the very top part of the LAS-z diagram shown by SB, even without correcting for projection effects. It further exacerbates the problem of the intrinsic sizes of the superluminal sources, in the context of the directed relativistic beaming models. The large range in observed position angles in the outer structure of 3C120 suggests that the nuclear ejection axis undergoes a

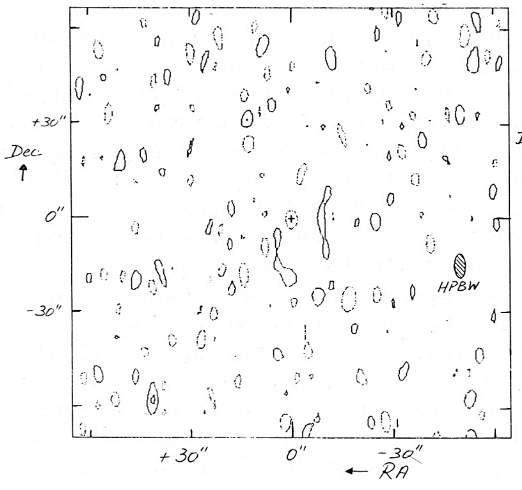
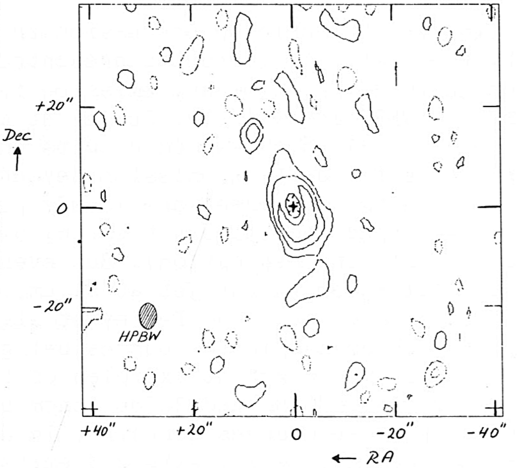


Fig. 1a) 6 cm map of W Coma (1219+28) after removal (at the cross) of a 1.91 Jy core. Contours are at ±0.04% (=0.8mJy) intervals.



1b) 6 cm map of BL Lac after removal (at the cross) of a 3.74 Jy core. Contours are at ± 0.02% (=0.75 mJy) intervals.

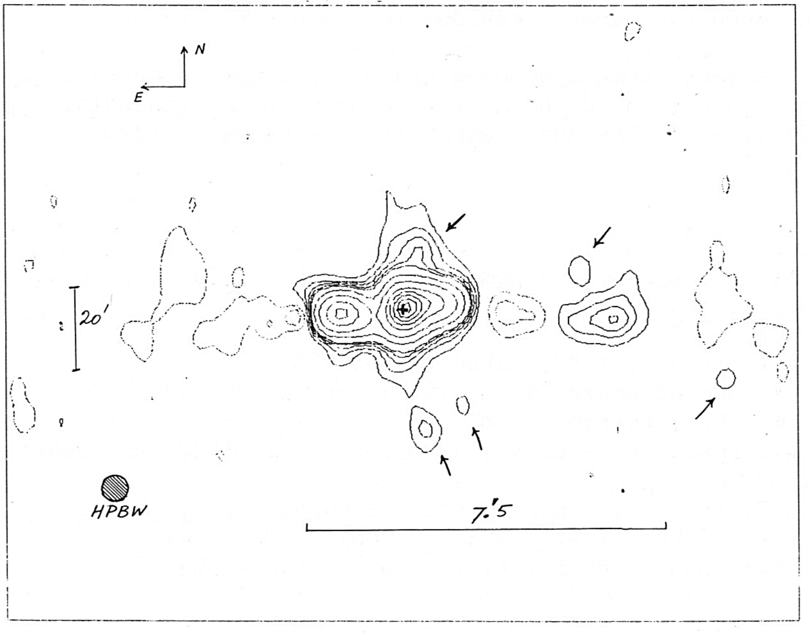


Fig. 2 Smoothed map of 3C120 at 21 cm after subtraction of a core (at the cross) of 3.25 Jy. The beam measures 34"x365" at half width; note that the declination scale has been compressed to yield a circular beam. Contours are at -5, -2.5, 2.5 (2.5) 12.5, 25, 50 (50) 300 mJy/beam. Arrows point to unrelated discrete background sources.

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significant wobble or precession in the course of time, just as demanded by the statistical results presented by SB. Our 21 cm and 49 cm results on 3C345 do not show any emission features beyond the 20" region mapped by the WSRT and VLA (SB, Perley et al., 1982; Rudnick and Jones, 1983). The 6 cm, 21 cm and 49 cm results on 3C273 thusfar have not produced any evidence for diffuse emission beyond 20" west or east of the core. Our best limits at present are 10 mJy per beam (12"x300" stripscan) at 21 cm but we expect to improve these by a considerable factor (de Bruyn and Schilizzi, in preparation). But even these limits, compared to 16 Jy total emission in the jet at 21 cm,, establish 3C273 as a unique one-sided source (see also Perley et al., 1982; Browne et al., 1982).

3) A third sample of sources being investigated by one of us (AGdB) are the brightest examples of the steep spectrum core sources, namely 3C48, 3C147 and 3C286 (them being the primary WSRT calibrators). Each of these sources contains, in addition to emission on the arcsecond scale (Perley, 1982), extended emission on scales of 20"-60". This transforms to linear dimensions of several hundred kpc. The total flux density in these regions, however, is only 0.2-0.5% of the core flux densities. Not much can be said as yet about the structure of these components since they are not more than a few beams across. But they do show that relativistic plasma (beams?) does manage to escape the inner regions of these quasars (see also van Breugel, this symposium), and that large amounts of energy resides in the outer regions.

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