# A *VLBI* search for compact components in extended high redshift quasars

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**Summary.** Sensitive 21 cm *VLBI* observations of components in extended high-redshift quasars have been made with the European Network. In most sources in the sample, compact ($< 1$ kpc) components of varying complexity were detected; these components account for a substantial fraction of the total source flux density.

Identification with hot spots in the radio lobes was possible in most cases. Some ultracompact hot spots were detected, with energy densities of the order of $10^{-6}$ erg/cm³. Two kpc-size double sources at redshifts of 1.875 and 2.594 have been found. Correlations between "compactness" and other parameters are briefly discussed, as well as cosmological implications.

**Key words:** quasars – very long baseline interferometry

## Introduction

From high resolution observations of extended extragalactic radio sources it has become clear that the compact high-brightness regions with sizes of a few kpc ("hot spots") which are embedded in lower brightness, more extended regions may themselves exhibit complex structure when studied with sufficiently high resolution. The first observation of a complex hot spot was reported by Miley and Wade (1971) who found that the north-western hot spot of Cyg A appeared to be double. Laing (1981, 1982) and Dreher (1981) have reported and discussed further examples in nearby sources. The resolution achievable with connected element interferometers is sufficient to resolve complex hot spots in low redshift sources, but for radio sources at high redshift (say $z > 1$), one needs higher resolution, 0".1 or better. Instruments capable of studying these structures are the recently completed Jodrell Bank MERLIN array (e.g. Lonsdale, 1981) and very long baseline interferometers. The first *VLBI* search for compact components in extended extragalactic radio sources was carried out by Kapahi and Schilizzi (1979a, b), subsequently to be referred to as KS. With a 1.26 M$\lambda$ interferometer KS detected components $\lesssim 0".15$ in a large fraction of their steep-spectrum 3CR subsample. In most cases these compact components could be unambiguously identified with hot spots in the extended radio lobes of the sources. Although KS made only a few short scans per source, it is clear from their measured correlated flux densities that the detected hot spots do not always have circular symmetric structure.

This paper gives the first results of a project to study the morphology of hot spots at high redshift. The observed structure of these hot spots should be affected by the physical conditions inside and outside the radio sources, as well as by the geometry of the Universe. Our eventual aim is to study hot spot properties as a function of redshift.

We report here on observations of extended, steep spectrum radio quasars at redshifts higher than 1.40. After a description of the source sample and the observational procedure, the results for the individual sources will be given. Finally, we briefly discuss the implications of the observations.

## The source sample

The quasars were selected from the compilation of Hewitt and Burbidge (1980) to have the following properties: (1) $z > 1.40$, (2) $\delta_{1950} > 0°$, (3) $\alpha \lesssim -0.7$ ($S_\nu \propto \nu^\alpha$), (4) $S_{1417} > 500$ mJy, and (5) known, extended radio structure. The radio structure of few high-redshift quasars is known; the Hewitt and Burbidge Catalogue contains only 13 quasars which satisfy all the above criteria. These are listed in Table 1, together with some relevant parameters and references for recent maps of their radio structure. Column 1 gives the quasar name in the IAU convention, column 2 some alternative names, column 3 the emission-line redshift, column 4 a spectral index, column 5 the total flux density (mJy) at 1417 MHz, column 6 the largest angular size LAS (arcsec), and column 7 the references to radio maps and/or structure information. Four sources which do not fulfil all the above selection criteria were added to the observing program for various reasons: 1334 + 119, which has a large angular size for its redshift and 0805 + 046, 0843 + 136, and 2338 + 042 which are very powerful (log $P_{408} = 28.4$, 28.0, and 29.1 W Hz$^{-1}$, respectively[1]) high-redshift quasars with steep radio spectra.

For most of the sources in Table 1 the LAS is typically 10", with two exceptions: 1258 + 404 and 1606 + 289 which have LAS = 22" and 31" respectively.

## Observations and data reduction

Parameters of the interferometer array are given in Table 2. The polarization was LCP.

The three interferometers are sensitive to structures smaller than $\sim 150$ mas². For $z > 1.40$ the conversion to linear size is almost

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**Table 1.** The source sample

| QSO | Other name | $z$ | Spectral index | $S_{1417}$ | LAS | Ref. |
|---|---|---|---|---|---|---|
| 0017+154 | 3CR9 | 2.012 | $\alpha^{5000}_{1400} = -1.1$ | 1900 | 10 | d, i |
| 0730+257 | 4C25.21 | 2.686 | $\alpha^{1400}_{178} = -0.8$ | 600 | 7 | k |
| 0835+580 | 3CR205 | 1.534 | $\alpha^{5000}_{1400} = -1.1$ | 2200 | 16 | d, i |
| 1023+067 | 3C243 | 1.699 | $\alpha^{5000}_{1400} = -1.0$ | 700 | 11 | m, n |
| 1206+439 | 3CR268.4 | 1.400 | $\alpha^{5000}_{1400} = -1.1$ | 2000 | 9 | d, e, i, l |
| 1218+339 | 3CR270.1 | 1.519 | $\alpha^{5000}_{1400} = -0.9$ | 2750 | 9 | c, l |
| 1258+404 | 3CR280.1 | 1.659 | $\alpha^{5000}_{1400} = -1.1$ | 1250 | 22 | a, c, d |
| 1318+113 | 4C11.45 | 2.171 | $\alpha^{5000}_{1400} = -0.9$ | 2300 | 5 | c, m |
| 1606+289 | 4C28.40 | 1.989 | $\alpha^{1400}_{178} = -0.8$ | 600 | 31 | h, j, k |
| 1702+298 | 4C29.50 | 1.927 | $\alpha^{1400}_{178} = -0.7$ | 1300 | 3 | b |
| 2120+168 | 3CR432 | 1.805 | $\alpha^{5000}_{1400} = -1.1$ | 1500 | 12 | c, g |
| 2222+051 | 4C05.84 | 2.323 | $\alpha^{1400}_{178} = -1.0$ | 850 | $\simeq 3$ | n |
| 2354+144 | 4C14.85 | 1.810 | $\alpha^{5000}_{1400} = -0.9$ | 1000 | 13 | g |
| 0805+046 | 4C05.34 | 2.877 | $\alpha^{1400}_{178} = -0.7$ | 550 | < 7 | c, m |
| 0843+136 | 4C13.39 | 1.875 | $\alpha^{1400}_{178} = -0.9$ | 500 | < 9 | c, m |
| 1334+119 | MC2 | (1.760) | $\alpha^{1400}_{408} = -0.9$ | 275 | 10 | f |
| 2338+042 | 4C04.81 | 2.594 | $\alpha^{5000}_{1400} = -0.9$ | 1600 | | |

*References*
a) Burns et al. (1981) (1.4 GHz) – "probable background source"
b) Hooley et al. (1978) (15 GHz)
c) Jenkins et al. (1977) (5 GHz)
d) Laing (1981) (2.7 GHz, 15 GHz)
e) Lonsdale (1981) (408 MHz, 1.67 GHz)
f) Miley (unpublished) (VLA data)
g) Miley and Hartsuijker (1978) (600 MHz, 1.4 GHz, 5 GHz)
h) Perryman and Ryle (1977) (2.7 GHz)
i) Pooley and Henbest (1974) (5 GHz)
j) Pottasch and Wardle (1979) (2.7 GHz, 8.1 GHz)
k) Riley and Pooley (1975) (5 GHz)
l) Schilizzi et al. (1982) (1.4 GHz, 5 GHz)
m) Wardle and Miley (1974) (2.7 GHz, 8.1 GHz)
n) Wills (1979) (2.7 GHz, 8.1 GHz)

**Table 2.** Parameters of the interferometer array

| Telescope | Location | Diameter$(m)$ | $T_s$(K) | $T_0$(K/Jy) | Freq. standard |
|---|---|---|---|---|---|
| MPI | Effelsberg, FRG | 100 | 85 | 1.5 | H-maser |
| WSRT (3 km) | Westerbork, NL | 93[a] | 87 | 1.3 | Rubidium |
| Jodrell | Jodrell Bank, UK | 76 | 100 | 0.9 | Rubidium |

| Baseline | Max. projected baseline (M$\lambda$), for $\delta = 20°$ source | rms noise level (mJy), after 10 m coherent integration |
|---|---|---|
| MPI – WSRT | 1.25 | 4 |
| MPI – Jodrell | 3.30 | 5 |
| WSRT – Jodrell | 2.80 | 5 |

[a] Equivalent diameter

redshift-indepedent: 150 mas $\simeq$ 750 pc, using $H_0 = 75$ km s$^{-1}$ Mpc$^{-1}$ and the Einstein-de Sitter world model (these values will be used throughout the paper). Detecting correlated flux density in a (not too low declination) source on all three baselines means that the compact structure is certainly smaller than $\sim 0\rlap{.}''05$ ($\sim 250$ pc), if we assume it to be circular.

The observations took place between 02.00 UT on Dec. 14 and 14.00 UT on Dec. 15, 1980. Parts of the experiment were repeated during the week August 24–31, 1981. A number of short scans, typically 3–8, each of 10–30 min, were made for each source at different hour angles. The data were recorded using the standard MkIIC *VLBI* System, with a 2 MHz bandwidth (Clark, 1973). Cross correlation of the tapes was carried out at the Max-Planck-Institut für Radioastronomie, Bonn, FRG. The measured correlation coefficients were calibrated according to Cohen et al. (1975), assuming the primary calibrator OQ208 to be unresolved on all baselines with a 1417 MHz flux density of 760 mJy.

From checks on the calibrator scans coherence losses were determined for long integration times (up to 15$^m$). The error in the correlated flux density appeared to vary between 5 and 15%,

caused by phase errors from ionospheric disturbances over the array. Calibrators were observed regularly to allow determination of the position of the beam centre as a function of the residual fringe rate for each baseline. In a considerable number of cases, multiple peaks were found in the fringe rate spectrum after long integrations, indicating more than one compact component near the beam centre. In these cases relative positions in the sky could be obtained.

## Results

Correlated flux densities exceeding the $5\sigma$ level were detected in most of the sources observed.

The result of the observations are discussed below for each source separately. The observations reported here for the MPI-WSRT baseline are consistent with KS for the 3CR sources in common.

### 0017+154

This very luminous (log $P_{408}=29.0$ Watt/Hz) high redshift D1 quasar was marginally detected: $S_{cor}\lesssim55\pm7$ mJy, on the MPI-WSRT baseline, $S_{cor}<35$ mJy on the long baselines.

### 0730+257

A relatively compact component is seen in the map of this large D2 source made by Riley and Pooley (1975). This component is resolved out by the VLBI observations: $S_{cor}<30$ mJy on all baselines.

### 0805+046

This very high redshift quasar was not resolved by the Cambridge 5 km telescope (Jenkins et al., 1977). The present observations show that the source has a core-halo structure. The best fit to the measured 21 cm visibilities is achieved with a $350\pm25$ mJy core (size $\lesssim10$ mas), embedded in a $200\pm20$ mJy halo, with size $\gtrsim150$ mas.

### 0835+580

The measured correlated flux densities and the fringe rate spectra indicate rather complex structure. A $70\pm20$ mJy hot spot in the $E$ lobe, seen on the short MPI-WSRT baseline is resolved out on the long baselines. The data observed on the long baselines appear mainly to reflect the beating between the nucleus $N$ and the $W$ lobe. This $W$ lobe contains a $2''$ double hot spot in p.a. $45°$ Laing (1981). Although this double structure is consistent with the fringe rate spectra measured in this experiment, the structure of the $W$ hot spot might be more complex. Denoting the subcomponents of the $W$ hot spot by $A$, $B$ ($B$ for the southern subcomponent), the 1417 MHz flux densities are $S_A=130\pm30$ mJy, $S_B=40\pm15$ mJy, $S_N=40\pm15$ mJy and $S_E=70\pm20$ mJy, all measured at 1.4 GHz. The eastern hot spot has a size $\gtrsim60$ mas, the other components are $\lesssim20$ mas.

### 0843+136

Jenkins et al. (1977) report this QSO to be $<2''$ in RA and $<9''$ in decl. The VLBI observations show rapid beating in the measured visibilities, and the fringe rate spectra show some clear double

peaks. A $2''0\pm0''4$ double in p.a. $55°\pm25°$ with flux densities $180\pm15$ mJy (west) and $120\pm15$ mJy (east) gives a good fit to the data. Such a double would account for $60\%$ of the total 21 cm flux density. There is no indication that the two components are resolved. The resulting component sizes of $\lesssim20$ mas imply a component separation to size ratio for this source of about 100. The linear size of this $2''$ double is about 11 kpc.

### 1023+067

Wardle and Miley (1974), and subsequently Wills (1979), found an $11''4$ double structure for this quasar, with the NRAO interferometer at 2.7 and 8.1 GHz, with the $E$ component being the brighter one. The present VLBI observations show beating between weak hot spots in the two components: $S_W=40\pm10$ mJy and $S_E=20\pm10$ mJy. The sizes are estimated to be $\lesssim20$ mas.

### 1206+439

Beating between the nucleus and the $W$ lobe is detected. This $W$ lobe contains complex structure which is resolved on the long baselines: $S_{cor}\leqq500\pm25$ mJy on short projected baselines, $S_{cor}\leqq100\pm8$ mJy on long projected baselines. Lonsdale (1981) and Schilizzi et al. (1982) show 18 and 6 cm maps respectively of this source in which the $W$ lobe contains a $1''$ double hot spot in p.a. $125°$, in good agreement with the observations reported here. On the long baselines the compact components appear to be resolved, indicating sizes $\gtrsim40$ mas.

### 1218+339

Schilizzi et al. (1982) show a 6 GHz VLA map of this source in which there is some indication that the southern lobe is slightly extended to the SW. In the present observations correlated flux density between $100\pm8$ and $230\pm18$ mJy is detected, which varies with IHA. Due to ionospheric disturbances, location of compact components in the overall structure is difficult, but as the correlated flux densities are highest when observing this source with EW baselines, the compact structure must be mainly in NS direction, roughly the overall p.a. of the source. The structure reported here must have angular size $\lesssim20$ mas. Preuss et al. (1977) also detected this source with a 100 M$\lambda$ VLB interferometer at 5 GHz.

### 1258+404

KS detected weak compact structure in this large high redshift QSO and located components in the nucleus and the W lobe. The present observations are consistent with that, although location of components in the overall structure is not possible: $S_{cor}\leqq40\pm7$ mJy.

### 1318+113

This bright high redshift quasar is detected on all baselines and resolution effects are apparent on the long baselines. $S_{cor}$ varies with IHA, between $35\pm7$ and $150\pm12$ mJy. Location of the compact structure in this $5''$ (Jenkins et al., 1977) radio source was impossible.

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**Table 3**

| QSO | $F_{21}$ | $C$ | $\log P_{178}$ (W/Hz/sr) |
|---|---|---|---|
| 0017+154 (3C9) | 0.03 | 1.00 | 28.6 |
| 0833+654 (3C204) | 0.03 | 0.78 | 27.8 |
| 0835+580 (3C205) | 0.12 | 0.98 | 28.1 |
| 0850+140 (3C208) | 0.01 | 0.78 | 28.0 |
| 0855+143 (3C212) | 0 | 1.00 | 27.8 |
| 1206+439 (3C268.4) | 0.26 | 0.70 | 27.9 |
| 1258+404 (3C280.1) | 0 | 0.53 | 28.2 |
| 2120+168 (3C432) | 0.06 | 0.82 | 28.3 |

*1334+119*

On the MPI-WSRT baseline this weak source is clearly detected at some hour angles, whereas on the long baselines there are some marginal detections: $S_{cor} \lesssim 35 \pm 7$ mJy. The total source flux density, as measured with the WSRT is $275 \pm 15$ mJy. Unpublished *VLA* observations by Miley show that the source has a 10″ D2 structure in p.a. 51°. The redshift of this QSO is uncertain.

*1606+289*

Apart from one $4\sigma$ detection on the MPI-WSRT baseline, no compact structure is seen in this large (Riley and Pooley, 1975) high redshift quasar.

*1702+298*

A 15 GHz map of this D2 source has been published by Hooley et al. (1978). Strong variations in correlated flux density with IHA are seen in the present observations, indicating complex compact structure: $40 \pm 7 \lesssim S_{cor} \lesssim 330 \pm 16$ mJy. The variations occur on rather long timescales on all baselines, implying that the components must be close together ($\lesssim 1''$), and have sizes $\sim 20$ mas.

*2120+168*

Only the short projected baselines detected weak compact structure ($S_{cor} \lesssim 35 \pm 6$ mJy), but there is a rapid increase to $S_{cor} = 93 \pm 10$ mJy at $(U, V) \simeq (0.1, 1.0)$ M$\lambda$, indicating complexity.

*2222+051*

Wills (1979) resolved this source, using the NRAO interferometer at 2.7 and 8.1 GHz. It was clearly detected in some of the *VLBI* scans, but not in others: $S_{cor} \lesssim 45 \pm 8$ mJy. At $(U, V) = (-1.6, 1.1)$ M$\lambda$ there is a rapid increase in correlated flux density: $S_{cor} = 90 \pm 10$ mJy. The visibility data are too limited to yield (compact) structural information.

*2338+042*

A number of scans on this very luminous ($\log P_{408} = 29.1$ W/Hz) high redshift QSO show a continuous rapid beating which can be fitted with a $1''0 \pm 0''2$ double in p.a. $90° \pm 25°$. On the longest

baseline (MPI-Jodrell) the correlated flux density varies between $250 \pm 20$ and $670 \pm 40$ mJy. On MPI-WSRT the observed minimum is deeper ($150 \pm 10$ mJy) so the weaker of the two components seen on MPI-Jodrell must have a $\sim 100$ mJy halo with size $\sim 0''1$. Note that due to the fact that this source has a low declination, good NS resolution was not achieved. The component fluxes are: $S_A = 460 \pm 30$ mJy ($\lesssim 10$ mas), $S_B = 210 \pm 20$ mJy ($\lesssim 10$ mas). $S_{halo,B} = 100 \pm 30$ mJy ($\sim 0''1$). There remains a 180° ambiguity in the p.a. of the double, and the model accounts for about 50 % of the total flux density at 1.4 GHz.

*2354+144*

Miley and Hartsuijker (1978) found a size of $13'' \pm 3''$ in p.a. 140° $\pm 12°$ for this source, using the WSRT at 5 GHz. The *VLBI* observations show rapid beating on all baselines, which is consistent with a $5''0 \pm 1''5$ double in p.a. $90° \pm 30°$. At the highest resolution the beating occurs between $50 \pm 10$ and $110 \pm 10$ mJy whereas on the shorter baselines the maximum correlated flux density is higher. The component sizes are therefore likely to be $\sim 30$ mas. Only 25 % of the total 21 cm flux density was detected.

**Discussion**

The observations reported here are sensitive only to structures $< 0''2$ ($\sim 1$ kpc), so throughout this discussion a compact component is taken to mean a region (much) smaller than 1 kpc.

The observations have resulted in detection of components in $11/13 = 85$ % of the sources in the sample. Unambiguous identification with high brightness regions in the radio lobes of the extended radio structure is not always possible, but the high variability observed in the correlated flux densities strongly suggests that complex (multiple) structure is present in most of the sources in the sample.

Recent high resolution observations of hot spots in five nearby radio galaxies have been reported by Dreher (1981). These hot spots appear to have a $\sim 1$ kpc head and a tail, pointing back several kpc, and in some cases complex, multiple hot spots were detected.

The present observations have revealed smaller hot spots in some distant quasars. The radio structures of $0835+580$ and $1206+439$ contain hot spots with sizes $\lesssim 250$ pc. The strong hot spots detected in $0843+136$, $1702+298$, $2338+042$, and $2354 +144$ have linear sizes $\lesssim 150$ pc. We note with interest that the overall sizes of these four sources are also small, almost subgalactic. Most notable are $0843+136$ and $2338+042$ where hot spots with linear sizes smaller than 100 pc and flux densities of a few hundred mJy have been detected.

Assuming a filling factor of 1 and equal contributions from relativistic protons and electrons some properties of the brightest component in $2338+042$ have been calculated, using the standard formulae (Moffet, 1975). Note that the radio spectrum of this source is completely straight: $S_\nu \propto \nu^{-0.9}$ between 178 MHz and 5 GHz (Kühr et al., 1979). The radio luminosity of the component is found to be $7 \; 10^{44}$ erg s$^{-1}$, and, since the volume is smaller than about $1.5 \; 10^{61}$ cm$^3$, its minimum energy density is as high as $7 \; 10^{-6}$ erg/cm$^3$. Also $B_{eq} = 9$ mG and the lifetime against synchrotron losses for the electrons at 1.4 GHz (observed frequency) is about 500 yr. These values are not very sensitive to $H_0$ and $q_0$, and are much larger than normally found for hot spots (Miley, 1980).
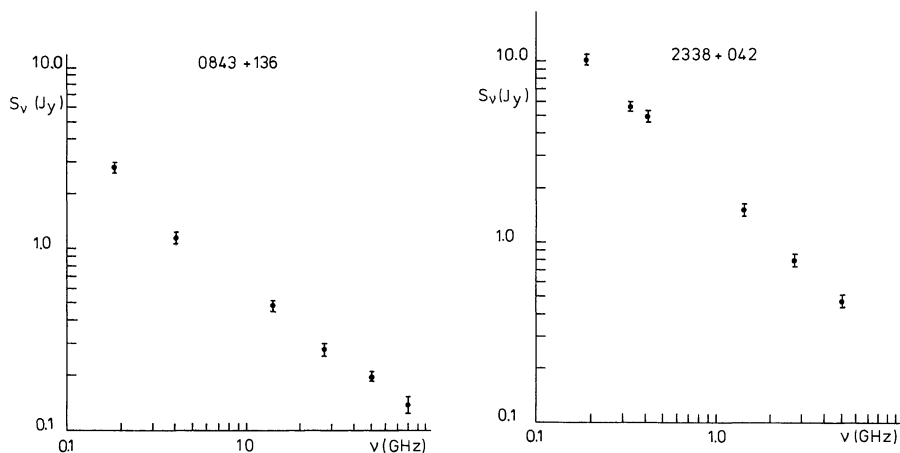
**Fig. 1.** Radio spectra for 4C13.39 (0843+136) and 4C04.81 (2338+042), compiled from data taken from Gower et al. (1967), Large et al. (1981), Ehman et al. (1974), Wardle and Miley (1974), Jenkins et al. (1977), and Kühr et al. (1979)

Ram pressure confinement of such spots seems to be impossible without invoking galactic densities.

Subsequent high-resolution *VLA* (Barthel et al., in preparation) and MERLIN observations (Barthel and Lonsdale, 1983) have confirmed the presence of these subgalactic hot spots.

Another interesting result of these observations is the detection of several cases of complex (multiple) hot spot structure. A double hot spot is found in 1206+439 and is very likely present in 0835+580. Complicated structure must be present in 1218+339 and 1318+113. In 0017+154, 2120+168 and 2222+051 the limited data available indicate the presence of elongated compact components in the radio structure. Hybrid maps made with the European *VLBI* array are in preparation, as well as MERLIN maps at different wavelengths.

A subject of some controversy has been the existence of possible correlations between source luminosity and the hot spot size and intensity, in the 3CR source sample (e. g. Kapahi, 1978; Neff and Rudnick, 1980; Laing, 1981). This has arisen from the uncertainty of defining a hot spot as a bright region with unresolved or slightly resolved structure. Since one is interested in the linear size of a hot spot, this is not a clear definition. The present observations are sensitive to radio emission from regions smaller than 1 kpc, as mentioned earlier. Using existing synthesis maps of the Fanaroff-Riley class II 3CR sources in the present sample and assuming their core spectra to be flat we can calculate (a lower limit to) the flux density emitted by hot spots smaller than 1 kpc, at 1417 MHz, and also the quantity $F_{21}$, defined as the fraction of the total minus nuclear flux density emitted by hot spots smaller than 1 kpc. Table 3 lists the values of $F_{21}$ for the sources in common with Jenkins and McEllin (1977). We have added the FRII 3CR quasars with $1.00 \leq z \leq 1.40$ from KS, for which the same arguments held. In this Table we also list the "compactness" $C$, defined by Jenkins and McEllin (1977) as the fraction of the total flux density (excluding the central component) that originates in hot spots ($< 15$ kpc) at 178 MHz, as well as the radio power at 178 MHz (emitted frequency).

Inspection of Table 3 shows that despite the sources having similar values for their radio power, they span a range in $F_{21}$, and comparing our $F_{21}$-parameter with the $C$-parameter we find that the differences can be considerable. This may indicate that the correlation between compactness and radio luminosity for FR II sources, as found by Jenkins and McEllin (1977), depends on the definition of a hot spot.

A further conclusion is that the deficit of strong scintillators at high redshift, as reported by Hewish et al. (1974) and Readhead and Hewish (1976) can be partly due to the blending of very compact components separated by about one arcsecond in these sources. For example, 2338+042 has 38 % of its 21 cm flux density in compact components, according to the present observations, whereas Readhead and Hewish (1974) call this source a weak scintillator. According to these authors (1702+298 is a probable scintillator – the *VLBI* measurements yield 21 % compact component flux density. Furthermore, 0843+136 is not expected to scintillate much, although it contains very compact components. The cosmological implications of the IPS results (Hewish et al., 1974) should therefore be viewed with caution.

A final remark concerns the detection of two steep spectrum compact double sources: 0843+136 and 2338+042. These sources are characterized by component sizes $\lesssim 10$ mas and component separations 1″–2″ which means component dimensions $\lesssim 100$ pc, overall size 5–10 kpc and separation to size ratio 50–100. It should be noted that not all the total 21 cm flux density has been detected in the *VLBI* observations: shorter spacings are needed to locate the remaining flux density. Radio spectra of the two sources are shown in Fig. 1, and these spectra show scarcely any sign of self-absorption; in fact they are indistinguishable from the radio spectra of large QSOs such as 3C205. Subsequent high-resolution *VLA* observations (Barthel et al., in preparation) have shown that 0843+136 is indeed a 1″7 double, whereas in 2338+042 a third, low-brightness component has been detected, in addition to the 1″2 double structure.

Roland et al. (1982) have recently discussed the double morphology of some compact very steep spectrum radio sources and argued that we might be witnessing a short phase of steepening of the radio spectrum in a period when energetic electrons are not being replenished. Evidence for another class of compact double sources has been put forward by Phillips and Mutel (1982). Their compact doubles have separation of up to 50 mas ($\ll 1$ kpc) and component separation to size ratios up to 30. However, the spectra of these sources show clear evidence of self-absorption near 1 GHz, and were selected for observation on this basis. For some of these sources not all the flux density (at 1.67 GHz) comes from the compact components: for example in DA344 $\sim 25$ % of the total flux density has not been located yet (Mutel et al., 1981). In their discussion Phillips and Mutel (1982) conclude that these sources are indeed double radio sources, not near the line of sight, and in a

very early stage of evolution. During their (non relativistic) expansion the lobes should evolve and become optically thin after some time. Whether the two arcsecond double sources discovered in the experiment reported here fit into these schemes and how if they do, remains at present unclear: observations at other frequencies are needed before any firm conclusions can be drawn. Firstly, the missing flux density in the arcsecond as well as the milliarcsecond doubles should be located, and secondly, spectral information is needed for the compact components themselves. Such observations are in preparation for the arcsecond doubles.

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