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Compact radio cores in extended quasars

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Summary. A complete sample of quasars with extended radio structure and bright radio cores has been surveyed for ultra compact core components. Using a transatlantic VLBI system at 5 GHz we found a high detection rate for compact radio core components, implying linear sizes $\lesssim 10$ pc. In some quasar cores multiple component structure was detected, with separations (projected on the overall source axis) of about 10 pc.

Key words: quasars – radio structure – VLBI

1. Introduction

Because of their relative faintness, there have been few VLBI studies of the structure of compact cores associated with extended lobe-dominated radio sources. The best candidates for such studies are the cores of extended quasars, since they are stronger and more luminous on average than their counterparts in radio galaxies (see e.g. Miley, 1980). We have started a project to study the properties of these quasar cores.

There are three main grounds for this study: (1) comparison of the parsec scale with the hundreds of kiloparsec scale morphologies can give information about the evolution of extended radio sources; (2) relations between radio core sizes and properties in other wavelength bands such as optical luminosity and polarization, emission line widths etc., may be useful in studying the nature of activity in galactic nuclei; and (3) observations of the core structures at different epochs may provide tests for the different models explaining superluminal motion (Marscher and Scott, 1980) since these radio sources of large linear dimension are expected to be oriented close to the plane of the sky and hence light travel time effects should play only modest roles.

We report here on transatlantic VLBI observations of compact radio cores in a complete sample of quasars containing core emission brighter than 100 mJy (at 5 GHz) and extended radio structure. It should be noted that few statistically complete samples have been studied using the VLBI technique. Broderick and Condon (1975) and Schilizzi (1976) reported a high detection rate in their observations of compact (<20 mas[1]) component in samples of quasars and extended radio galaxies respectively. A large sample of 103 sources from the PKS $\pm 4°$ catalogue was studied by Preston et al. (1983), resulting in a high detection rate for milliarc second cores in quasars. In a VLBI survey for compact components in a complete sample of 57 flat spectrum radio sources, Zensus et al. (1984) report a dependence of compactness on the type of optical identification. An extensive mapping program is presently being carried out by Pearson and Readhead (1981, 1984) on the strongest 65 sources in the S4 and S5 catalogue.

The following sections of the paper describe in turn the source sample, the observational procedure and the results for each source. In the concluding section we discuss the implications of the observations, and indicate directions for further work.

2. The source sample

The quasars were selected from the compilation of Burbidge et al. (1978–BCS) to have the following properties: (1) $\delta(1950) > 0°$, (2) known extended radio structure, and (3) core flux density at 5 GHz > 100 mJy when measured with synthesis telescopes.

Not many bright radio cores are to be found in extended quasars mapped with synthesis instruments; we found 18 quasars satisfying the above criteria. These are listed in Table 1, together with some relevant parameters and references to 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 the radio structure according to the classification of Miley (1971), column 5 the linear size[2] of the extended structure, column 6 the total source flux density as measured with the Effelsberg (MPI) 100 m telescope during the VLBI observations and column 7 references to recent radio maps.

Our sample is certainly not complete, given the 1984 data base on quasar radio structure. For example 1218+339 (3C270.1) was not included because when the project was defined in 1979, this source was not known to contain a bright core (Stocke et al., 1982).

Some of the quasars in the sample have radio structures with galactic dimensions: 0838+133 (3C212) and 1040+123 (3C245) have overall linear dimensions smaller than 50 kpc. The quasars 0214+108, 0742+318 and 1721+343 have very large overall dimensions (>500 kpc).

3. Observations and data reduction

The observations took place between 18.00 UT on April 7, and 23.30 UT on April 8, 1981. A number of short observations, typically 3–4, each of about 15 min were made for each source at different hour angles. The frequency was 4990 MHz.

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1 mas = milliarc second

2 $H_0 = 75\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$, $q_0 = 0.5$

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Table 1. The source sample

Source	Alternative names	Redshift	Type	Linear size (kpc)[a]	5 GHz flux density (mJy)	References
0003+158	4C15.01	0.450	*T*	140	363±22	9
0214+108	4C10.06	0.408	*T*	510	400±39	9
0610+260	3C154	0.580	*T*	250	1778±95	13
0742+318	4C31.30	0.462	*T*	530	843±47[c?]	2, 10
0836+195	4C19.31	1.691	*D2*	70	170±13	6
0838+133	3C207	0.684	*T*	50	1270±76	12
0855+143	3C212	1.048	*T*	50	845±55	6, 8
0932+022	4C02.27	0.659	*D2*	270	297±24	4, 9
1040+123	3C245	1.029	*T*	45	1553±84	3, 4, 7
1047+096[d]	4C09.37	0.786	?	380?	157±10	4, 9
1055+201	4C20.24	1.110	*D2*	130	1605±82[c]	4, 11
1058+110	4C10.30	0.420	*T*	140	220±16	9, 14
1137+660	3C263	0.652	*T*	240	1100±80	9, 12
1203+109[d]	4C10.34	1.088	?	40	155±10	4, 9
1222+216	4C21.35	0.435	*T*	100	1200±61[c]	4, 10
1548+114	4C11.50	0.436	*T*	300	510±27[c]	1, 4
1618+177	3C334	0.555	*T*	250	675±37	4, 6, 9
1721+343	4C34.47	0.206	*T*	1270	800±50[b, c]	5

[a] Calculated with $H_0=75\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ and $q_0=0.5$
[b] Overall source size is 7′, which exceeds the MPI beam; flux density from ref. 5
[c] Comparison with other measurements indicates core variability – see text, Sect. 4
[d] Source has been deleted from the sample – see Sect. 4

References: 1. Argue et al. (1974); 2. Fanti et al. (1977); 3. Foley (1982); 4. Hintzen et al. (1983); 5. Jägers et al. (1982); 6. Jenkins et al. (1977); 7. Laing (1981a); 8. Laing (1981b); 9. Miley and Hartsuijker (1978); 10. Neff (1982); 11. Peacock and Wall (1982); 12. Pooley and Henbest (1974); 13. Riley and Pooley (1975); 14. Wardle and Miley (1974)

Table 2. Parameters of the interferometer array, at λ6 cm

Telescope location	Abbreviated name	Diameter (m)	T_{sys}(K)	Antenna sensitivity (K/Jy)
Effelsberg, FRG	MPI	100	80	1.55
Onsala, Sweden	Onsala	25	34	0.06
Green Bank, VA, USA	NRAO	43	70	0.27
Big Pine, CA, USA	OVRO	40	135	0.23

Baseline	rms noise level (mJy), after 4 min coherent integration
MPI–Onsala	15
MPI–NRAO	10
MPI–OVRO	15
Onsala–NRAO	35
Onsala–OVRO	50
NRAO–OVRO	35

Parameters of the interferometer array are given in Table 2, where rms noise values are given for 4 min coherent integrations.

The most sensitive baselines include the MPI 100 m telescope: 3σ noise <50 mJy after 4 min coherent integration. The measured sense of polarization on the sky was LCP.

The fringe spacings of the interferometers vary between 20 mas and 1.5 mas. Figure 1 shows the full *u–v* coverage for an hypothetical source at Dec+30°. Our observations were in fact short cuts.

The data were recorded using the standard Mk II VLBI System with 1.8 MHz bandwidth (Clark, 1973). Cross-correlation of the video tapes was carried out at the Max-Planck-Institut für Radioastronomie, Bonn, FRG. The coherently averaged correlation coefficients were calibrated according to Cohen et al. (1975), assuming the primary calibrator 0235+164 to be unresolved on the inter-European and inter-USA baselines. Corrections were applied for coherence losses for the long integration times (up to 6 min).

The experiment reported here is a repeat of observations which were originally carried out in January 1980, using the MPI, Westerbork (WSRT-phased array) and Green Bank telescopes, but most of which failed for technical reasons. However, some successful scans were obtained during the 1980 experiment, and

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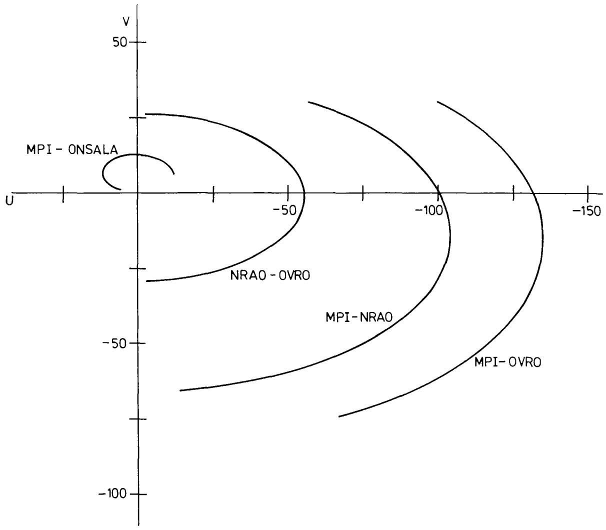

Fig. 1. Tracks in the (u, v) plane by four different baselines for an hypothetical source at Dec $+30°$

these will also be reported here. Note that MPI-WSRT is a very short but also very sensitive baseline (lobe spacing ~50 mas, rms noise ~8 mJy after 4 m in integration).

4. Results

Correlated flux densities exceeding three times the rms noise (see Table 2) were detected for most of the sources observed. The results of the observations are discussed below for each source separately. The estimated error in S_{cor} values, consisting of the root-sum-square of 0.05 S_{cor} and the rms noise on each baseline is 5–10%. Care should be taken in interpreting the S_{cor} values listed in the following, since they correspond to a limited number of (u, v) points in the resolution plane. The inferred core angular sizes correspond to the FWHM of Gaussian components. Table 3 lists the conversion of angular to linear size for the world model adopted here ($H_0 = 75\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$, $q_0 = 0.5$) and for various redshift values.

0003+158

Miley and Hartsuijker (1978) measured a 5 GHz flux density of 135±20 mJy for the core of this quasar. The quasar was detected on all but the longest baselines: $S_{cor} = 120$–150 mJy on MPI-WSRT (1980) and MPI-Onsala; 150 mJy on NRAO-OVRO; 70–100 mJy on MPI-NRAO. Resolution effects are apparent and we deduce a size of 1 mas for the radio core.

Table 3. Conversion angular – linear size ($H_0 = 75\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$, $q_0 = 0.5$)

Redshift	1 milli arc s corresponds to
0.10	1.6 pc
0.25	3.3 pc
0.50	4.7 pc
0.75	5.4 pc
1.00	5.7 pc
2.00	5.5 pc

0214+108

We detected this large quasar only on the shortest and on the most sensitive baselines: $S_{cor} = 110$–140 mJy on MPI-WSRT (1980) and MPI-Onsala; $S_{cor} \sim 70$ mJy on MPI-NRAO. Resolution effects are apparent; the size of the core is about 1 mas. Since Miley and Hartsuijker (1978) measured 100±8 mJy for the 5 GHz core flux density the core may be variable.

0610+260

Riley and Pooley (1975) measured a 5 GHz flux density of 540±50 mJy for the core of this large quasar. We find S_{cor} between 275 and 440 mJy on the MPI-Onsala baseline, between 50 and 160 mJy on the MPI-NRAO and Onsala-NRAO baselines, about 180 mJy on NRAO-OVRO and about 60 mJy on MPI-OVRO.

The 1980 experiment detected $40 \lesssim S_{cor} \lesssim 600$ mJy on MPI-WSRT. Structure on the tens of mas, as well as on the 1 mas scale is evident.

0742+318

Fanti et al. (1977) measured a 5 GHz flux density of 750 mJy for the core of this very large quasar, whereas Neff (1982) reports a 5 GHz core flux density of 644±2 mJy (measured in 1979), probably indicating variability. The present experiment detected S_{cor} between 480 and 700 mJy on MPI-Onsala, between 180 and 270 mJy on NRAO-OVRO, between 165 and 350 mJy on MPI-NRAO and Onsala-NRAO, and between 125 and 210 mJy on MPI-OVRO and Onsala-OVRO. The 1980 experiment detected $S_{cor} \sim 600$ mJy on MPI-WSRT. Variations in S_{cor} with IHA are apparent, implying structure on the mas and the tens of mas scale. Projection of the measured correlated flux densities on the axis of the overall source structure (position angle −40°) in the u–v plane reveals the presence of a minimum, suggesting a double structure along the source axis with a separation of about 2 mas (10 pc).

0836+195

Jenkins et al. (1977) report a 5 GHz core flux density of 100±20 mJy for this weak, high-redshift D2 quasar. Note that the angular size of 18″ for the source as listed by these authors is not correct. High-resolution VLA observations (Barthel et al., in prep.) yield an angular size of 14″ (80 kpc). The VLBI observations detected weak correlated flux density only on the most sensitive baselines: $55 \lesssim S_{cor} \lesssim 70$ mJy on MPI-WSRT (1980), MPI-Onsala and MPI-NRAO. The inferred angular size for this weak core is <1 mas.

0838+133

Pooley and Henbest (1974) report a 5 GHz flux density of 510±30 mJy for the core of this small quasar. The VLBI observations detected strong correlated flux densities; between 370 and 490 mJy on MPI-Onsala and MPI-WSRT (1980), ~400 mJy on NRAO-OVRO, ~300 mJy on MPI-NRAO and Onsala-NRAO and 200–240 mJy on the longest baselines (Europe-OVRO). The measured correlated flux densities indicate a core angular size of $\lesssim 1$ mas.

0855+143

Jenkins et al. (1977) measured a 5 GHz flux density of 310±50 mJy for the core of this small quasar. The present observations detected 135–175 mJy on the MPI-Onsala baseline and about 135 mJy on

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the longer baselines, and seem to indicate a somewhat resolved core component ($\lesssim 1$ mas) of ~ 175 mJy as well as ~ 150 mJy in structure on the 0.1 arc s scale.

0932+022

The 5 GHz "core" flux density of 156 ± 9 mJy as measured by Miley and Hartsuijker (1978) originates from a core-jet-structure (Hintzen et al., 1983). Assuming that the core has a flat spectrum, we expect a core flux density of about 85 mJy, as Hintzen et al. (1983) measured 83 mJy at 20 cm wavelength. The VLBI observations detected of ~ 90 mJy on MPI-Onsala and ~ 50 mJy on MPI-NRAO. The derived component size is <1 mas.

1040+123

Laing (1981a) reports core flux densities of 910 ± 90 mJy at 5 GHz and 540 ± 30 mJy at 15 GHz. Hintzen et al. (1982) find a 1.4 GHz peak flux density at the core position of ~ 1450 mJy; the core component obviously has a fairly steep spectrum: $\alpha_5^{15} = -0.5$, where $S_\nu \propto \nu^\alpha$. See also Laing (1981a). High-resolution observations at 408 MHz have shown that the source has a compact triple structure (Foley 1982). The VLBI observations yielded detections on all baselines: 640 mJy on MPI-WSRT (1980), 250–400 mJy on MPI-Onsala, 300–350 mJy on NRAO-OVRO, 170–280 mJy on MPI-NRAO and Onsala-NRAO and about 100 mJy on MPI-OVRO. Structure on the mas as well as tens of mas scale is apparent.

1047+096

Miley and Hartsuijker (1979) measured a 5 GHz core flux density of 122 ± 7 mJy in this weak D2 quasar. The high-resolution map obtained by Hintzen et al. (1983) shows complicated structure, and it is not at all clear if and how the components are physically related. In the present observations we only made two marginal detections on the most sensitive baseline: $S_{cor} \sim 25$ mJy on MPI-NRAO. The source has not been included in further work on the sample.

1055+201

The 5 GHz core flux density as measured by Miley and Hartsuijker is 608 ± 30 mJy. Peacock and Wall (1982) measured 430 ± 60 mJy at 2.7 GHz and Hintzen et al. (1983) measured 303 mJy at 1.4 GHz for this component. The VLBI observations resulted in strong detections on all baselines: 990 mJy on MPI-WSRT (1980) and 800–950 mJy on the other baselines. These observations seem to indicate an inverted radio spectrum as well as variability for the quasar core. The angular size of the core is certainly smaller than 1 mas. Measured variations in the overall source flux density (Miley and Hartsuijker, 1978; Kühr et al., 1980, Table 1) also reflect the core brightening.

1058+110

This quasar contains a weak core, with 5 GHz flux density 96 ± 6 mJy (Miley and Hartsuijker, 1978). The source was not detected in the present observations, putting limits of 30–40 mJy on any correlated flux density. The core, however, shows extended structure on the arcsecond scale, and has a steep radio spectrum (Wardle and Miley, 1974).

1137+660

Miley and Hartsuijker (1978) measured a 5 GHz core flux density of 162 ± 8 mJy, whereas Pooley and Henbest (1974) report 130 ± 20 mJy. The VLBI observations indicate some mas structure: S_{cor} between 150 and 190 mJy on MPI-WSRT (1980) and MPI-Onsala, ~ 190 mJy on NRAO-OVRO, 125–190 mJy on MPI-NRAO and Onsala-NRAO, and 100–145 mJy on MPI-OVRO.

1203+109

High resolution observations (Hintzen et al., 1983) show that the radio structure of this quasar is more complicated than suggested by Miley and Hartsuijker (1978). The Miley and Hartsuijker "core" flux density of 147 ± 7 mJy corresponds to the entire radio source. As Hintzen et al. (1983) detected a 1.4 GHz flux density of 347 mJy the source has a steep radio spectrum: $\alpha_{1.4}^{5} = -0.7$ ($S_\nu \propto \nu^\alpha$). The VLBI observations detected weak correlated flux density: about 50 mJy on MPI-WSRT (1980) and MPI-Onsala, probably reflecting the mas-scale core in this quasar. The source has been deleted from the sample.

1222+216

The core of this quasar has an inverted radio spectrum: the peak flux density measured at 1.4 GHz by Hintzen et al. (1983) is 480 mJy, whereas Neff (1982) finds 630 ± 22 mJy at 1.6 GHz and 825 ± 5 mJy at 4.9 GHz. Its large scale radio structure is strongly curved (Hintzen et al., 1983). The radio core has brightened from 675 ± 34 mJy (Miley and Hartsuijker, 1978), measured in 1973/74 to 825 ± 5 mJy (Neff, 1982) measured in 1979. The measured variations in overall source flux density (Miley and Hartsuijker, 1978; Kühr et al., 1980, Table 1) also reflect this core brightening. The VLBI observations indicate the presence of a bright radio core that is likely to be unresolved (<1 mas): an S_{cor} between 550 and 600 mJy is detected on all baselines. Since the total source flux densities reported here (Table 1) and in Neff (1982) are in good agreement, about 225 mJy should reside in core structure on the 0.1 arc s scale.

1548+114

After some controversy as to the identification of the radio source (4C11.50) it has become clear that the source is associated with a $z = 0.436$ quasar (Argue et al., 1974; Hintzen et al., 1983). The 5 GHz core flux density measured with the Cambridge 5 km telescope is 225 mJy (Argue et al., 1974). The peak flux density at 1.4 GHz is 125 mJy (Hintzen et al., 1983). The VLBI measurements have detected considerably higher core flux densities. On the shorter baselines (MPI-Onsala, NRAO-OVRO) we measured $270 \lesssim S_{cor} \lesssim 340$ mJy; on the transatlantic baselines correlated flux densities of about 250 mJy were detected, indicating mas structure. These observations indicated an inverted spectrum as well as variability for the core. The measured variations in overall source flux density (Argue et al., 1974; Kühr et al., 1980, Table 1) also reflect the core brightening.

1618+177

Jenkins et al. (1977) measured a 5 GHz core flux density of 170 ± 20 mJy for this quasar; Miley and Hartsuijker (1978) measured 150 ± 20 mJy. The 1.4 GHz core flux density is 134 mJy (Hintzen et al., 1983 – peak flux density in their map). The VLBI observations yielded correlated flux densities between 90 and 110 mJy on the sensitive baselines to MPI, showing that the core of this quasar consists of an unresolved (<1 mas) component with a flux density of about 100 mJy, and about 50 mJy in structure on the 0.1 arc s scale.

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Table 4. Results

Quasar	VLBI core		Missing core flux density	Notes
	size	flux density[a]		
0003+158	~1 mas	150 mJy	–	–
0214+108	1 mas	140	–	–
0610+260	mas structure	440	~160[b] mJy	–
0742+318	mas structure	740	–	1?, 2
0836+195	<1 mas	70	–	–
0838+133	$\lesssim$1 mas	490	–	–
0855+143	$\lesssim$1 mas	175	~150	5
0932+022	$\lesssim$1 mas	90	–	–
1040+123	mas structure	400	500[c]	3, 5
1055+201	<1 mas	950	–?	1, 4
1058+110	resolved	<50	50–100	3, 5
1137+660	mas structure	190	–	–
1222+216	<1 mas	600	225	1, 4, 5
1548+114	~mas structure	340	–	1, 4
1618+177	<1 mas	110	~ 50	5
1721+343	mas structure	375	–	1, 2

[a] Highest S_{cor} on MPI – Onsala baseline
[b] Has been detected on MPI – WSRT (1980) baseline
[c] Of which 250 mJy has been detected on MPI – WSRT (1980) baseline

Notes
1. Core flux density variable
2. Optical polarization variable (Stockman et al., 1983)
3. Steep core spectrum
4. Inverted core spectrum
5. Core structure on 0.1–1 arc s scale (see Sect. 4)

1721+343

Jägers et al. (1982) detected 440±30 mJy at 5 GHz in the radio core of this largest known quasar, and noticed 5 GHz core brightening. The VLBI observations reported here detected significant variations of correlated flux density with hour angle on all baselines; resolution effects as well as mas structure are apparent. On the shorter baselines (MPI-WSRT (1980), MPI-Onsala, NRAO-OVRO) S_{cor} between ~100 and ~375 mJy was detected and on the transatlantic baselines between about 100 and 200 mJy. Projection of the measured correlated flux densities on the axis of the overall source structure (p.a. −17°) in the u–v plane revealed the presence of a minimum, suggesting a double structure along the source axis, with separation of about two mas (6 pc).

5. Discussion

The results of our observations for the revised sample of 16 quasars are summarized in Table 4. We have listed the inferred angular sizes for the milli arc s core component(s), the flux density originating in the VLBI core (highest S_{cor} as measured on MPI-Onsala baseline, with fringe spacing of ~15 mas), the missing core flux density (compare Sect. 4) and some notes on other properties of the sources.

Although one is interested in the linear rather than the angular size of the quasar cores, Table 3 shows that for the quasars in the present sample the conversion to linear size for $q_0=0.5$ is almost redshift independent: 1 mas corresponds to a few parsec. Inspection of Table 4 shows that for most of the quasars observed, the VLB interferometers detected all the core flux density, indicating that these quasar cores have linear sizes on the order of, or smaller than 10 pc. Our detection rate is in agreement with the results obtained by Preston et al. (1983) on sources from the PKS ±4° catalogue. Previous studies (Riley and Jenkins, 1977; Miley and Hartsuijker, 1978) have shown that the core flux density fraction for quasars is, on average, an order of magnitude higher than for radio galaxies; the present observations show that these quasar cores have sizes comparable with the dimension of the optical broad line region (Osterbrock, 1984).

For the sources for which reasonably good u–v coverage was obtained and mas structure was detected, the S_{cor} values tend to be highest when observing the source with baselines perpendicular to the overall source axis. This indicates that the parsec scale nuclear structure is well aligned with the large-scale outer structure. This has also been observed previously in the cores of several radio galaxies having extended large scale structure (see e.g. Preuss, 1983).

The main result of the work reported here are therefore the *common occurrence* of parsec scale cores, in several cases *well aligned* with the large scale radio structure in extended quasars.

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It is appropriate here to stress the major differences between isolated compact radio sources and the compact cores of extended radio sources considered in the present study. Isolated compact radio sources are usually associated with quasars or BL Lac objects and are nearly all variable in flux density. Their radio spectra, being usually flat, undulating or inverted, are generally believed to be due to opacity variations in a small number of distinct components. In many cases the source structures as well as the flux density behaviour are complex, and the relation between source structure and variability is not at all clear (Kellermann and Pauliny-Toth, 1981). In the case of the cores of large, extended quasars possible relations between core structure, variability and other properties might be simpler, since the structure appears to be linear on the various scales.

For some of the quasar cores for which we detected structure on the mas (10 pc) scale, variations in radio flux density as well as in optical polarization have been reported. Careful monitoring of a large sample of cores in extended quasars might discover relations between the development of pc-scale radio structure and other core properties, and hybrid maps obtained over a period of several years may show us the evolution of nuclear radio structure. We note that 1055+201 is a good candidate for such a monitoring project; the core of this quasar recently brightened by about 50%, but no change in the core structure has yet been seen. If this is caused by time delay and/or insufficient resolution, observations in forthcoming years should detect the development of mas structure.

A correlation between the emission line widths and the presence of extended radio structure in quasars has been discovered by Miley and Miller (1979). We have tried to correlate recent measurements of emission line widths with the inferred core angular sizes, but due to the small sample size and the scarcity of optical data results are inconclusive. Variations in optical luminosity have been reported for many of the quasars in our sample – see the m_v values as listed in BCS or in the more recent Hewitt and Burbidge (1980) Catalog. Therefore we were also not able to correlate the optical luminosity with the inferred angular sizes. We expect nevertheless that a careful comparison of an enlarged VLBI data set with the above mentioned parameters can contribute useful information to our understanding of quasars, and we intend to pursue such a study.

A good correlation between core spectrum steepness and radio power has been found for steep-spectrum cores in extended radio galaxies (Bridle and Fomalont, 1978; Fomalont et al., 1980); the greater the radio power, the steeper the spectrum. In contrast, Saikia (1981) has noted that quasars as a class show more scatter in the α–P plane than radio galaxies. The one steep-spectrum quasar core in our sample, 3C245 (1040+123) is a good example of this; its core spectrum is too flat given its large radio power.

Finally, we stress the need to (i) enlarge this sample, and (ii) investigate detailed structures for several quasars studied here. We have begun programs to accomplish both of these aims. In particular, VLBI mapping programs of several of these quasar cores are in progress.

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