REDSHIFT DISTRIBUTIONS OF STEEP AND FLAT-SPECTRUM RADIO QUASARS AND RELATIVISTIC BEAMING

V.K.Kapahi
T.I.F.R. Centre, P.B. No. 1234, Bangalore 560012, India

V.K.Kulkarni
Radio Astronomy Centre (TIFR), P.B. No. 8
Ootacamund 643001, India

ABSTRACT. Redshift distributions of almost complete samples of steep as well as flat-spectrum radio quasars are investigated. It is found that flat-spectrum (core-dominated) quasars contain a higher fraction of high redshifts ($z \gtrsim 1.4$) compared to steep-spectrum ones. The difference can be understood in the 'unified scheme' in which the two types of quasars differ only in the orientation of their jet axes with respect to the observer.

At high redshifts most of the radio quasars are found to be of the flat-spectrum core-dominated variety (see e.g. Barthel, this Volume, p.181). Although it was suggested by Kraus & Gearhart (1975) and Pacht (1976) that high redshifts are found preferentially in quasars with a 'centimetre excess' spectrum, it has not been possible to confirm this result (e.g. Wills & Lynds 1978) for lack of large and complete samples of steep and flat-spectrum quasars. Recent availability of deep optical identifications and spectroscopy now makes it possible to compare the redshift distributions of almost complete samples of the two types selected from strong and intermediate flux density surveys at high frequencies.

We consider quasars from the following flux limited samples that are near-complete with regard to spectral classification and redshifts, and contain a reasonably large number of sources

1. The SGPS (South Galactic Pole Strong) sample of the 63 sources selected from the Parkes 2.7 GHz surveys that have $\alpha_{5.0}^{2.7} < 0.5$ ($S_\nu \propto \nu^{-\alpha}$); $22^h < RA < 05^h$; $-30° < \delta < -4°$ and $S_{2.7} \geq 0.5$ Jy (Condon et al. 1978; Wright et al. 1983). Identification and spectroscopic data for the corresponding sample of steep-spectrum sources in the region are much less complete. We have therefore compared the z-distribution of the flat-spectrum SGPS sample with that for quasars in the 3CR sample (Laing et al. 1983), which has roughly the same sensitivity limit for steep-spectrum sources ($\alpha \sim 1$).
2. The All-Sky sample of Wall & Peacock (1985;WP) with $S_{2.7} \geq 2$ Jy.
3. The PR sample (Pearson & Readhead 1984) of 65 sources selected from the S4 and S5 NRAO-MPIfR surveys at 5 GHz, and defined by $S_5 \geq 1.3$ Jy; $\delta > 35°$. Some additional redshifts for this sample have been reported recently by C.R.Lawrence et al. (1985, OVRO preprint).

G. Swarup and V. K. Kapahi (eds.), Quasars, 207–210.

Table 1. Numbers of flat-spectrum and steep-spectrum quasars.

Sample	Flat-Spectrum ($\alpha < 0.5$)			Steep-Spectrum ($\alpha > 0.5$)		
	Total	Unknown z	$z \geq 1.4$	Total	unknown z	$z \geq 1.4$
SGPS;$S_{2.7} \geq 0.5$ Jy	35	0 (+8 EFs)	17(49%)			
3CR;$S_{178} \geq 10$ Jy				39	2(+6 EFs	8(20%)
WP-All Sky; $S_{2.7} \geq 2$ Jy	45	7(+1 EF)	13(29%)	26	3(+5 EFs)	2(8%)
PR;$S_5 \geq 1.3$ Jy	20	4(+1 EF)	7(35%)	7	0(+1 EF)	0

The statistics about quasars in these samples are summarized in Table 1 and the z-distributions are shown in Figures 1, 2 and 3. In all the three samples the distributions appear to extend to higher redshifts for the flat-spectrum quasars compared to the steep-spectrum ones. The fraction of quasars with $z > 1.4$, which is considerably higher for the flat spectrum quasars is indicated in Table 1

The occurrence of higher redshifts among flat-spectrum quasars could partly be responsible for some large scale inhomogeneities in the sky distributions of high-redshift quasars reported in the literature (e g. Shastri & Gopal-Krishna 1983; Arp 1984), because quasar identifications and spectroscopy in some areas of the sky are based largely on surveys at low frequencies and in some regions on surveys at high frequencies (see Kapahi, this volume, p.511)

The different z distributions could of course arise if the two populations are physically quite distinct, with different luminosity functions and/or different evolutionary behaviour with cosmic epoch. It is interesting, however, to see if the distributions are consistent with the predictions of the 'unified scheme' of Orr & Browne (1982), based on the relativistic beaming scenarios of Scheuer & Readhead (1979) and Blandford & Konigl (1979). In this scheme the flat spectrum quasars are normal double quasars seen almost end-on. In order to check this we assume that quasars in a low frequency survey, such as the 3CR, are unbiased with regard to orientation, and have the following average values for the parameters describing relativistic beaming in their cores :

$$R_T \text{ (5 GHz emitted)} = 0.024; \quad \alpha_c = 0; \alpha_e = 0.9 \text{ and } \gamma = 4.7$$

Here R_T is the ratio of the flux density in the core to that in outer lobes (assumed to be moving nonrelativistically) when the jet axis is transverse to the line of sight ; α_c and α_e are the spectral indices of the core and outer lobes respectively and γ is the Lorentz factor in the core. The above values were found by Orr & Browne to provide the best fits to the observed proportions of flat-spectrum quasars in flux limited samples at different frequencies. The only other information required to determine the z-distributions for both steep-spectrum (defined to have $\alpha_{2.7}^{5} > 0.5$) and flat-spectrum ($\alpha_{2.7}^{5} < 0.5$) quasars in flux limited samples selected at different frequencies is the radio luminosity function (RLF) at different epochs. We have used the local RLF given by Fanti & Perola (1977) for $q_0 = 1$ and simple evolution functions of the type $\rho(z) \propto \rho(z{=}0)\, e^{m(1-t/t_0)}$, where (t_0-t) is the look back time). An effective cutoff in redshift is also required in order to limit the number of quasars with very high redshifts.

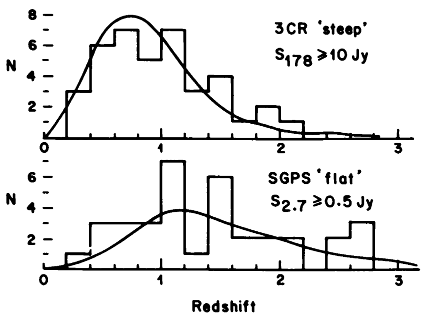

Figure 1.

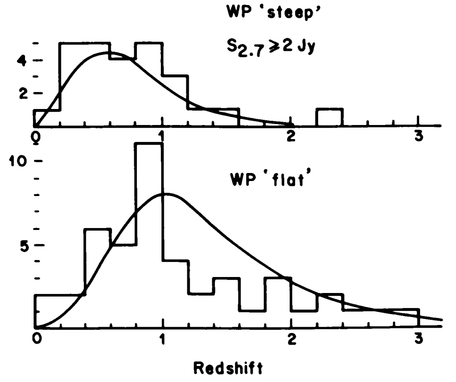

Figure 2.

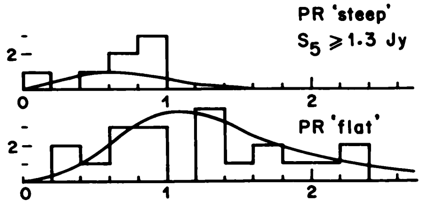

Figure 3.

Figs. 1,2 & 3 show distributions of the observed redshifts of quasars in different samples. Curves are predictions of the 'unified scheme'

A value of m=10 together with an exponential redshift cutoff function of the form $e^{-(z-1)}$ for z > 1 was found to give a reasonable fit (see figures 1 to 3) not only to the shapes of the redshift distributions but also to the total numbers of quasars observed in the areas of the sky covered by the different samples. Note that in our calculations the only normalization of the amplitude of the local RLF has been done by fitting the observed and predicted number of quasars in the 3CR sample.

We conclude therefore that the observed redshift distributions of flat and steep spectrum quasars in high frequency surveys provide additional support to the 'unified scheme'.

References

Arp,H. 1984, Ap.J. **277**, L22
Blandford,R.D., Konigl,A. 1979, Ap.J., **232**, 34
Condon,J.J., Jauncey,D.L., Wright,A.E. 1978, A.J., **83**, 1036
Fanti,R., Perola,G.C. 1977, in 'Radio Astronomy and Cosmology' (ed.) D.L.Jauncey, D.Reidel, p 171
Kraus,J.D., Gearhart,M.R. 1975, A.J., **80**, 1
Laing,R.A., Riley,J.M., Longair,M.S. 1983, M.N.R.A.S., **189**, 433
Orr,M.J.L., Browne,I.W.A. 1982, M.N.R.A.S., **200**, 1067
Pacht,E. 1976, A.J., **81**, 574

Pearson,T.J., Readhead,A.C.S. 1984, in 'VLBI and compact Radio Sources' (eds. R.Fanti, K.Kellermann & G.Setti), D.Reidel, p 15
Shastri,P, Gopal-Krishna 1983, J.Astrophys.Astron., **4**, 109
Wall,J.V., Peacock,J.A. 1985, M.N.R.A.S., **216**, 173
Wills,D., Lynds, R. 1978, Ap.J.Supp., **36**, 317
Wright,A.E., Ables,J.G., Allen,D.A. 1983, M.N.R.A.S., **205**, 793
Scheuer,P.A.G., Readhead,A.C.S. 1979, Nature, **277**, 182

DISCUSSION

Barthel : Given possible large redshifts in the samples the K corrections can be considerable. You have therefore to be careful in using spectral indices over 2.7 & 5 GHz. I do agree however that you have proven that beaming plays a role.

Kapahi : We have for simplicity assumed constant spectral indices α_e and α_c . The resulting K corrections are of course included in the calculations.

Kuhr : Deep CCD and IR observations of a complete sample of EF sources with flat spectra from our 1 Jy catalogue indicate that these source can be identified with radio galaxies, QSOs and BL Lac objects of about equal numbers. The objects are probably not EFs because of very high redshifts, but because they all have "cut-off" spectra, i.e., they look like the rest of the sources between radio and IR but their flux drops steeply towards the optical.

https://doi.org/10.1017/S0074180900152696 Published online by Cambridge University Press