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Relation between Radio Polarization and Spectral Index of Blazars

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Abstract. University Michigan RAdio Observatory (UMRAO) supply many radio photometries and polarimetries. We select a sample of 81 blazars from UMRAO and analyse the correlations between their spectral index and polarizations. Out of 35 BL Lacs and 46 FSRQs in the sample, 8 and 15 show strong correlation.

Key words. Galaxies—blazars—generally—correlative coefficient.

1. Introduction

Blazars are a very special class of extragalactic objects showing some special properties, including rapid variability, high and variability polarization, high luminosity and superluminal motion, etc. Their optical variability timescales can cover a range of hours to years from radio to γ-rays (Fan *et al*. 2004; Ulrich *et al*. 1997).

When we analyse the different characters of blazars, spectral index (α) is very important. Based on the flat spectrum ($|\alpha| < 0.5$), FSRQs can be defined. A good correlation between the spectral index and the accretion rate has been found (Zhang *et al*. 2008). The long-term spectral variability show quasi-periodicity (Yuan & Fan 2010, 2011).

Radio polarization of blazars are dominated by the synchrotron emission. The polarization provide important information about the structure of the magnetic field in the jet (Angel & Stockman 1980). The polarization show short and long term variabilities (Kochanev & Gabuzda 1998; Yuan 2011).

This paper is arranged as follows: in section 2, spectral index and results are presented, and in section 3, discussion and conclusions are presented.

2. Spectral index and results

Our samples come from UMRAO (University of Michigan RAdio Astronomy Observatory database), which contains more than 100 blazars. For these sources, we use the averaged flux densities at three frequencies (4.8, 8 and 14.5 GHz), and the relation between the spectral index and flux density($F_\nu \propto \nu^\alpha$) to obtain the spectral index (α).

We choose 81 blazars (35 BL Lacs and 46 FSRQs), with extensive data on their spectral index α to analyse the correlation ($r_{\alpha \mathrm{P}}$) between spectral index and

Table 1. The relation between the spectral index (α) and polarization/flux density (1).

IAU name (1950)	z	Type	$p_{\alpha P}$ (%)	$r_{\alpha P}$	$p_{\alpha F}$ (%)	$r_{\alpha F}$
$0003-066$	0.347	BL	<0.01	−0.559	<0.01	0.827
$0007+106$	0.09	FSRQ	3.9	−0.667	0.18	0.531
$0016+731$	1.781	FSRQ	<0.01	−0.429	<0.01	0.83
$0048-097$	0.2	BL	<0.01	0.003	<0.01	0.573
$0106+013$	2.107	FSRQ	<0.01	−0.051	<0.01	0.589
$0109+224$	0.265	BL	<0.01	−0.365	<0.01	0.394
$0133+476$	0.859	FSRQ	<0.01	−0.313	<0.01	0.494
$0202+149$	0.833	FSRQ	<0.01	0.036	<0.01	0.743
$0212+735$	2.367	FSRQ	<0.01	−0.457	<0.01	0.755
$0215+015$	1.721	BL	<0.01	−0.667	<0.01	0.68
$0219+428$	0.444	BL	<0.01	0.359	<0.01	0.922
$0234+285$	1.21	FSRQ	<0.01	−0.069	<0.01	0.702
$0235+164$	0.94	BL	<0.01	−0.146	<0.01	0.464
$0300+470$	0.475	BL	<0.01	0.191	<0.01	0.761
$0306+102$	0.863	FSRQ	<0.01	0.444	<0.01	0.718
$0316+413$	0.0172	FSRQ	<0.01	0.092	<0.01	−0.007
$0333+321$	1.258	FSRQ	<0.01	−0.485	<0.01	0.745
$0336-019$	0.852	FSRQ	<0.01	−0.481	<0.01	0.764
$0355+508$	1.52	FSRQ	<0.01	−0.564	<0.01	0.28
$0420-014$	0.915	FSRQ	<0.01	−0.151	<0.01	0.51
$0422+004$	0.31	BL	<0.01	−0.34	<0.01	0.622
$0430+052$	0.033	FSRQ	<0.01	−0.572	<0.01	0.624
$0518+165$	0.759	FSRQ	<0.01	−0.008	<0.01	0.386
$0528+134$	2.06	FSRQ	<0.01	−0.336	<0.01	0.723
$0552+398$	2.365	FSRQ	<0.01	−0.216	<0.01	0.966
$0607-157$	0.323	FSRQ	<0.01	−0.458	<0.01	0.416
$0716+714$	0.3	BL	<0.01	−0.122	<0.01	0.772
$0735+178$	0.424	BL	<0.01	0.08	<0.01	0.677
$0754+100$	0.266	BL	<0.01	−0.26	<0.01	0.147
$0804+499$	1.436	FSRQ	<0.01	−0.745	<0.01	0.591
$0814+425$	0.53	BL	<0.01	−0.049	<0.01	0.81
$0818-128$		FSRQ	0.016	0.559	0.02	0.533
$0829+046$	0.174	BL	<0.01	−0.179	<0.01	0.279
$0836+710$	2.172	FSRQ	<0.01	−0.45	<0.01	0.929
$0838+133$	0.6808	FSRQ	0.045	0.633	0.044	0.866
$0851+202$	0.3056	BL	<0.01	−0.238	<0.01	0.722
$0906+430$	0.67	FSRQ	0.015	0.247	0.016	0.798
$0917+624$	1.446	FSRQ	<0.01	−0.316	<0.01	0.647
$0954+658$	0.368	BL	<0.01	−0.587	<0.01	−0.007
$0957+227$	0.418	BL	0.13	−0.886	0.14	0.856
$1040+123$	1.028	FSRQ	0.016	−0.259	0.016	−0.108
$1055+018$	0.89	BL	<0.01	−0.051	<0.01	0.939
$1101+384$	0.03	BL	<0.01	−0.317	<0.01	0.596
$1127-145$	1.184	FSRQ	<0.01	−0.427	<0.01	0.798
$1147+245$	0.2	BL	0.045	−0.506	0.045	0.288
$1156+295$	0.724	FSRQ	<0.01	−0.413	<0.01	0.774

polarization. We use the linear correlation to analyse the correlation ($r_{\alpha F}$) between spectral index and flux density. The results have been listed in Tables 1 and 2. From Tables 1 and 2, we find that 8 BLs and 15 FSRQs show strong $r_{\alpha P}$, 23 blazars show strong $r_{\alpha P}$ and $r_{\alpha F}$. Most of the $r_{\alpha P}$ show negative correlation, and most of the $r_{\alpha F}$ show positive correlation. We give an example: for $1226+023$, $r_{\alpha F} = -0.88$ and $r_{\alpha F} = 0.95$ (see Fig. 1).

If we calculate the absolute values of $r_{\alpha P}$ and $r_{\alpha F}$, we can find that, for most of the blazars, $r_{\alpha F} > r_{\alpha P}$ and $r_{\alpha P}$ show weak correlation (see Fig. 2).

Table 2. The relation between the spectral index (α) and polarization/flux density (2).

IAU name (1950)	z	Type	$p_{\alpha P}$ (%)	$r_{\alpha P}$	$p_{\alpha F}$ (%)	$r_{\alpha F}$
$1215+303$	0.13	BL	0.016	−0.221	0.016	0.741
$1219+285$	0.102	BL	<0.01	−0.224	<0.01	0.097
$1226+023$	0.158	FSRQ	<0.01	−0.872	<0.01	0.929
$1253-055$	0.536	BL	<0.01	0.125	<0.01	0.902
$1308+326$	0.996	BL	<0.01	0.029	<0.01	0.376
$1328+307$	0.849	FSRQ	<0.01	−0.145	<0.01	0.83
$1358+624$	0.431	FSRQ	0.045	−0.024	0.042	0.925
$1413+135$	0.2467	BL	<0.01	−0.218	<0.01	0.839
$1418+546$	0.152	BL	<0.01	−0.073	<0.01	0.583
$1510-089$	0.36	FSRQ	<0.01	−0.041	<0.01	0.609
$1538+149$	0.605	BL	<0.01	−0.391	<0.01	0.756
$1611+343$	1.397	FSRQ	<0.01	−0.423	<0.01	0.937
$1633+382$	1.814	FSRQ	<0.01	−0.261	<0.01	0.312
$1641+399$	0.593	FSRQ	<0.01	−0.211	<0.01	0.66
$1642+690$	0.751	FSRQ	<0.01	0.262	<0.01	0.217
$1652+398$	0.034	BL	<0.01	0.458	<0.01	0.386
$1741-038$	1.054	FSRQ	<0.01	−0.14	<0.01	−0.205
$1749+096$	0.322	BL	<0.01	−0.427	<0.01	0.647
$1749+701$	0.77	BL	<0.01	−0.603	<0.01	0.414
$1803+784$	0.68	BL	<0.01	0.177	<0.01	0.143
$1823+568$	0.664	BL	<0.01	−0.151	<0.01	0.754
$1901+319$	0.635	FSRQ	<0.01	−0.422	<0.01	0.578
$1921-293$	0.352	FSRQ	<0.01	0.135	<0.01	0.516
$1928+738$	0.302	FSRQ	<0.01	−0.242	<0.01	0.918
$2005+403$	1.736	FSRQ	<0.01	0.042	<0.01	−0.125
$2007+777$	0.342	BL	<0.01	−0.055	<0.01	0.732
$2121+053$	1.941	FSRQ	<0.01	−0.286	<0.01	0.308
$2131-021$	1.285	BL	<0.01	0.369	<0.01	0.561
$2134+004$	1.932	FSRQ	<0.01	−0.186	<0.01	0.445
$2145+067$	0.99	FSRQ	<0.01	−0.188	<0.01	0.177
$2155-304$	0.116	BL	<0.01	0.075	<0.01	0.559
$2200+420$	0.0686	BL	<0.01	−0.07	<0.01	0.539
$2223-052$	1.404	FSRQ	<0.01	−0.243	<0.01	0.796
$2230+114$	1.037	FSRQ	<0.01	−0.271	<0.01	0.944
$2251+158$	0.859	FSRQ	<0.01	−0.328	<0.01	0.761

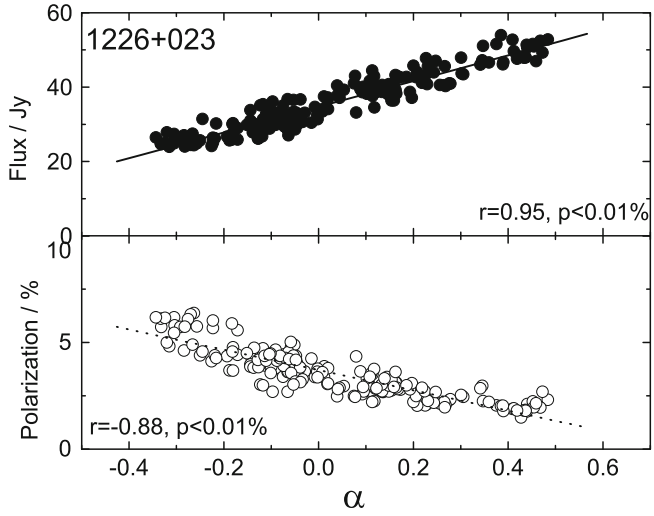

Figure 1. *Upper panel*: Scatter plot of spectral index (α) and flux at 14.5 GHz for object 1226 + 023. *Lower panel*: Open circle for the same source. There are strong positive and negative correlations in the upper and lower panels, respectively.

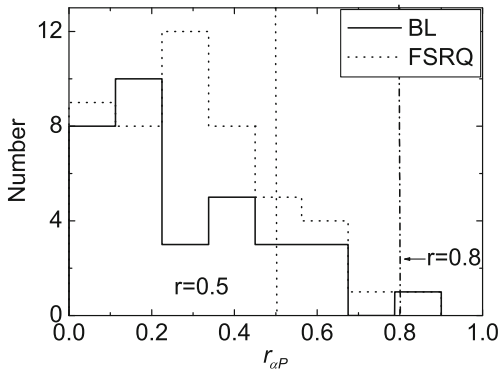

Figure 2. The distribution of the absolute correlative coefficient $|r_{\alpha P}|$ for the two subclasses. Most of the blazars show weak correlation.

3. Discussion and conclusions

The radio flux and polarization of blazars are generally dominated by the synchrotron emission. Correlations between the flux and polarized variations have been observed in a number of blazars, such as Mrk 421 (Tosti *et al*. 1998), AO0235 + 164 (Hagen-Thorn *et al*. 2008), OJ287 and 3C279 (Yuan 2012). The spectral index are calculated from the flux, so they have tight correlations, which also appear in Table 1 (see $r_{\alpha F}$).

Here we find that most blazars in our sample show negative α-polarized correlation and positive α-flux correlation. In particular, there are 8 BL Lacs and 15 FSRQs that show strong correlations for α-polarization.

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