

A COMPARISON OF THE X-RAY SPECTRA OF QUASARS AND BL LAC OBJECTS

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1. INTRODUCTION AND ANALYSIS

Quasars with similar core-compact radio properties can be classified by their differences at optical and infrared frequencies. Their X-ray properties might be expected to be similar if the synchrotron self-Compton mechanism relates their radio and X-ray emission. We have compared the 0.2–3.5 keV mean power-law energy spectral indices, $\bar{\alpha}$, for 4 quasar classes: 12 Highly Polarized QSOs (HPQs), 19 Flat Radio Spectrum, core-compact, low-polarization, QSOs (FRS QSOs), 24 radio-selected BL Lac objects, and 7 X-ray-selected BL Lac objects.

The data were taken from the *Einstein Observatory* Imaging Proportional Counter (IPC) data bank. We included all the HPQs, FRS QSOs, and BL Lac Objects observed on axis with sufficient counts ($\gtrsim 80$) to allow determination of the IPC gain and spectral fitting. We assumed a power-law spectrum with energy index α for each source, and computed the probability distribution of α with normalization and N_H (column density of intervening Galactic matter) as free parameters. Multiple observations of the same source were fit simultaneously. The exception was the X-ray-selected BL Lac object 2155-304: the only source for which separate observations were inconsistent with a constant spectral index.

Maximum likelihood analysis was used to find the best-fit mean power-law spectral index, $\bar{\alpha}$, and standard deviation, σ , for each class, assuming the intrinsic distribution is Gaussian.

$$\text{Model Distribution} = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(\alpha - \bar{\alpha})^2}{2\sigma^2}\right)$$

2. RESULTS

Results for the HPQs and FRS QSOs are similar, with best-fit mean indices of $\bar{\alpha} \approx 0.5$, whereas for the radio-selected and X-ray-selected BL Lac objects, $\bar{\alpha} \approx 1.0$. Our individual spectral fits for the brightest sources are consistent with those previously published (*e.g.*, Madejski 1985; Wilkes and Elvis 1987). The brightest FRS QSOs fit $N_H < \text{galactic } N_H$ in agreement with Wilkes and Elvis (1987) who infer the presence of soft excess emission. Some sources require $N_H > \text{galactic } N_H$.

Our results are dominated by the brightest sources in each class, but there is no strong evidence that their spectral parameters differ from the weaker sources. For the HPQs, the weakest 10 sources and strongest 2 sources provide approximately equal weights to the results. For the FRS QSOs and radio-selected BL Lac objects the corresponding numbers are 17 and 2, and 18 and 6, respectively.

The HPQs, FRS QSOs, and radio-selected BL Lac objects are consistent with $\sigma = 0$ (see results

in Figure 1). The Kolmogorov-Smirnov (KS) significance level needed to reject the hypothesis of a constant α , and the significance levels when every source is fit to its best-fit α are:

	Constant α	Best-Fit α
19 FRS QSOs	$\alpha = 0.5$ 41%	64%
12 HPQs	$\alpha = 0.5$ 46%	30%
24 Radio-selected BL Lac objects	$\alpha = 1.0$ 22%	48%

In contrast, the X-ray-selected BL Lac objects are *inconsistent* with a single spectral index. The result is *not* given entirely by the discrepant measurements of 2155-304.

8 X-ray-selected BL Lac objects	$\alpha = 1.1$ 4%	41%
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The KS-test results for fits to each source's best-fit α show that a single-component power-law model is acceptable for the sources in all 4 samples.

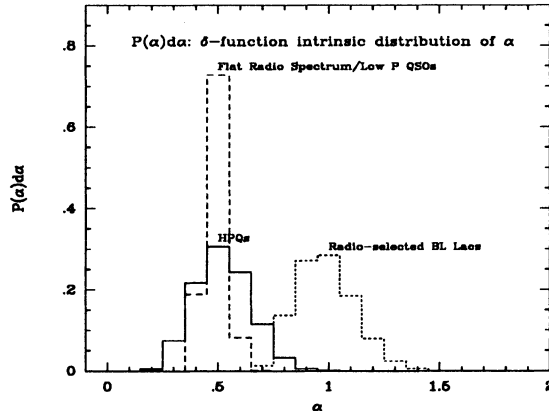


Figure 1. The probability distributions of α for the special case of a constant intrinsic α for each sample ($\sigma = 0$).

3. DISCUSSION

BL Lac objects and HPQs display broadly similar continuum spectra from the radio to X-ray wave bands, and they are often treated together in statistical studies under the name ‘Blazar’. However, we have found that their X-ray spectral indices are different on average. This is an intriguing result, but does not necessarily violate a strong connection between the broadband continuum emission of BL Lac objects and QSOs. For example, while superluminal radio components have been detected in members of each class, there is evidence that BL Lac objects are less relativistically beamed at X-ray than radio frequencies (*e.g.*, Maraschi *et al.* 1986). This may indicate a reduced level of 0.2–3.5 keV Compton radiation in the BL Lac objects with respect to the HPQs and FRS QSOs, and then may explain the difference in X-ray spectral indices.

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References

Madejski, G.M. 1985, Ph.D. Thesis, Harvard University.
 Maraschi, L., Ghisellini, G., Tanzi, E.G., and Treves, A. 1986, *Astrophys. J.*, **310**, 325.
 Wilkes, B.J. and Elvis, M. 1987, *Astrophys. J.*, **323**, 243.