

A MULTI-WAVELENGTH STUDY OF X-RAY SELECTED AGN

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1. Observations

A sample of Active Galactic Nuclei (AGN) have been discovered during a program to identify the optical counterparts of X-ray sources detected by the Modulation Collimator experiment of the High Energy Astronomy Observatory-1 (HEAO-1). UV-excess techniques were used to identify the X-ray sources (Remillard *et al.* 1986) and the details of the identifications are given elsewhere (Remillard *et al.* 1988, Brissenden *et al.* 1988). We report here the preliminary results of a multi-wavelength study of these new AGN.

The majority of the sample, comprised of 17 Seyfert 1 galaxies, 5 BL Lac objects and 4 QSOs were observed with the VLA during 1988 May 4 or 7, at both 20 cm and 6 cm with the C array in "snapshot" mode. Two additional QSOs observed and detected by Parkes at 3.6 cm and the Fleurs Synthesis Telescope at 20 cm were also included. All but two Seyfert 1 galaxies and two QSOs were detected at 6 cm with the VLA (all detections being greater than 5σ above the background rms noise). None of the objects were resolved with a typical resolution of $4'' \times 7''$ at 6 cm. The mean 6-20 cm spectral index α ($f_\nu \propto \nu^{-\alpha}$) was flatter for the BL Lac objects (0.2) than the Seyfert 1 galaxies and QSOs (0.7).

2. Broadband Spectral Indices

We take continuum points in the X-ray, optical and radio spectral regions at 2 keV, 2500 Å and 6 cm respectively and form the indices α_{ro} and α_{ox} (Tananbaum *et al.* 1983). The radio flux at 6 cm is taken directly from the VLA results except for the two southerly QSOs where the value is interpolated from the 20 cm and 3.6 cm data. The optical flux at 2500 Å was calculated from the B magnitude using the zero magnitude calibration of Allen (1973), a galactic reddening correction and an assumed power law between 4400 Å and 2500 Å of $\alpha = 1.0$ for the Seyfert 1 galaxies and QSOs and $\alpha = 2.0$ for BL Lac objects. The correction for galactic reddening was derived from $A_V = 0.18 * \text{cosec}(b)$ where b is the galactic latitude (Schmidt 1968), a ratio of total to selective absorption of 3.2 and $A_\lambda = 4.09 * E(B-V)$ for $\lambda = 4400$ Å (Seaton 1979). The monochromatic 2 keV X-ray flux was calculated from the 2-10 keV LASS count rate (Wood *et al.* 1984) using a conversion factor of 0.0021 and 0.0027 per $10^{-11} \text{erg cm}^{-2} \text{s}^{-1}$ for Seyfert 1 galaxies (and QSOs) and BL Lac objects respectively. The assumed X-ray power law for Seyfert 1 galaxies and QSOs was $\alpha = 0.7$ and for BL Lac objects was $\alpha = 1.2$. The data are presented in Figure 1.

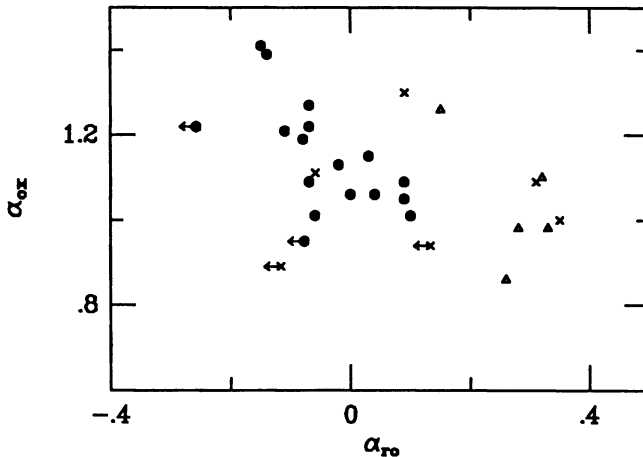


Figure 1. Broadband spectral indices from radio (6 cm) to optical (2500 Å) and optical to X-ray (2 keV) continuum points. Seyfert 1 galaxies, QSOs and BL Lac objects are represented by filled circles, crosses and open triangles respectively. 3σ upper limits given.

3. Results and Discussion

The high detection rate of these X-ray observed AGN with the VLA, allows us to specify their location in the α_{ro} - α_{ox} plane. The BL Lac objects lie in a separate, well defined region of Figure 1 ($\langle \alpha_{ro} \rangle = 0.27 \pm 0.07$, $\langle \alpha_{ox} \rangle = 1.04 \pm 0.15$; the error is the dispersion about the mean) coincident with other X-ray selected BL Lac objects and having flatter overall spectra than radio selected BL Lac objects. The mean redshift of the Seyfert 1 galaxies (QSOs) is 0.05 ± 0.03 (0.19 ± 0.07) with mean B magnitude of 15.67 ± 0.88 (16.41 ± 0.65). They are characterized by very flat optical-radio spectra with $\langle \alpha_{ro} \rangle = -0.03 \pm 0.08$ (0.17 ± 0.19 ; for detections) and steeper optical-X-ray spectral index $\langle \alpha_{ox} \rangle = 1.15 \pm 0.13$ (1.06 ± 0.15). The mean values of α_{ro} and α_{ox} are very similar to mean values for optically selected Seyfert 1 galaxies (QSOs). We note that the spectral index and luminosity distribution of the present sample coincide with the hard (2-10 keV) selected sample of Piccinotti *et al.* (1982) but that the mean redshift is higher and mean B magnitude is fainter. Finally, the 2 keV X-ray luminosity and 4.9 GHz radio luminosity are found to correlate for the Seyfert 1 galaxies but no correlation is found between the fluxes. No luminosity correlation is seen for the small number of QSOs and BL Lac objects in the sample.

4. References

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