SOFT X-RAY SPECTRA OF AGN DISCOVERED

VIA THEIR HARD X-RAY

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The subject of this study were Active Galactic Nuclei (AGN) which were first discovered via their hard (1 – 10 keV) X-ray emission, and identified by the scanning modulation collimator experiment on the first High Energy Astronomy Observatory (HEAO-1). From all of these, we selected those with less than 3×10^{20} H-atoms per cm^2 in the line of sight through our galaxy, and which were at low ecliptic latitudes for observations with the ROSAT position sensitive proportional counter (PSPC). This detector enabled us to make spectral measurements from 0.2 to 2 keV. We were seeking spectral information over a broad energy range which would relate to the question of how important a contribution to the diffuse X-ray background arose from AGN.

Our proposal was awarded a mix of Category B and Category C targets. Ultimately 9 objects were observed, of which eight AGN had sufficient counts for detailed spectral study. We analyzed the spectra according to two prescriptions. The first, standard method, was to fit a single power law. It was previously known that exact power law fits to AGN spectra gave results which were too steep to allow AGN to make up the diffuse X-ray background, which had a flatter spectral shape. Thus in the second method we fit a log-Gaussian shape which flattened toward higher energies. Such a shape had been previously suggested by Schwartz and Tucker (1988) to resolve the above "spectral paradox."

The spectral results were very diverse. Some sources gave spectral fits which preferred the pure power law, while others required a log-Gaussian (as compared to a pure power law) shape. We presented these results as paper 35.06 at the 181st AAS meeting. The Abstract was published in BAAS, vol 24, p1173 and is as follows:

> "ROSAT Spectra of AGN Selected by Their hard X-ray Emission"
>
> D. A. Schwartz, P. Zhao (CfA), R. Remillard (MIT)
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> We have performed ROSAT observations of AGN which were first discovered via their hard (1 – 10 keV) X-ray emission. We selected objects identified by the scanning modulation collimator (MC), from the NRL Large Area Sky Survey catalog, at galactic latitudes greater than 20 degrees, and galactic hydrogen column density $< 3 \times 10^{20}$. We have received data from observations of nine of these objects. We will report on their soft X-ray spectral shape, and on confirmation of the HEAO-1 identifications. We are especially motivated to test the hypothesis of Schwartz and Tucker that the AGN energy spectra do not have exact power laws, but exhibit constant flattening with energy. We describe a novel adaptation of the PROS software to allow us to perform fits to a Log-Gaussian spectral shape. This research was supported in part by NASA grant NAG5-1884.

We also found several bright, interesting, serendipitous AGN and clusters of galaxies in our ROSAT fields. Papers on these were presented at the 182nd AAS meeting, and abstracts published in the BAAS, vol 25, 811:

> ROSAT Observations of an AGN with an Extremely Steep X-ray Spectrum
>
> D. A. Schwartz, P. Zhao (SA0), R. A. Remillard (MIT)
>
> The Scanning Modulation Collimator (MC) experiment on the first High Energy Astronomical Observatory (HEAO-1) has produced two candidate identifications

for the bright hard X-ray source 1H0122-281. ROSAT observations of this field suggest Ton S210, at z=0.114, as the HEAO-1 identification. However, the second candidate, RXJ0119.6-2821, at z=0.351, has an extremely steep spectrum, with a fit to the energy index of alpha = 3.0. Another newly discovered AGN at z=0.434 gives the more conventional spectrum of alpha = 1.2, while Ton S210 shows alpha = 1.7. The two more distant quasars are fit to intrinsic absorption about 40% more than the nominal galactic value of 1.6×10^{20} cm^{-2}. This research was supported in part by NASA grant NAG5-1884.

and vol 25, 837:

X-ray Spectra and Structures of 7 Clusters of Galaxies

Ping Zhao, D. A. Schwartz (SAO), R. A. Remillard (MIT)

We have studied the soft X-ray spectra and spatial structures of 7 clusters of galaxies, using our ROSAT PSPC data. The 7 clusters, 6 of them listed in the (Abell, Corwin, Olowin 1989) catalog, have redshifts ranging between 0.07 and 0.17. Three of them are located within a one degree cone and are in the same PSPC frame. This is advantageous for fitting their X-ray spectra because the hydrogen column density can be determined more accurately. The X-ray emissions fit well with thermal bremsstrahlung spectrum. The cluster surface brightness radial profiles were fitted to a hydrostatic-isothermal gas model. The gas temperatures, core radii and energy per unit mass ratio between galaxies and gas were determined based on the spectral and spatial fits. Using these fitting parameters, central density, luminosity and velocity dispersion of each cluster can be calculated. Our study agrees with previous results that the intracluster gas has a larger scale height than that of the galaxies, implying that there is more energy per unit mass in the gas than in the galaxies. This research was supported in part by NASA grant NAG5-1884.

Because of the great diversity of spectral shapes, it did not seem that our small sample of objects could be used for any general conclusions on the contribution of AGN to make up the diffuse X-ray background. Instead we took note that the ROSAT fluxes which we measured deviated widely (factor of ten) from each other, in contrast to the hard X-ray fluxes which were within a factor of two (being near the faint limit of the HEAO-1 instruments). We have followed the consideration of how one converts broad band measured fluxes into intrinsic emitted luminosity of the source, in other work we are doing on an investigation funded by Project JOVE. In that work we have applied maximum likelihood methods to derive the evolutionary luminosity function of the X-ray selected AGN in the Einstein Extended Medium Sensitivity Survey. A paper on that topic has been submitted, and is pending publication subject to response to the reviewers comments.