Carnegie Observatories Astrophysics Series, Vol. 1:
Coevolution of Black Holes and Galaxies, 2004
ed. L. C. Ho (Pasadena: Carnegie Observatories,
http://www.ociw.edu/ociw/symposia/series/symposium1/proceedings.html)

XMM-Newton Survey of a Distance-limited Sample of Seyfert Galaxies

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Abstract

An unbiased estimate of the average intrinsic X-ray properties and column density distribution of Seyfert galaxies in the local Universe is crucial to validate unified models of active galactic nuclei (AGNs) and to synthesis models for the X-ray background. We present here preliminary results obtained from an on-going $XMM-Newton$ study ($\sim$250 ks awarded in the EPIC GT) on a well-defined, statistically complete, and significant sample of nearby Seyfert galaxies.

1.1 Introduction

It has become clear, after *ASCA* and *BeppoSAX* results, that X-ray observations of Seyfert galaxies are key to verifying the predictions and, thus, the validity of unified models of active galactic nuclei (AGNs). They are clearly also crucial to test the applicability of standard accretion disk theories down to the lowest ($L_B=10^8$-10^{11} $L_\odot$) nuclear luminosities.

Hard X-ray samples of nearby Seyfert galaxies available to date (e.g. from *GINGA*, *ASCA* and *BeppoSAX*; Smith & Done 1996, Turner et al., 1998, Bassani et al. 1999) have been necessarily biased towards the most X-ray luminous, and less absorbed AGNs. However, studies by Maiolino et al. (1998) and Risaliti, Maiolino and Salvati (1999) suggest the existence of a large fraction ($\gtrsim$50-60%) of highly obscured AGNs in the local Universe. Other recent studies by Ho et al. (2001) with *Chandra* have made possible, for the first time, the detection of point-like nuclear sources in a large sample of nearby galaxies at unprecedented low luminosities (down to less than 10^{38} erg/s), and such studies seem to suggest that the standard unified model for Seyfert galaxies (Antonucci 1993) may not hold down to these very low luminosities.

With the aim of sorting out the questions raised by the above observations, here new results obtained with the EPIC CCDs on-board $XMM-Newton$ are presented. We are now completing a survey of all known northern Seyfert galaxies with D<22 Mpc using the Revised-Ames Catalog of Bright Galaxies (Sandage & Tamman 1981) spectroscopically classified by Ho, Filippenko & Sargent (1997). The final sample contains 28 galaxies (see Table 1 in Cappi et al., 2002) and is the deepest and most complete local sample of Seyfert galaxies in the optical energy band. Compared to previous studies, the strenght of using $XMM-Newton$ rests on two main facts: its high-throughput (especially at E>2 keV) allows to search spectral components with absorption columns up to $N_{\rm H} \sim 10^{22}$-10^{24} cm^{-2}, and its spatial resolution (HPR$\simeq$7 arcsec) allows to minimize any strong contamination from off-nuclear sources to the soft (E< 2 keV) and/or hard (E>2 keV) energy band.

1.2 Spectral Analysis: Preliminary Results

About 250 ksec of EPIC Guaranteed Time (Di Cocco et al., 2000) have been given to our team to perform this survey. To date, 20 out of 28 Seyfert galaxies have been observed, and the data analyzed. Exposures of 5, 10, 15 and 20 ks, were requested in order to obtain $\sim$1000 source counts per galaxy. Spectra were fitted using data from the 3 CCD detectors (MOS1, MOS2 and PN) simultaneously. Data were fitted between 0.3-10 keV for MOS1/2 and between 0.5-10 keV for the PN.

Every spectrum has been fitted using a set of standard models: a single power-law model with Galactic absorption plus either i) free absorption, or ii) a warm-absorber, or iii) a single soft-scattered component, or iv) a single soft thermal component, or v) a scattered plus thermal soft component. We then added a narrow FeK emission line if detected. Six examples of such spectra are shown in Figures 1.1, 1.2 and 1.3 to illustrate the data available and some of our early results. Best-fit spectra and model parameters will be reported elsewhere (Cappi et al., in preparation).

Figure 1.1 shows two examples of Seyfert 1.5 galaxies (NGC5273 and NGC3227) that do have significant ionized absorption (with ionized columns equivalent to $\sim$ 1 and 7 $\times$ 10^{22} cm^{-2}, respectively). Figure 1.2 shows two examples of Seyfert 2 galaxies (NGC4725 and NGC4168) that do not have significant absorption in excess of the Galactic value. Figure 1.3 (left) illustrates a case of an underluminous Seyfert 2 galaxy ($L_{2-10{\rm keV}} \sim 5 \times 10^{38}$ erg/s, to be compared to an expected value, based on the observed $L_{H\alpha}$, that is $\sim$ 40 times larger). Figure 1.3 (right) shows the single clear case (NGC3079) yet in our sample of a Compton thick source, that is evidenced by the strong FeK line (with EW$\sim$1.9$\pm$0.5 keV).

In addition to the high-quality $XMM-Newton$ images available, we also checked the *Chandra* snapshot observations (available for 12 sources out of the 20 analyzed yet) to check for possible bright off-nuclear point sources that may have contaminated the $XMM-Newton's$ spectra. We estimate that off-nuclear point-sources and/or diffuse emission may contaminate both the soft and hard emission in less than $\sim$ 1/5$^{\rm th}$ of the sources, while up to $\sim$ 1/3$^{\rm rd}$ of the sources could be contaminated in the soft band only. Further work is under way to quantify and take this effect into account in the scientific analysis.

1.3 Conclusions

Results so far obtained can be summarized as follows:

i) Three out of the five Seyfert 1/1.5 present in the sample do show heavy ($\sim$$10^{22}$ cm^{-2}) ionized absorption in X-rays, in agreement with what found also in higher-luminosity type 1 AGNs (e.g. Reynolds 1997).

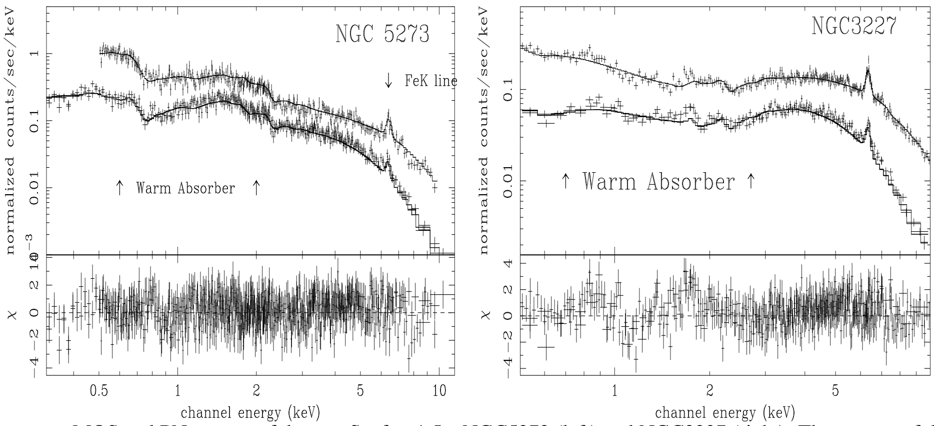

Fig. 1: MOS and PN spectra of the two Seyfert 1.5s: NGC5273 (left) and NGC3227 (right). The spectra of these type-1 sources illustrate the effects of a strong warm absorber in these sources.

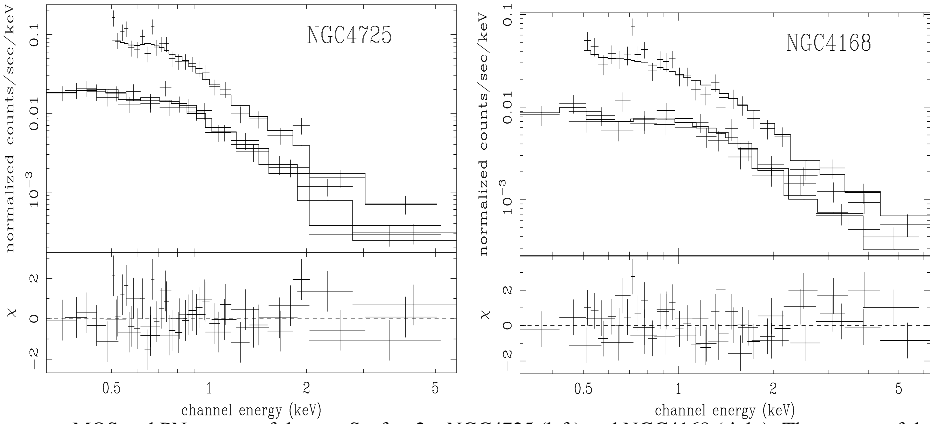

Fig. 2: MOS and PN spectra of the two Seyfert 2s: NGC4725 (left) and NGC4168 (right). The spectra of these type-2 sources illustrate well the lack of any absorption in these sources.

ii) Most Seyfert $1.9/2$ are underluminous in X-rays with respect to what expected from their H_{α} luminosities (Cappi et al., in preparation), in agreement with what was found by Ho et al. (2001) and Terashima et al. (2000).

iii) Most Seyfert 1.9/2 do not show neither strong absorption, nor strong FeK lines. In some sources, the low absorption could be due to the extra contribution in soft X-rays from nearby off-nuclear sources. We estimate however that this effect is not relevant in the majority of the cases studied so far. The possibility that such sources might be Compton-thick appears also unlikely given the absence of a strong FeK line (except for NGC3079). If confirmed, these results appear to be in contrast with the simplest version of unified models.

Correlation of X-ray data with emission at other wavelengths and statistical properties of the whole sample are under-way.

References

Antonucci, R. R. J. 1993, ARA&A, 31, 473

Bassani, L., Dadina, M., Maiolino, R., Salvati, M., Risaliti, G., Della Ceca, R., Matt, G., & Zamorani, G. 1999, ApJS, 121, 473

Cappi, M., et al. 2002, astro-ph/0202245

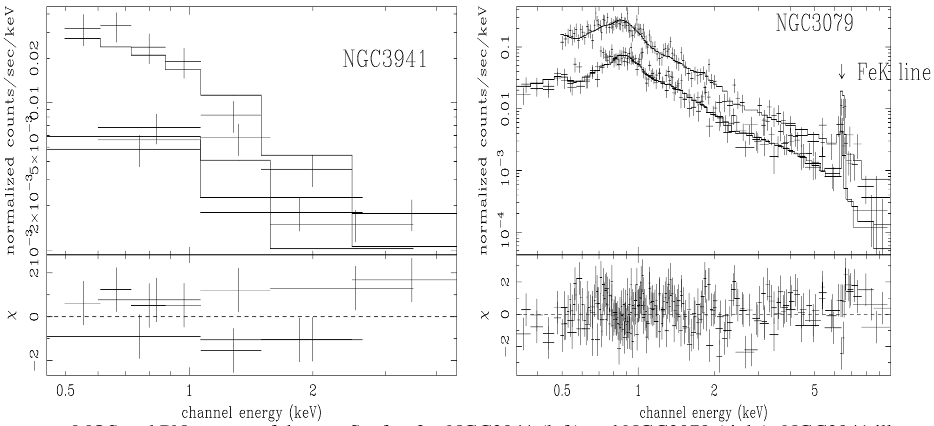

Fig. 3: MOS and PN spectra of the two Seyfert 2s: NGC3941 (left) and NGC3079 (right). NGC3941 illustrates the case for the source with lowest luminosity of our sample (and very underluminous with what expected from its H_α luminosity) and NGC3079 the case for a Compton-thick source (see the strong FeK line detected).

Di Cocco, G., Cappi, M., Trifoglio, M., Gianotti, F., & Stephen, J. 2000, HEAD, 32, 04.05

Ho, L. C., et al. 2001, ApJ, 549, L51

Ho, L. C., Filippenko, A. V., & Sargent, W. L. W. 1997, ApJS, 112, 315

Maiolino, R., Salvati, M., Bassani, L., Dadina, M., Della Ceca, R., Matt, G., Risaliti, G., & Zamorani, G. 1998, A&A, 338, 781

Reynolds, C. S. 1997, MNRAS, 286, 513

Risaliti, G., Maiolino, R., & Salvati, M. 1999, ApJ, 522, 157

Sandage, A. R., & Tammann, G. A. 1981, Revised Shapley-Ames Catalog of Bright Galaxies (RSA)

Smith, D. A., & Done, C. 1996, MNRAS, 280, 355

Terashima, Y., Ho, L. C., Ptak, A. F., Yaqoob, T., Kunieda, H., Misaki, K., & Serlemitsos, P. J. 2000, ApJ, 535, L79

Turner, T. J., George, I. M., Nandra, K., & Mushotzky, R. F. 1998, ApJ, 493, 91