PROBING LOCAL SEYFERT GALAXIES: CONSISTENT WITH UNIFIED MODELS, BUT NOT WITH STANDARD ACCRETION?

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ABSTRACT

Results obtained from an X-ray survey of a complete sample of Seyfert galaxies using XMM-Newton and Chandra are reported. The sample, which has been selected from the Palomar optical spectroscopic survey of nearby galaxies (Ho et al. 1997), covers a wide range of nuclear power from $L_{2-10keV} \sim 10^{42}$ erg/s down to very low luminosities ($L_{2-10keV} \sim 10^{37}$ erg/s). A high fraction of Compton thick sources has been identified (>30%), confirming previous studies. After taking into account the effect of heavy absorption, we have found that the X-ray and multiwavelength properties of our sources are consistent between type 1 and type 2 Seyferts, as expected from 'unified models', and consistent with those of brigther AGNs, with exceptions at a $\sim$ 10% level. However, when we consider black hole mass estimates, it appears that Seyferts are accreting at very low Eddington ratios which are more typical of ADAF-like regimes, rather than of radiative efficient accretion.

Key words: X-rays:galaxies; galaxies: Seyfert.

1. INTRODUCTION

The fundamental paradigm on which our understanding of AGN activity is based is the accretion onto a supermassive black hole. In the last decades, unification of different classes of AGN has been based on orientation of the line of sight. It has been shown that X-ray observations of Seyfert galaxies are key to verifying the predictions and, thus, the validity of unified models of AGN. Several studies seem to suggest that the standard unified model for Seyfert galaxies (Antonucci 1993) may not hold down to very low luminosities (Ho et al. 2001, Panessa & Bassani 2002). Fundamental parameters, such as black hole mass, Eddington ratio, and perhaps the black hole spin, might help in the comprehension of the whole AGN phenomenon. By studying the X-ray properties, their correlation to other wavebands and to black hole masses of a sample of nearby Seyfert galaxies, we aim at testing the applicability of unification models and verifying standard accretion disk theories down to the lowest (L_B=10^8-10^{11} $L_\odot$) nuclear luminosities.

2. STARTING POINT: XMM-NEWTON SURVEY OF A DISTANCE LIMITED SAMPLE OF 27 SEYFERT GALAXIES

An X-ray spectral survey has been performed on a well defined sample of Seyfert galaxies taken from Ho, Filippenko & Sargent (1997, hereafter HFS97) using *XMM–Newton* (Cappi et al. 2005). The optically selected sample is complete in B magnitude and distance limited: it consists of the nearest (D $\leq$ 22 Mpc) 27 Seyfert galaxies (9 of type 1, 18 of type 2). Hard X-ray nuclear spectra have been assembled for all the sources except two Seyfert 2s which are not detected between 2 and 10 keV. Nuclear luminosities reach values down to 10^{38} erg s^{-1}. A high fraction of Compton-thick (CT) objects ($\geq$ 30% among type 2s) affects the shape of the distribution of X-ray parameters. CT sources have been identified either directly from their intense FeK line and flat X-ray spectra, or indirectly with flux diagnostic diagrams which use isotropic indicators. A correction factor has been applied to the column density and X-ray luminosity values of the identified CT 'candidates'. After taking into account these highly absorbed sources, we find that the intrinsic X-ray spectral properties (i.e., spectral shapes and luminosities above 2 keV) are consistent between type 1 and type 2 Seyferts, as expected from "unified models". The column density distribution (see Fig.1) shows that Seyfert galaxies as a whole are distributed fairly continuously over the entire range of $N_{\rm H}$, between 10^{20} and 10^{25} cm^{-2}, and while Seyfert 1s tend to have lower $N_{\rm H}$ and Seyfert 2s tend to have the highest, we find 30% and 10% exceptions, respectively.

With the exception of a few cases, the average instrinsic properties of nearby Seyfert galaxies are consistent with predictions of 'unified models' of Seyfert galaxies and extend their validity down to low luminosities.

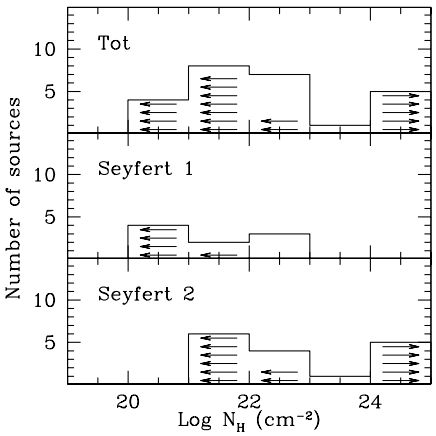

Figure 1. Column density distribution after correction for Compton thick candidates (Cappi et al. 2005). Upper and lower limits are indicated with arrows.

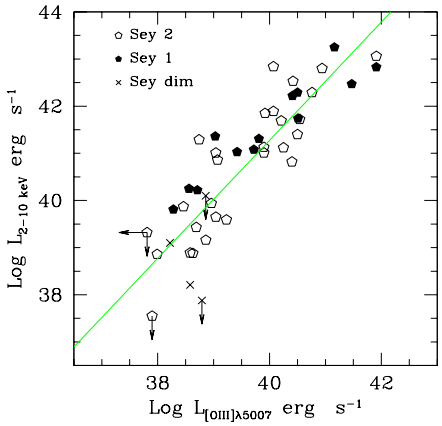

Figure 2. 2-10 keV luminosity versus [OIII] luminosity corrected for Galactic and NLR extinction. The solid line shows the best fit linear regression line (Panessa et al. in prep.)

3. EXTENDED SAMPLE: XMM-NEWTON & CHANDRA SURVEY OF A COMPLETE SAMPLE OF 60 SEYFERT GALAXIES

The X-ray spectral analysis has also been performed on the extended version of the Cappi et al. (2005) Seyfert sample: all the sources classified as Seyferts galaxies in the HFS97 sample have been selected without limitations in distance. The total sample of 60 Seyfert galaxies includes, 39 type 2 (type 2, 1.8 and 1.9), 13 type 1 (type 1.0, 1.2, 1.5) and 8 "dim Seyferts"[1]. Nuclear X-ray spectra have been obtained using both *Chandra* and *XMM–Newton* observations. Similarly to Cappi et al. (2005), we have investigated the issue related to the distribution of the absorption among objects in our sample. The fraction of identified CT 'candidate' objects ranges from 20% up to 50% in good agreement with Cappi et al (2005).

To verify the physical continuity between our sample and bright AGNs, the X-ray luminosities have been correlated with the H$_\alpha$ and the [OIII]λ5007 luminosities, which are both often considered to be absorption independent quantities and good tracers of the nuclear emission. Both L_X vs. L_{H_α} and L_X vs. $L_{[OIII]}$ correlations are highly significant in our sample (see Fig.2), expecially when the Cappi et al. (2005) correction factor is applied to the X-ray luminosities of Compton thick 'candidates', indicating that a common nuclear process is involved in the production of multi-wavelength radiation. Both correlations scale with luminosity, i.e. they have similar slopes to those of more powerful objects (Ho et al. 2001). It is therefore likely that low-luminosity Seyfert galaxies are powered by the same physical processes which operates in brighter AGNs such as QSOs.

Black hole masses estimates are available for 44 objects from literature. They have been obtained from gas, stellar and maser kinematics, or from reverberation mapping.

[1]Objects in which the Seyfert classification was not dominant but still present (L2/S2, H/S2 or T2/S2) have been included in the present sample.

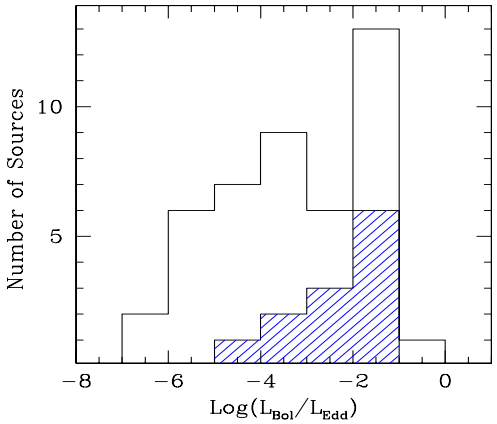

Figure 3. Distribution of the bolometric luminosity (derived using the conservative assumption that $L_{Bol}/L_X \sim 30$) over the Eddington luminosity. Type 1 Seyfert's distribution is marked with a shaded area.

No correlation is found between X-ray or optical emission and black hole masses. A large range of accretion rates is present (see Fig.3). Surprisingly, these sources are accreting at very low accretion rates (down to $\sim 10^{-7}$) which are more typical of ADAF-like regimes than of Standard Accretion Disk regime. Possible explanations will be discussed in a forthcoming paper, Panessa el al. in prep.

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