BLACK HOLE MASSES AND EDDINGTON RATIOS OF AGNS CONTRIBUTING MOST OF THE XRB

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ABSTRACT

The discovery of relationships between the masses of the local supermassive black holes and their spheroidal host components has revealed a connection between the formation and evolution of galaxies and the formation and growth of supermassive black holes. To gain insight into this process we have investigated the properties of a sample of X-ray selected active nuclei and of their host galaxies in the framework of the Great Observatory Origins Deep Survey. Here we present the results of a morphological and photometric analysis of the ACS-HST images in four bands, based on bidimensional deconvolution. Our findings on black hole masses, nuclear bolometric luminosities and Eddington ratios indicate that these systems are already formed objects in which we see a renewal of low level activity, in an environment poor of gas.

Key words: Active Galactic Nuclei; X-ray background.

1. INTRODUCTION AND SAMPLE SELECTION

Recent deep surveys have resolved most of the $2-10$ keV X-ray background (XRB), showing that it is produced by a mixture of obscured and unobscured Active Galatic Nuclei (AGNs) with a redshift distribution peaking at $z \sim 0.7$. To investigate the galaxy evolution in the redshift domain in which a major fraction of the black hole (BH) mass observed in the local universe is expected to be accreted, we began studying the nuclear activity of a sample of AGNs at redshift between 0.4 and 1.

The starting point is the deep high-resolution optical imaging performed in the F435W (B), F606W (V), F814W (i) and F850LP (z) bands with ACS onboard HST in the framework of the GOODS program (Giavalisco et al., 2004). X-ray sources are selected by cross-correlating the GOODS optical catalogs with the CDFS and the HDFN X-ray catalogs (Alexander et al., 2003; Giacconi et al., 2002; Tozzi et al., 2005). To bracket the bulk of the sources making the XRB and at the same time to have a sufficient signal–to–noise ratio, we pick out only sources with spectroscopic or photometric redshift between 0.4 and 1 (Barger et al., 2003; Szokoly et al., 2004; Zheng et al., 2004). Finally, *bona fide* AGNs are selected by imposing a cut in X-ray luminosity, $L_{\text{2-8 keV}} > 10^{42}$ ergs s^{-1}. This lead to an initial sample of 74 sources.

To carry out a morphological analysis, the simultaneous availability of high-quality, non-crowded B, V, i and z ACS images is necessary. We further concentrate only on X-ray sources with *spectroscopic* redshifts. Thus, the final sample is made of 30 objects; taking into account their redshift and the luminosity distributions, we can conclude that our sample is representative of the AGNs contributing the XRB at $z \leq 1$.

2. MORPHOLOGICAL ANALYSIS

To disentangle the main galactic components for the AGNs in our sample, we carry out two-dimensional fits to galaxy profiles (performed using the image decomposition program GALFIT; Peng et al. 2002). We assume a galaxy model composed by a bulge, a disk and a nuclear source (described by a De Vaucouleur model, an exponential function and a pointlike profile, respectively).

Having images in four bands, where the three model components have different weight, we set up a three-step procedure (details will be reported in Ballo et al. 2005, in prep.). The initial guesses for the parameters are drawn from the GOODS ACS public catalog. Thus we derive magnitudes in four bands for the three galactic components.

3. AGN PROPERTIES

The information provided by the deconvolution allows us to study the nuclear activity of the analysed galaxies. Using the magnitudes of the bulge component we can estimate the **mass of the central BH**. In order to use the

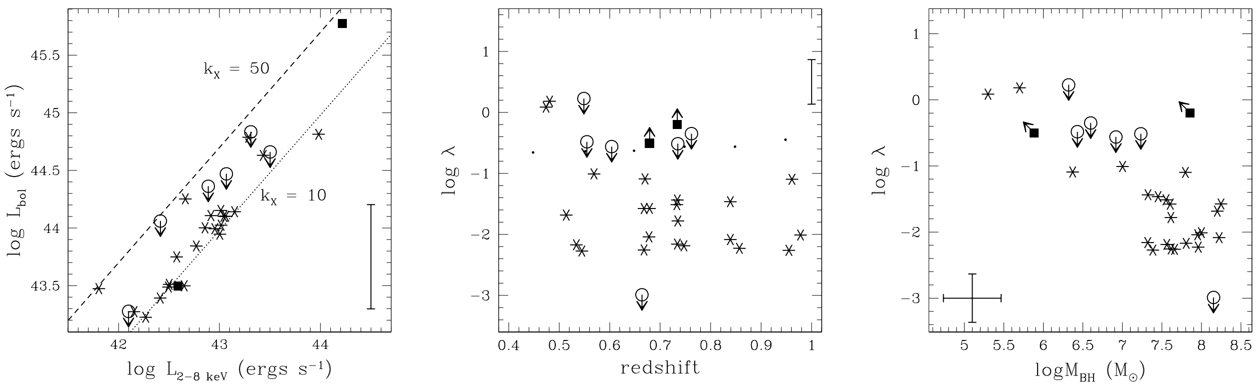

Figure 1. Distributions of derived M_{BH}, L_{bol} and λ; stars refer to sources for which we are confident that the results from the morphological deconvolution are reliable; filled squares and open circles mark nucleus–dominated and host–dominated sources, for which we can provide only upper limits on M_{BH} and L_{bol} respectively. The error bars reported represent the mean uncertainties in the derived quantities.

local $M_{R,\,\rm bulge}$–$M_{\rm BH}$ relation found by McLure & Dunlop (2002), we fit an integrated Single Stellar Population (SSP) spectrum at the redshift of the source to the deconvolved bulge magnitudes. A template of local elliptical galaxy, normalized from this fit, provides the rest-frame *evolved* R-band bulge magnitude (assuming *passive evolution*).
Fitting the nuclear SED (de-absorbed X-ray emission + deconvolved optical magnitudes) with a library of templates of type 1 AGNs for a set of X-ray–to–optical ratios (see Monaco & Fontanot, 2005) we draw the **nuclear bolometric luminosity**.

4. RESULTS

From the estimated black hole masses and nuclear bolometric luminosities, and the consequent **Eddington ratios** $\lambda = L_{\rm bol}\ [{\rm ergs\ s^{-1}}]/\left(1.3\times 10^{38} M_{\rm BH}\,[M_\odot]\right)$, we found that:

1. the ratios $k_{\rm X} = L_{\rm bol}/L_{\rm X}$ are lower than previous claims (Barger et al., 2005), but in agreement with Fabian (2004); see Fig. 1, *left panel*;
2. the Eddington ratios are lower than at higher redshift; a similar trend is also suggested by observations (even if optically selected quasars show higher mean values, see McLure & Dunlop 2004 – dots in Fig. 1, *central panel*), and proposed by Shankar et al. (2004) to match the accretion mass function and the local supermassive BH mass function.

The wide range of $M_{\rm BH}$ and the low values of λ (Fig. 1, *right panel*) suggest that we are observing a **renewal** of activity in previously formed objects. This finding is consistent with the antihierarchical behaviour already found in AGN evolution and expected on the basis of a bimodal scenario for the cosmic mass accretion history (Cavaliere & Vittorini, 2000; Granato et al., 2004).

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