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The Bright Side of the X-ray Sky: The XMM-Newton Bright Survey ⋆

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Abstract. We discuss here the main goals and some interesting results of the "XMM-Newton Bright Serendipitous Survey", a survey program conducted by the XMM-Newton Survey Science Center in two complementary energy bands (0.5-4.5 keV and 4.5-7.5 keV) in the bright (above $\sim 7 \times 10^{-14}$ erg cm^{-2} s^{-1}) flux regime. The very high identification rate (96%) for the X-ray source sample selected in the 4.5-7.5 keV energy range is used here to have an "unbiased view of the extragalactic X-ray sky in this energy domain and at the sampled fluxes.

Key words. Diffuse X-ray Background – X-ray surveys– Active Galactic Nuclei

1. Introduction

Deep *Chandra* and *XMM–Newton* observations (Brandt et al. 2001; Rosati et al. 2002; Moretti et al. 2003; Hasinger et al. 2001; Alexander et al. 2003; Brandt and Hasinger 2005) have recently resolved more than ∼ 80% of the 2–10 keV cosmic X-ray background (CXB) into discrete sources down to $f_x \sim 3{\times}10^{-16}$ erg cm^{-2} s^{-1}. The X–ray data (stacked spectra and hardness ratios) of these faint samples are consistent with AGN being the dominant contributors of the CXB and, as inferred by the X–ray colors, a significant fraction of these sources have hard, presumably obscured, X–ray spectra, in agreement with the predictions of CXB synthesis models (Setti and Woltjer 1989; Comastri et al. 2001; Gilli et al. 2001; Ueda et al. 2003).

However, the majority of the sources found in these medium to deep fields are too faint to provide good X–ray spectral information. Furthermore, the extremely faint magnitudes of a large number of their optical counterparts make the spectroscopic identifications very difficult, or even impossible, with the present day ground–based optical telescopes. Thus, notwithstanding the remarkable results obtained by reaching very faint X–ray fluxes, the broad–band physical properties (e.g. the re-

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⋆ The XMM-Newton Bright Serendipitous Survey is part of the follow-up program being conducted by the XMM-Newton Survey Science Center (SSC, see http://xmmssc-www.star.le.ac.uk.), an international collaboration involving a consortium of 10 institutions, appointed by ESA to help the SOC in developing the software analysis system, to pipeline process all the XMM-Newton data, and to exploit the XMM serendipitous detections. The OABrera is one of the Consortium Institutes.

lationship between optical absorption and X-ray obscuration and the reason why AGN with similar X-ray properties have completely different optical appearance) are not yet completely understood. In the medium flux regime a step forward towards the solution of some of these problems has been undertaken by Mainieri et al. (2002), Piconcelli et al. (2003), Perola et al. (2004) and Mateos et al. (2005).

With the aim of complementing the results obtained by medium to deep X-ray surveys, we have built the "The XMM-Newton Bright Serendipitous Source Sample". We describe below the main characteristics of this sample and discuss some of the results obtained so far. The contribution of this project to the solution of some critical open (and "hot") questions like the relationship between optical absorption and X-ray obscuration and the physical nature of the "X-ray bright optically normal galaxies" have been already discussed in Caccianiga et al. (2004) and Severgnini et al. (2003), respectively. We stress that many of these issues are investigated with difficulties using the fainter X-ray samples because of their typical poor counts statistics available for each source.

Table 1. The current optical breakdown of the BSS and HBSS Samples

	BSS	HBSS
Objects[1]	389	67
Area Covered (deg^2)	28.10	25.17
Identified:	308	64
Identification rate	79%	96%
AGN-1	201	38
AGN-2	29	20
Galaxies[2]	8	1
Clusters of Galaxies [3]	6	1
BL Lacs	6	2
Stars[4]	58	2

[1] Fifty-six sources are in common between the BSS and HBSS samples; [2] We stress that some of the sources classified as "Optical Normal Galaxy" could indeed host an optically elusive AGN (see Severgnini et al. 2003); [3] The source detection algorithm is optimized for point-like objects, so the sample of clusters of galaxies is not statistically complete nor representative of the cluster population; [4] All but one of the sources classified as stars are coronal emitters.

2. The XMM-Newton Bright Serendipitous Source Sample

The XMM Bright Serendipitous Source Survey, a project led at the *Osservatorio Astronomico di Brera*, consists of two flux-limited samples: the XMM BSS and the XMM HBSS sample having a flux limit of $\sim 7\times10^{-14}$ erg cm^{-2} s^{-1} in the 0.5-4.5 keV and 4.5-7.5 keV energy band, respectively. This approach was dictated by the need of studying the composition of the source population as a function of the selection band and of reducing the strong bias against absorbed sources which occurs when selecting in soft X-rays.

Two hundred and thirty-seven suitable XMM fields (211 for the HBSS) at $|b| > 20$ deg (see Della Ceca et al. 2004) were analyzed and a sample of 400 sources was selected (see Table 1 for details).

The majority of the X-ray sources have enough statistics (hundreds to thousands of counts when the data from the three EPIC detectors are considered) to allow X-ray studies in terms of energy distributions, absorption properties, source extent and flux variability. Moreover the optical counterpart of $\sim$ 90% of the X-ray sources has a magnitude brighter than the POSS II limit (R $\sim$ 21mag), thus allowing spectroscopic identification at a 2-4 meter class telescope; this fact, combined with the positional accuracy of XMM for bright sources (90% error circle of 4″) implies that, in the large majority of the cases, only one object needs to be observed to secure the optical identification.

Up to now 318 X-ray sources have been spectroscopically identified (either from the literature or from our own observations) leading to a 79% and 96% identification rate for the BSS and HBSS samples respectively (see Table 1 for a summary).

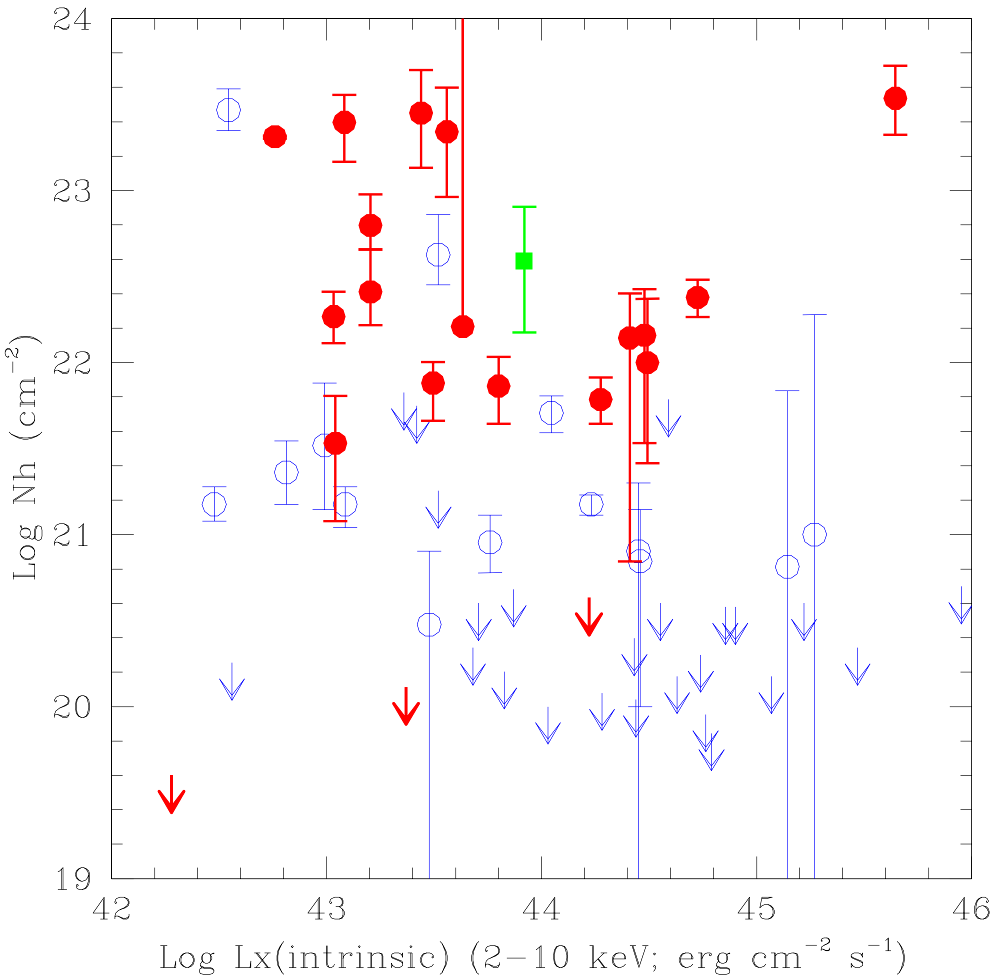

Fig. 1. Intrinsic 2-10 keV luminosity vs. absorption column densities (both quantities derived from a complete spectral analysis) for the sources belonging to the HBS sample. We have used differents symbols to mark the different objects according to their optical classification. The arrows indicated the 90% upper limit on N_H. Optically Type 1 AGN: open circles and thin arrows. Optically Type 2 AGN: filled circles and thick arrows. Optically normal galaxies: filled squares.

3. The HBSS sample

The HBSS sample is now almost completely identified (96% of spectroscopic identifications), so it can be used to have an unbiased view of the high galactic ($|b| > 20$) 4.5-7.5 keV X-ray sky in the bright flux regime. First results, based on a complete subsample of 28 objects completely identified, have been already discussed in Caccianiga et al. (2004).

We stress that an identification rate around 80% (as e.g. in the BSS sample or in other samples recently appeared in literature) could be not enough to have this unbiased view. Indeed, interesting classes of X-ray emitting sources (e.g. the narrow line AGN population), which could represent an important minority of the source population, could be more difficult to identify.

In figure 1 we show the intrinsic 2-10 keV luminosity vs. absorption column densities for the sources belonging to the HBSS sample. Both the intrinsic 2-10 keV luminosity (e.g. de-absorbed from the measured N_H at the source redshift) and the intrinsic absorption column densities have been derived from a complete X-ray spectral analysis.

As already discussed in Caccianiga et al. (2004) some hot questions could be investigated from a close inspection of figure 1, especially considering the fact that we are dealing with a well defined and complete sample which has been almost completely identified. The main results can be summarized in these points:

• we do not find a strong evidence of a large population of absorbed ($N_H > 10^{22}$ cm^{-2}) optically type 1 AGNs. We only have two objects belonging to this category, [1] i.e. about 3% of the extragalactic population and 5% of the Type 1 AGN population shining in the 4.5-7.5 keV sky and at the sampled fluxes;

• among optically type 2 AGNs about 65% are characterized by an N_H greater than 10^{22} cm^{-2}, 20% by an N_H between $10^{21.5}$ and 10^{22} cm^{-2} and 15% are apparently unabsorbed ($N_H < 10^{21.5}$ cm^{-2}). Two of the three unabsorbed sources are Seyfert 1.9;

• as already pointed out by other investigations we find a strong deficiency of the number of high luminosity ($L_x > 10^{44}$ erg s^{-1}) absorbed ($N_H > 10^{22}$ cm^{-2}) AGNs i.e. the so called type 2 QSOs. The HBSS sample list 5 type 2 QSOs with 4 of them having an absorbing column density in a narrow range between 10^{22} cm^{-2} and $\sim 3 \times 10^{22}$ cm^{-2};

• at the fluxes sampled in the HBSS the 4.5-7.5 keV selection is an efficent way to sample AGNs with absorbing column densities up to $N_H \simeq 10^{24}$ cm^{-2}. Furthermore we have no compelling evidence of $N_H > 10^{24}$ cm^{-2} for the three optical type 2 AGNs that are unabsorbed in the X-ray regime, e.g. the presence of a strong Iron line. So, unless some of our absorbed objects are characterized by a dual absorber model (with an absorbed component not visible below 10 keV) we do not find Compton thick AGNs. We are now evaluating if this result can be used to set constraints on the density of the elusive Compton thick AGNs in the local Universe; • we only have one object that is optically classified as normal galaxy, but the $H\alpha$ line is not sampled at the moment. Its absorbing column density and luminosity are highly indicative of the presence of an absorbed AGN. A deeper investigation is in progress.

[1] For one of them the X-ray spectra could also be described by a typical AGN 1 power-law model with a large relativistic Iron line. A deeper investigation is in progress.

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