The cosmic X-ray background: news on the Compton-thick AGN population

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Abstract: **The spectrum of the 1-300 keV cosmic X-ray background (XRB), combined with a large body of observational results below 10 keV, is used constrain the space density and evolution of heavily obscured Compton-thick AGN, which are poorly sampled by current X-ray surveys.**

Step 1

The 0.5-2 keV XLF of type 1 AGN by Hasinger et al. (2005, A&A, 441, 417) is assumed to represent the soft XLF of unobscured (logNH<21)AGN. The 2-10 keV XLF by Ueda et al. (2003, ApJ, 598, 886) and La Franca et al. (2005, ApJ, 635, 864) are assumed to fairly represent the hard XLF of unobscured plus moderately obscured (21<logNH<24) AGN. The number ratio R between moderately obscured and unobscured AGN is therefore fixed once the soft XLF by Hasinger et al. is converted to the hard band and subtracted from the total 2-10 keV AGN XLF. As shown in Fig. 1, the comparison between the XLFs suggests that **a ratio R decreasing with luminosity is favored with respect to a constant ratio.**

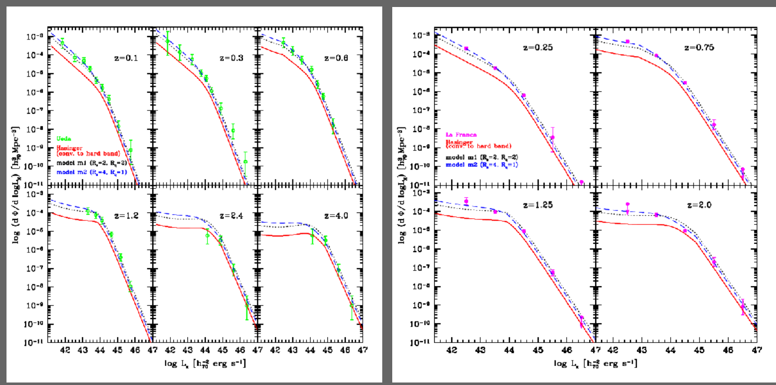
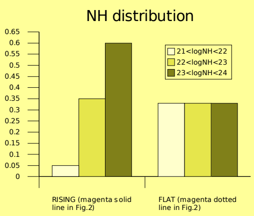
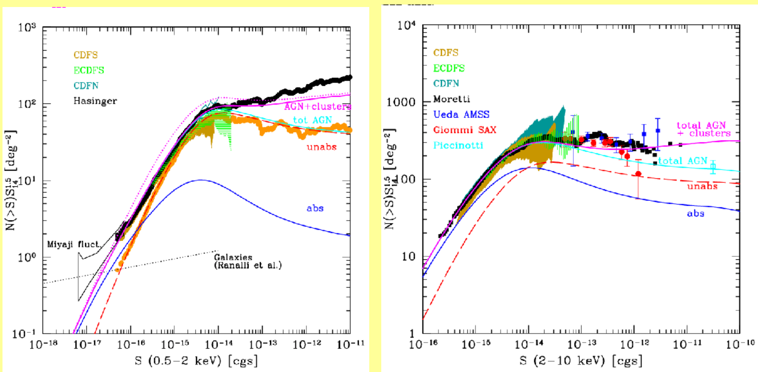


Fig1. The intrinsic 2-10 keV AGN XLF by Ueda et al. (*left*) and La Franca et al. (*right*) compared with model m1, in which R is constant with luminosity (R=2), and with model m2, in which R decreases with increasing luminosity (R=4 at logLx~42 ; R=1 at logLx~46). Model m2 provides the best agreement. **The ratio R is not found to depend significantly on redshift.**





Step 2

The XLF comparison fixes the ratio R, hence the total number of moderately obscured AGN. Their NH distribution is determined by matching the soft and hard X-ray counts. **An absorption distribution steeply rising towards high NH values is favored with respect to a flat NH distribution.**

Fig. 2. Cumulative source counts (normalized to a Euclidean Universe) in the soft (*left*) and hard (*right*) band compared with the predictions by model m2. Unabsorbed, absorbed, total AGN and total AGN + galaxy clusters counts are shown. **A flat NH distribution (dotted line) significantly overestimates the soft counts with respect to a skewed distribution (solid line).** Only the results for the rising NH distribution are shown in the right panel.

Step 3

Once the properties of the Compton-thin AGN population have been determined by fitting the available constraints (see Step 1 and 2) their contribution to the XRB is computed and as many Compton-thick AGN as needed to fit the residual high energy XRB are added. We assumed that these are equally splitted between "mildly" (24<logNH<25) and "heavily" (logNH>25) Compton-thick AGN. Besides the NH distribution, in this calculation we also considered a distribution of the intrinsic photon indexes (centered at Γ=1.9 with dispersion 0.2). The latter increases the integrated emission at 30 keV by 30% with respect to the case of a single average photon index Γ=1.9. **The number density of Compton-thick AGN is as large as that of Compton-thin AGN. In our baseline model therefore the total obscured to unobscured AGN ratio is 8 at low (logLx~42) luminosities and 2 at high (logLx~46) luminosities.**

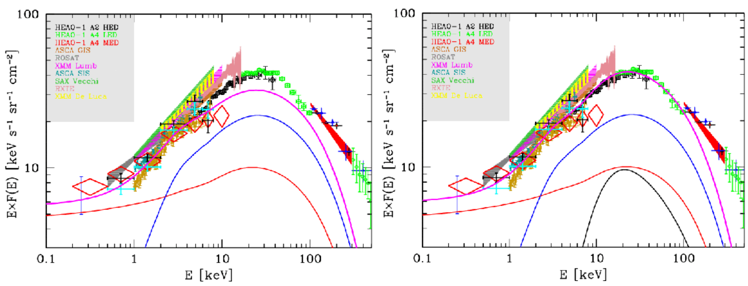


Fig. 3. The spectrum of the XRB compared with the results from model m2 excluding (left) or including (right) Compton-thick AGN (unobscured, obscured Compton-thin, **Compton-thick**, and total AGN curves are shown). When considering only Compton-thin AGN the XRB emission at ~30 keV is clearly underestimated.

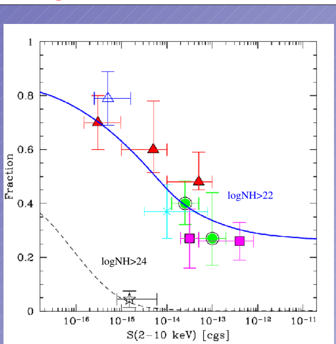


Fig.4 The fraction of AGN with logNH>22 (colourful points) compared with the predictions of model m2 (solid blue curve). The fraction of Compton-thick AGN observed in the CDFS (Tozzi et al. 2006, A&A 451, 457) is also shown (black star) and compared with the corresponding model prediction (dashed black curve).

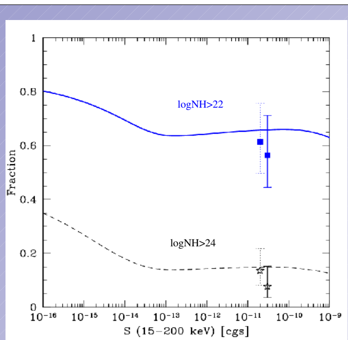


Fig.5. Same of Fig. 4 but for the 15-200 keV band covered by the Swift/BAT instrument. The number of obscured sources, and especially of Compton-thick AGN, is in very good agreement with the predictions by model m2. Points with dotted errorbars assume that objects without NH measurements (~10%) are mostly obscured AGN.

Step 4

The fraction of obscured AGN, and in particular of Compton-thick sources, are computed for different bands and fluxes and compared with the available data. Remarkably, **the fractions of Compton thick AGN observed in the Chandra Deep Field South (~5%) and in the first IBIS/INTEGRAL and Swift/BAT AGN catalogs (~15%) are in excellent agreement with those predicted by the model.**