Statistics of local hard X–ray selected AGN: implications for the CXB and unification model

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Resolving the cosmic X-ray background

Chandra Deep Field–North

~90% of the CXB below 2 keV is resolved

INTEGRAL Cen–Shapley region

~3% of the CXB at 17–60 keV is resolved
INTEGRAL All-Sky Survey

IBIS/ISGRI
17–60 keV

As of August 2006
>400 sources
Krivonos et al. 2007, Sazonov et al. 2007
AGN number density within 70 Mpc (averaged over a 45 deg cone) 
color map - INTEGRAL AGN 
contours - IRAS PSCz galaxies
80% of the sky: <5 mCrab
12% of the sky: <1 mCrab

1 mCrab = 1.4 \times 10^{-11} \text{ erg/cm}^2/\text{s}

Sensitivity is limited by photon statistics only, except for the GC region.

IRAS dipole (l=268°, b=27°)

IRAS anti-dipole
AGN catalog

All sky:
93 AGN (84 Seyferts, 9 blazars) detected on average map
+ 37 AGN detected in single observations
+ 40 unidentified sources

$|b| > 5^\circ$:
74 AGN (68 Seyferts, 8 blazars) detected on average map
+ 7 unidentified sources

The non-blazar sample is local ($z < 0.1$)
Hard X-ray luminosity function

AGN number density:

\[ n(L > 10^{41}) = (1.4 \pm 0.6) \times 10^{-3} \text{ Mpc}^{-3} \]

AGN luminosity density:

\[ \epsilon_{17-60 \text{ keV}} (L > 10^{41}) = (12.4 \pm 1.5) \times 10^{38} \text{ erg/s/Mpc}^3 \]

Blazars are excluded
Distribution of absorption column densities

- Fraction of absorbed AGN drops from 65–70% at low $L$ to 20–30% at high $L$
- Only 15–20% are Compton thick – all at low $L$

No selection bias!
$R = 3'$

$\text{IGR J13091+1137} = \text{NGC 4992}$

$z = 0.0251$

$N_H = (9 \pm 1) \times 10^{23} \text{ cm}^{-2}$
Average hard X–ray spectra of local AGN

\[ S = \sum f_i \]

\[ S = \sum \frac{L_i}{V_{\text{max},i}} \]
RXTE 3–20 keV Slew Survey

294 sources at $|b| > 10^\circ$, including 103 AGN and 16 unidentified

Revnivtsev et al. 2004; Sazonov, Revnivtsev 2004
Model: 
\[ f(N_H) \propto E^{-\Gamma} \exp\left(-\frac{E}{E_{\text{cut}}}\right) \]

distribution of absorption columns is as measured with INTEGRAL

\[ L > 10^{41} \text{ erg/s} \]

+ normalization uncertainty due finite number of sources
~20% for each sample
$L > 10^{43}$ erg/s
Redshift evolution of AGN X-ray luminosity density

A typical quasar contributing to the CXB is at $<z> \sim 1.5$

CHANDRA
Barger et al. 2005
see also Ueda et al., Hasinger et al...
Convolve the average hard X-ray spectrum of local AGN with a redshift dependence of AGN luminosity density $\epsilon = \text{const at } z>1$.
$\epsilon \sim 1/z \text{ at } z > 1$
Conclusions

- Ratio of obscured to unabsced AGN drops from 2:1 at low luminosities to 1:3 at high luminosities

- Fraction of Compton-thick AGN is not large (15–20%)

- A possible scenario for the CXB: AGN have undergone downsizing since z ~ 1–1.5 but their spectral properties and \( N_H \) distribution have not changed significantly
Distribution of exposure over the sky is important!

Average matter density is smaller for RXTE survey by a factor of $1.3 - 1.5$

Based on IRAS PSCz catalog
RXTE Slew Survey (Sazonov & Revnivtsev 04)