Hard X-ray surveys
and the X-ray Background

The HELLAS2XMM collaboration:

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Hard X-ray Surveys

- Most direct probe of the super-massive black hole (SMBH) accretion activity recorded in the XRB spectral energy density

- Chandra and XMM surveys: SMBH census is almost complete (integral)

- Obscured AGN make the bulk of the XRB

- The light-up and evolution of obscured accreting SMBH is still largely unknown (differential)

- XLF evolution of obscured AGN
Black Hole Mass Density

Soltan (1982) argument: the BH mass density due to growth by accretion

\[ \varepsilon_{\text{rad}}(1 + \langle z \rangle) = \eta \rho \cdot c^2 \quad (1) \]

\( \varepsilon_{\text{rad}} \) can be obtained by integrating the sources luminosity function (2) or from the background radiation they produce (3).

\[ \rho \cdot = \frac{k_{\text{bol}}}{\eta c^2} \int \frac{dt}{dz} \int L \phi(L) dL \quad (2) \]

\( \eta \) accretion efficiency, \( k_{\text{bol}} \) Bolometric correction

Using bright quasars optical counts, \( \eta = 0.1 \) and \( k_{\text{bol}}^B \approx 15 \)

2.2 \times 10^5 \, M_\odot \, Mpc^{-3} \ (Yu \ & Tremaine \ 2002)  
2 \times 10^5 \, M_\odot \, Mpc^{-3} \ (Salucci \ et \ al. \ 1998)

\[ \rho \cdot = \frac{k_{\text{bol}}}{\eta c^2} (1 + \langle z \rangle) \frac{4\pi I_0}{c} \quad (3) \]

\( I_0 \) Background Intensity

Using the XRB spectrum, \( \eta = 0.1 \) and \( k_{\text{bol}}^X \approx 30 \)

6 – 9 \times 10^5 \, M_\odot \, Mpc^{-3} \ (Fabian \ & Iwasawa \ 1999) 
7.5 – 17 \times 10^5 \, M_\odot \, Mpc^{-3} \ (Elvis, \ Risaliti, \ Zamorani \ 2002)
The local BH mass density

\[ \rho^{\text{direct}} \rightarrow \text{Using the } M_{\bullet} - M_{\text{bulge}} \]
\[ \sim 10 \times 10^5 \ M_{\odot} \ Mpc^{-3} \ (\text{Magorrian et al. 1998}) \]
\[ \rho^{\text{direct}} \rightarrow \text{Using the } M_{\bullet} - \sigma \]
\[ 2.5 - 3.5 \times 10^5 \ M_{\odot} \ Mpc^{-3} \ (\text{Yu & Tremaine 2002}) \]
\[ 4 - 5 \times 10^5 \ M_{\odot} \ Mpc^{-3} \ (\text{Ferrarese 2002}) \]

Where all the SMBH have gone ?
\( N(L), N(z), \text{efficiency, bolometric correction} ? \)
The deepest X-ray sky

HDFN (Brandt et al. 2001)

Chandra Surveys, 1 Ms exposures
DEEP FIELDS: Redshift Distributions

- CDFS, Gilli 2003
- CDFN, Barger et al. 2002
Cosmic Sheets

- CDFS
- CDFN
Luminosity function:

- Cowie et al. 2003
- Hasinger 2003
Space density:

- Cowie et al. 2003:
  \[ \rho_{BH} \sim 2 \times 10^5 \]

- Hasinger 2003
Deep Chandra surveys: limits

- **CDFS+ROSAT** (soft 0.5-2 keV band) plus type 1 AGN, miss obscured objects
- **CDFN:** small solid angle lack of high z high L objects
- Both of them limited by faint optical counterparts and thus incomplete at high-z
The Hellas2XMM survey

**Wide and shallow:**

- 3 deg² (15 XMM public fields)
- ~30 sources/field, \( F_x > 10^{-14} \)

**Bulk of the XRB**

**Rare and peculiar sources,**

- avoid cosmic variance

**Relatively “easy” multi-wavelength follow-up** (ESO-VLT, 3.6m, ATCA, VLA, TNG & Chandra)
$f_x/f_{\text{opt}} > 10$

Undetected in the $R$-band at $R=24-25$ (shallow), even $R>27-28$ (deep)

Constant fraction over a large range of fluxes

Shallow surveys pick-up brightest sources \textit{optical} identification is possible
317 sources (Hellas2XMM + Lockman + CDFN + SSA13
-15 < log flux < -13.3, 70% identified) Fiore et al. 2003
Redshift distribution (Opt + stat. ids)
The evolution of number and luminosity densities (Fiore et al. 2003)

- $\rho_{BH} \sim 4-6 \times 10^5$
ISAAC K-band observations

10/11 sources with a bright IR counterpart in the error box:

ALL with $R-K > 5$

Extremely red colors up to $R-K \sim 7$

Extended morphologies
Only two objects are compact (high $z$ AGN?)

Pointlike, $K=17.7$, $R-K>6.8$

(Mignoli et al, in prep.)
IR observations of high X/O H2XMM sources

Comparison with the K20 survey:

Rare objects, only <2% of the field K-selected sources are in the same region of the color-magnitude diagram.
Redshift from X-ray lines
Concluding Remarks

- **Obscured**: lower redshift + lower $L$, lower average BH masses → better agreement with local space density
- Census of high-z, highly-obs sources (X/O) urgently needed

- The COSMOS 2 sq. deg. Survey: XMM counts + Chandra positions over the 02h VIMOS deep field covered also by HST ACS and SIRTF SWIRE