The X-ray Background

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**Lockman Hole:** X. Barcons, H. Böhringer, H. Brunner, A. Fabian, A. Finoguenov, Y. Hashimoto, P. Henry, I. Lehmann, V. Mainieri, I. Matute, M. Schmidt, A. Streblyanska, G. Szokoly, M. Worsley

**Overall Sample & Luminosity Function:** T. Miyaji, M. Schmidt

22nd Texas Symposium, SLAC Stanford, December 14th, 2004
The X-ray Background

The background is the Echo of the formation of Supermassive Black Holes throughout the history of the Universe!
X-ray Background Spectrum

Revnivtsev et al., 2003 RXTE

XMM LH resolved

Worsley et al. 2004

from Gilli 2003

=> $E<2\text{keV}$ XRB resolved; at $E>5\text{keV}$ still very much work to do!
Large X-ray surveys

Alexander et al. 2003, AJ, 126, 539
The Deepest X-ray Surveys

CDF-N (HDF-N) CDF-S (ACS UDF)

Brandt & Hasinger, ARAA 2005
> 95% have spectro- or photo-z thanks to VLT, GOODS, GEMS, ACF UDS etc. Photo-z at higher z, but all peak at z~0.7

CDFS
Optical IDs

Szokoly et al., 2004 (spectro-z)
Wolf et al., 2004 (Combo-17)
Zheng et al., 2004
Mainieri et al., 2004 (photo-z)
Type 2 fraction

Fraction of type-2’s decreases with luminosity

Ueda et al., 2003; Szokoly et al., 2004
Lockman Hole
800 ks XMM-Newton observation

Keck Spectroscopy:
Lehmann et al., 2001
M. Schmidt, P. Henry
Average rest-frame spectra show relativistic Fe-lines.

type-1 AGN
EW~600eV

type-1 AGN
EW~600eV

Streblyanskaya et al., 2004

Large equivalent width can be explained by 3 x solar metallicity.
BH spin within reach.

Good news for XEUS/Con-X
The type-1 AGN 0.5-2keV X-ray luminosity function
Multi-Cone Surveys

- **Type-1 AGN in the 0.5-2 keV band**
  - Continuation of ROSAT work, most sensitive & complete

- **ROSAT Samples (Miyaji et al., 2000)**
  - ROSAT Bright Survey: 203 (0) AGN (Schwope et al., 2000)
  - RASS Selected North: 134 (5) AGN (Appenzeller et al., 1996)
  - RASS NEP Survey: 101 (9) AGN (Gioia et al., 2003)
  - RIXOS serendipitous: 194 (14) AGN (Mason et al., 2000)
  - ROSAT Deep Surveys: 84 (7) AGN (e.g. Schmidt et al., 1998)

- **XMM Deep Survey (Mainieri et al., 2002)**
  - Lockman Hole: 48 (8) AGN (Lehmann et al., 2001 ++)

- **Chandra Deep Surveys**
  - CDF North/HDF-N: 67 (21) AGN (Barger et al., 2003)
  - CDFS spec.+phot.: 113 (1) AGN (Szokoly, Zheng et al. 2003)

- **Total:** 944 (65) AGN

Yellow: unidentified
Multi-cone logN-logS
XLF
0.5-2 keV
type-1 AGN

Luminosity-dependent density evolution (LDDE) confirmed
AGN Space Density $\phi(z)$


M. Schmidt method
T. Miyaji treatment
(dotted: upper limit)
Semianalytic Model Comparison


M. Schmidt method
T. Miyaji treatment
(dotted: upper limit)
Densities in soft and hard band

Very similar behaviour in hard and soft band. Soft samples go deeper and are more complete.

Hasinger, Miyaji & Schmidt, 2005 based on ~1000 AGN-1

Ueda et al., 2003, based on ~250 AGN
Local BH mass vs. accreted BH mass function

- Accreted Black Hole mass function derived from X-ray background can be compared with the mass function of dormant relic black holes in local galaxies (Soltan 1982).

- These two estimates can be reconciled, if an energy conversion efficiency of $\varepsilon = 0.1$ is assumed.

- Such high efficiency requires a spinning Kerr-BH!

Marconi et al., 2004, MNRAS
X-ray vs. optical QSOs

Very large solid angle deep surveys are required to discover $z>5$ QSOs

E-CDFS
XMM/COSMOS
DUO

High-z decline now seen in X-rays at all luminosities!
Wide & Deep Chandra and XMM surveys

Extended Chandra Deep Field South

PI: N. Brandt (PSU); 4x250 ksec

Observations are ongoing

HST/XMM-Newton COSMOS Field

PI: N. Scoville (Caltech); XMM: 1.4 Msec, G. Hasinger (MPE)
DUO will detect same number $z>3$ QSO, than are known from all other surveys to date, including SDSS & 2dF
Summary

• X-ray background practically resolved below 2 keV
• At 2-10 keV about 50% resolved; still work to do
• Type-2 QSOs found, type-2 fraction decreases with $L_X$
• Background AGN have strong relativistic Fe line
• Luminosity-dependent density evolution
• Seyferts peak much later than QSO
• Anti-hierarchical evolution not predicted even by most recent semi-analytic models

$\Rightarrow$ Need (at least) 2 modes of BH accretion
Role of accretion through mergers?
Binary Black Holes in Major Mergers

Several more Binary Black Holes claimed in the meantime.

BBH could be present in a fraction of normal quasars.

Major accretion mode for quasars?
Co-evolution of Galaxy and BH

Simulation by Tiziana de Matteo, Volker Springel (MPA) & Lars Hernquist (CfA)
Thank you very much!