The AGN content of the COSMOS: the XMM-Newton view

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MPE: Boehringer, Brunner, Cappelluti, Finoguenov, Mainieri, Silverman

Others: Elvis, Griffiths, Impey, Le Fevre, Lilly, Miyaji, Scoville, Urry

May, 23 2006  AGN7 - Montagnana (PD)
Motivation of the XMM-COSMOS project

The main goal of the XMM-Newton Wide field survey in the COSMOS field is: "the evolution of (obscured) Active Galactic Nuclei over the cosmic time and the dependence of black hole growth on galaxy morphology and environment"

Evolution of AGN → complete picture of galaxy(-AGN) (co)evolution  
[see Alvio’s review]

Obscured AGN needed:
- to reproduce the X-ray background peak  
  (Setti & Woltjer 1989, Comastri et al. 1995 etc.)
- to reconcile local BH mass function with mass accreted on BH  
  (Fabian & Iwasawa 1999, Merloni 2004, Marconi et al. 2004 and many others)

to place AGN in the environments → large contiguous area

to compute physical quantities / study galaxies → DEEP multiwave coverage

Select AGN → Hard X-ray survey
Hard X-ray surveys with optical identifications

CDFN-CDFS 0.03 deg^2
Barger et al. 2003; Szokoly et al. 2004

Lockman Hole 0.12 deg^2
Mainieri et al. 2002

ELAIS 0.5 deg^2
Puccetti et al. 2006

HELLAS2XMM 1.4 deg^2
Cocchia et al. 2006

XMM HBSS ~25 deg^2
Della Ceca et al. 2004

COSMOS 2 deg^2
Eckart et al. 2006

Area
Contiguous
Serendipitous
The XMM-Newton view of COSMOS

AO3: 800 ks of XMM [25x32 ks pointings] → completed
~1400 AGN detected
~70 clusters/diffuse sources

AO4: Additional 600 ks of XMM → on-going
>2000 sources expected at the completion of the survey

Hasinger et al. 2006 1.4 deg

soft 0.5-2.0 keV
medium 2.0-4.5 keV
hard 4.5-10.0 keV
COSMOS source counts

$\log N - \log S$ (normalized to Euclidean slope)

→Confirm all previous results with unprecedent accuracy in flux range

<table>
<thead>
<tr>
<th>FLUX</th>
<th>ENERGY</th>
<th>#SOU</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-15.5, -12.5)</td>
<td>0.5-2 keV</td>
<td>~1200</td>
</tr>
<tr>
<td>(-14.5, -12.5)</td>
<td>2-10 keV</td>
<td>~700</td>
</tr>
<tr>
<td>(-14.0, -12.5)</td>
<td>5-10 keV</td>
<td>~150</td>
</tr>
</tbody>
</table>

Cappelluti et al. 2006
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Brandt & Hasinger 2005

Extreme X-ray/optical objects (EXO's)

- Optical identification
- X/O diagram

- "bright" sample
  \( I \leq 24 \)
  secure identified
  \( \sim 1200 \) (85%)

- statistical properties
- redshifts
- morphologies
- colors
- selection effects

- "faint" sample
  \( I \geq 24 \)
  problems with ID
  \( \sim 200 \) (15%)

- most interesting sources
- candidate high-z QSO2

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Brandt & Hasinger 2005

0.5–2 keV flux (erg cm\(^{-2}\) s\(^{-1}\))
Redshift distribution

compilation from ongoing spectroscopic projects
[IMACS/zCOSMOS + SDSS + literature data]

- ~380 “secure” spectroscopic identifications (z>0)
  [25% of the full sample, 50% completeness in the I<22 sample]

- BL AGNs dominate at z>1
  → High redshift type 2 objects missing (partly selection effect)
  [see also results from HELLAS2XMM, Cocchia et al. 2006, and from the SEXSI survey, Eckart et al. 2006, astro-ph/0603556]

- Redshift spikes → follow photo-z spikes in the galaxy sample

- First results on clustering signal suggest 8σ detection
  (Gilli et al., in preparation
  see also results on ACF – Miyaji et al. 2006)

Brusa et al. 2006
**ACS morphological information**

[First] morphological test on identifications

About **50%** of the IDs have **stellar** (or almost stellar; FWHM<3 pixels) profile on ACS data

- **blue points** = pointlike
- **red points** = extended

Very soft (HR=-1) sources are mostly point-like (dashed histogram)

Very hard (HR=1) sources are preferentially associated with extended objects (solid histogram)

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First look at ACS morphologies

Pointlike

Images: 20" x 20" in size

Extended

z=1.236

z=1.506

z=2.008

z=2.454

z=0.044

z=0.125

z=0.365

z=0.34

z=0.552

z=0.623

z=0.863

z=0.969
The majority (80%) of stellar-like objects from ACS occupy the locus of quasars in the U-B vs. B-V diagram.

Conversely, >70% of UBV selected objects recovered in the X-rays (90-100% expected with the completion of XMM-COSMOS).

Additional 50% (not shown) classified as extended \(\rightarrow\) missed in color selected diagrams.
Colors of X-ray sources (2)

R-K vs. K

Extended sources are significantly "redder" than point-like and associated with NOT BL AGN

Very soft (HR=-1) sources are mostly associated with "blue" sources (dashed histogram)

Hard sources (HR>-0.3) are preferentially associated with red objects (solid histogram)

("dichotomy" confirmed by spectral analysis Mainieri et al. 2006)

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Brusa et al. 2006
optically faint (I>24) $\rightarrow$ difficult to identify using optical bands only [see also Alexander et al. 2001]

~200 sources in the XMM-COSMOS sample: candidate high-z (z>1) obscured QSO, z>4 QSO...

Examples of XMM/IRAC coincidences

- ~120 objects in XMM-COSMOS identified through K and/or IRAC (most of them EROs)

- Very hard to get redshift from optical → alternative approaches: ISAAC/IRS spectroscopy and/or SED fitting

[Cfr. Also sample of highly obscured objects in Martinez Sansigre et al. 2005]

[Maiolino et al. 2006, Koekemoer et al. 2004]
Examples of XMM/IRAC coincidences (2)

- ~80 objects in XMM-COSMOS with multiple/none IRAC cps
  - more accurate X-ray positions are the only way to pick up the right cp
  - Chandra proposal on COSMOS

- XMM+Spitzer+Chandra:
  - test the XMM/optical/NIR association in ELAIS-S1
  - ~80% Chandra points to IRAC counterpart

(Courtesy C. Feruglio, F. Fiore ELAIS-S1)
Summary

- Full multiwavelength coverage needed to properly study and characterize AGN population as a whole
  - Check for selection criteria (X-ray vs. optical vs. IR)
  - Determine the bolometric output of the most important (numerous) population: obscured sources and low-L objects
    (not included in the Elvis et al. 1994 SEDs compilation)

- First results from XMM-COSMOS
  - Multicolor analysis of the “optically bright sample” suggests 80% agreement between spectroscopic, morphological and X-ray properties (as expected from unified schemes)
  - Candidate obscured QSOs isolated through K/IRAC photometry among the optically “unidentified” (faint) sources
XMM-COSMOS on-going projects

- Brusa, Zamorani, Comastri, Hasinger et al. 2006
  X-ray sources (AGN) identification and classification including morphological info
- Hasinger+2006
  Survey description and X-ray properties
- Cappelluti+2006
  Source counts, LogN-LogS
- Mainieri+06
  X-ray spectral analysis of point-like sources
- Miyaji+06
  Angular Correlation Function
- Finoguenov+06
  Study of groups and clusters in XMM-COSMOS
  http://www.mpe.mpg.de/XMMCosmos/PAPERS/

..and many others projects on-going!
including X-EROs (F. Civano), 3-D correlation function (R. Gilli), EXOs (A. Koekemoer),
photoz (M. Salvato), Type 1 QSO host (K. Jahnke) etc.

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COSMOS major components:

- HST/ACS (i-band – 590 orbits – I(AB)~27)
- Subaru imaging (~25 nights, b,v,r,i,z,)
- VLT (540 hours) & Magellan (12 nights)
- XMM-Newton (1.4 Ms)
- VLA (265 hours)
- GALEX deep (200 ks, AB~25)
- SPITZER (200 hours)

+ MAMBO, CFHT, TNG and others

all underway!

http://www.astro.caltech.edu/cosmos/
2-10 keV surveys with optical identifications

-16

~300-500 sources
(60% id)

CDFN-CDFS 0.03 deg2
Barger et al. 2003; Szokoly et al. 2004

-15

Lockman Hole 0.12 deg2
Mainieri et al. 2002

-14

ELAIS 0.5 deg2
Puccetti et al. 2006

-13

CHAMP/SEXSI 1-5 deg2
Silverman et al. 2004
Eckart et al. 2006

HELHAS2XMM 1.4 deg2
(Cocchia et al. 2006)

XMM HBS ~10 deg2
Caccianiga et al. 2004

-12

~450 objects
(75% id R<21)

~230 sources
(% id + zspec)

~30 sources
(100% id + zspec)

2-10 keV surveys with optical identifications

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