Perspectives of IXO follow-up of eROSITA AGN

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IXO Science Meeting (14-16 March 2011, Rome/CNR)
1) first sizable sample of X-ray selected z>6 AGN, i.e. first accreting BHs (see Gilli’s talk)

2) bright hard X-ray selected QSO2 samples at z=1-3, i.e. signposts of major events in galaxy-AGN coevolution (see Maiolino/Feruglio’s talk)

rare objects!

eROSITA key feature: AREA
IXO - matter under extreme conditions

(a) X-ray redshift at z=5 (XMS)

(b) Temperature and abundances of z=1.25 galaxy group

(c) AGN spin at z=1 via broad Fe line

(d) Ultra obscured Compton thick AGN at z=3.7

IXO/WFI 1Msec
Spectroscopy of high-z and obscured AGN up to the highest-z also key goals of IXO “matter under extreme conditions” & “the violent, evolving universe” science topics
Why IXO follow-up?

IXO can provide **UNIQUE spectral characterization** (absorption, outflows, spin) of well defined/selected samples of eROSITA sources detected with low-counts

**But, please note:**
- **numbers** may not be the final ones (background level, conversion factors, selections, actual instruments performance etc.), plus model predictions maybe not correct --> please take home **“order of magnitudes” estimates**!
- eROSITA deep observations **strategy not yet fixed/finalized** (area and exposure) --> all considerations are done for the all-sky survey

**best synergy strategy : eROSITA to preselect, IXO to follow-up**
High-z (z>6) AGN

PREDICTIONS for eROSITA survey:
1) assuming a limiting flux of ~1e-14 cgs in the soft band
2) using Gilli+2007 model (with decline model, e.g. Brusa+2009) http://www.bo.astro.it/~gilli/counts.html

~30 (lower limit) over the entire sky at logLx>45 erg/s (N.B. ZERO X-ray selected z>6 AGN in the XMM/Chandra/ROSAT samples; ~20 from optical surveys, SDSS & CFHT Fan et al. 2006, Jiang et al. 2009, Willott et al. 2009)
N.B. >20.000 z>3 QSOs expected in eROSITA!!

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Sensitivity needed & future large area surveys

XMM-COSMOS
0.5-2 keV sources at F>1e-14

[see also Brusa et al. 2010, WFXT White Book, arXiv:1008.1914]

Sensitivity of the order of I~24 and K~22 needed on the all sky
(identifications problems may affect 5-10% of the sources)

Key resources (existing and foreseen):
PanSTARRS: I~24.2 (+grzy)
DES: R~24 (rgizY)
LSST: I~25.5 (+ugrzy)
SDSS-III (BOSS) (large FOV, large # fibers)
4MOST (new dedicated spectrograph @ESO): for efficient spectroscopic follow up
VISTA/VHS: K~20-21 (+HJY) (60-80% of the cp)
EUCLID: K~23.5 (+zJH)
WISE: 3.6~19.5 (not enough?)
LOFAR: 0.8 mJy at 120 MHz (= 0.1 mJy at 1.4 GHz)
“radio” emitters (AGN and starburst)

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**XMM-COSMOS**
0.5-2 keV sources at F>1e-14

N.B.:
eROSITA = COSMOS x 1e4 !

Identification of z>3 and z>6 QSOs among the few million eROSITA AGN is not trivial at all!
- dropouts
- optical/IR color-color plots and color-magnitudes diagrams
- “rough” photo-z from multi-\(\lambda\) coverage
- follow-up with and/or cross-corr with ALMA, LOFAR, JWST samples

(long way to go...)

other lambda information is mandatory, but X-ray detection is the **fingerprint of accretion**!

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IXO observations of z~6 QSOs

logNH=23.6
EW=600 eV

redshift constrained at <0.02

logNH=22.6
EW=150 eV

redshift constrained at <0.05

X-ray redshift determination feasible with reasonable exposure times

BUT you need to know where to point IXO!

response matrix: ixo-glass-wfi-alpp-20100625.rsp

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2-10 keV all sky survey

30-years old 2-10 keV HEAO-1 all sky map

36 AGN (Piccinotti et al. 1982) at flux > $3.1 \times 10^{-11}$ cgs

(+clusters of galaxies, LMC, SMC, M82..)

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PREDICTIONS for eROSITA survey:
1) assuming a limiting flux of 1e-13 cgs
2) using Gilli+2007 model

~130,000 over the extragalactic sky!
with a clear and uniform selection function

N.B.: (as a comparison)

~5500 pointlike sources (|\theta|>20°) in the 2XMM catalog (Watson et al. 2009) with flux >1e-13 cgs (over a smaller area, very different/complicate selection)

IXO Science Meeting (14-16 March 2011, Rome/CNR)
130,000 2-10 keV selected AGN at f>1e-13 cgs

67% unobscured (NH<22)

0.2% CT (NH>24) 220 obj!!

33% Compton Thin (NH=22-24)

“OBSCURATION” SPACE (see Reynolds and Matt talks tomorrow)

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(digression/advertisement)

stacking analysis of 2XMM sample

- stacking of ~250 2XMM catalog sources (selected from Watson+2009) & redshifts from NED (Chaudhary et al. 2010, Chaudhary, MB et al. 2011, in prep); additional threshold in number of counts; total of ~200,000 counts in the 2-10 keV band

Results tested against different modeling (w and w/o pexrav, broad vs. diskline) and continuum simulations

Different methods and approaches have been tested (averaged ratios, averaged spectrum etc.)

similar results Brusa+2011 CDFs
(see debate in literature on ubiquity of relativistic line in stacked spectra e.g. Streblyanska+05 vs. Corral+08)
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(NH=22-24)

20% at z<0.3
(complete for Lx>42
at ~300 Mpc)

33% at z~0.5
(0.3<z<0.7)
Lx>44

33% at z>1.3
Lx>45 (>3000 with
NH>23!)

20% at z~1 (0.7<z<1.3)

“OBSCURATION”
SPACE
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Picking up most obscured/interesting sources

1) Hardness ratios

Watson+09 (2XMM)

Della Ceca+04 (XMM-BSS)

Cappelluti et al. 2009 (COSMOS)

Picking up most obscured/interesting sources
most of these sources have been revealed (and will be revealed with eROSITA) with low counting statistics (20-100 cts)

2) Cross-correlation with other lambda catalogs

X/O ratio vs. HR
Della Ceca+04 (XMM-BSS)

X/O ratio vs. R-K
(Brusa et al. 2010)

most of these sources have been revealed (and will be revealed with eROSITA) with low counting statistics (20-100 cts)

Require extensive use of VO and large astronomical databases

see also criteria based on IR data presented and explored by Daddi+07, Fiore+08,09, Alexander+10, Treister+09, Feruglio+11 etc...

highly contaminated...

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Conclusions

1) eROSITA will provide (among others) the first all sky survey 2-10 keV after HEAO-1 at considerable \(10^{-13}\) cgs depth, and will detect sizable samples of high-z QSO (z>3)

2) IXO can provide UNIQUE spectral characterization of well defined/selected sample of eROSITA sources, e.g.:
   
   a) obscured z=1-3 luminous quasars, i.e. signposts of galaxy/AGN evolution
   
   b) first accreting SMBHs at z>3-6

   **eROSITA contribution:** single out the best candidates (X-ray detection is the smoking gun)
   **IXO contribution:** characterizing spectral parameters, redshifts and spin (physics)

3) While waiting for IXO... Broad/relativistic lines studies can be pushed to fainter fluxes with stacking (Literature results differ by one order of magnitude);
   broad component needed, but EW < 200 eV

4) eROSITA still to be launched... we are happy IXO will fly in >10 years!

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QSO2 signposts of major events

Most luminous, obscured X-ray selected sources are redder
--> effect of relative contribution of AGN and host or feedback more efficient to stop star formation, or dusty environment?

Very short phase (<< 1Gyr): need larger brighter samples (RARE OBJECTS!!)

Sources like XID 2028 within the limit of the eROSITA all sky!

From XRB models: expected 0.2/deg² objects with Lx>45, NH=23-26, z=1-3, i.e. 3600 in the all sky hard eROSITA survey (likely upper limit, XRB models overpredict obscured AGN fraction at the highest luminosities, Brusa et al. 2010)

Physics laboratory for the AGN-galaxy coevolution models, BUT direct evidence of feedback from AGN at z~1-2 not yet found!

Ideal targets for ALMA / WFC3 / X-shooter / JWST follow-up and deep IR spectroscopy --> detect nucleus in the IR and molecular outflows in the millimeter!
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