Revealing X-ray obscured Quasars in SWIRE sources with Extreme Mid-IR/Optical flux ratios

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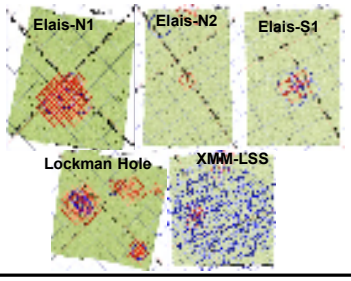
Abstract - Recent results indicate that IR colour selection criteria can be used to build large samples of obscured QSO candidates at z ~ 1. We report X-ray spectroscopic study of 44 bright (F 24μm>1.3 mJy) SWIRE sources with extreme mid-IR/Optical Flux ratios (MIR/O>2000). The aim of this project is to probe the AGN nature of these extreme sources and provide a direct measurement of the N_H of the absorber. We constrained the N_H value for 55% of sources in the sample. 95% of them are found to be obscured AGN ($N_H > 10^{22}$ cm^{-2}) at z≥1 and, remarkably, half of them show column densities larger than 10^{23} cm^{-2}. Furthermore, on the basis of their N_H and X-ray luminosity, at least half of sources can be classified as type 2 QSOs. A complete discussion of this work will be presented in a forthcoming paper (Lanzuisi et al. 2008 in prep).

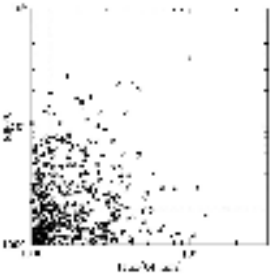
The SWIRE Survey: a unique opportunity to find out QSO2s

The accretion history of the Universe is still an unresolved issue since the integrated emission from the sources detected even in the deepest Chandra/XMM surveys fails to account for the CXB emission peak at ~30 keV and a missed population of heavily obscured AGN is still required. In particular, due to the low space density of highly luminous obscured QSOs these class of object has been largely missed so far and, therefore, a wide-area survey is needed to find them out.

The SWIRE survey covers 50 deg^2 with mid/deep IRAC and MIPS photometry. The X-ray coverage of the 5 SWIRE fields (Elais-N1, Elais-N2, Elais-S1, LH and XMM_LSS), covers ~ 7 deg2 and is highly inhomogeneous (in figure blue circles are XMM fields and red squares Chandra fields)

The XSWIRE catalog is available at http://www.oa-roma.inaf.it/~fiore/XSWIRE





Flux (24 mm) vs MIR/O for the SWIRE sources. Filled (empty) circles are sources with (without) X-ray coverage

Sample Selection

Highly obscured AGN can be recovered thanks to the reprocessing of the Optical/UV emission in the infrared, by selecting sources with high luminosities in the mid-IR but faint optical and near IR emission, where dust and gas block most of the nuclear emission (Martinez-Sansigre et al. 2005, Fiore et al. 2008).

We applied the following selection criteria:

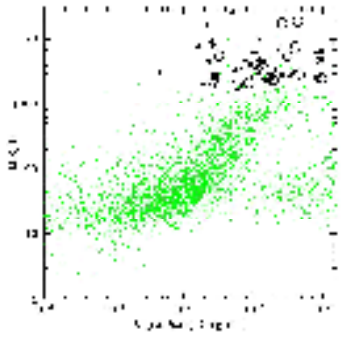
- **MIR/O > 2000**
- **Flux (24μm) > 1.3 mJy**
- **X-ray coverage**

The final sample consists of 44 sources

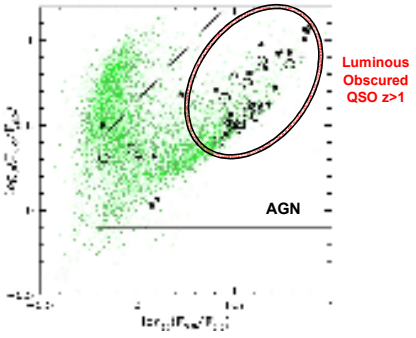
- 23 source (**X-ray sample**) with N_H determination
  - 12 from spectral analysis
  - 11 from HR analysis
- 21 undetected in both the Soft (0.5-2 keV) and Hard (2-10 kev) band
- 7 with Spectral Redshift 0.22 < zspec < 2.54
- 37 with Photometric redshift 0.54 < zphot < 3.77

Mid-IR Properties of the sample

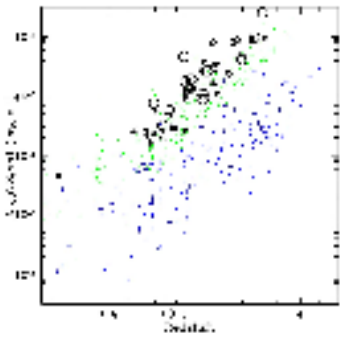
Given that MIR/O correlates with the IR luminosity, our selection is well suited to find obscured AGN of high luminosity. *Green points are SWIRE sources. Black circles (asterisk) are X-ray detected (undetected) sources in our sample. Small (big) symbols represent sources with exp time < 15 (>15) ks.*



All but one sources fall in the AGN region in the IRAC color-color plot (solid line, e.g. Lacy et al. 2004). Most of them show extreme $F_{3.6}/F_{5.8}$ and $F_{4.5}/F_{8.0}$ ratios (> 0.4). In this region falls QSO2s found in Polletta et al. 2008. *Symbols as in previous figure.*



The MIR/O>2000 + F_{24} > 1.3 mJy selection applied to a large area survey like SWIRE allows to collect AGN with L_{IR} by a factor 5 higher of C-COSMOS (*2 deg^2, blue points*) AGN and factor 15-20 higher of CDF-S (*<0.1 deg^2, green points*) AGN.

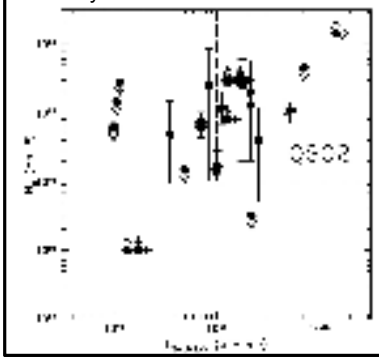


Spectral results for the X-ray sample

- **95%** of the sources are found to be **absorbed** with a column density $N_H > 10^{22}$ cm^{-2} (50% are highly absorbed with $N_H > 10^{23}$ cm^{-2}).
- **50%** of the sources show L_X and N_H typical of **QSO2**. (*e.g. Piconcelli poster G42*)
- **18%** of the sources are promising **Compton-thick QSO 2s** candidates.

Details on this work will be presented in **Lanzuisi et al. 2008** in prep.

For comparison we show in the table the fractions obtained from a sample of randomly-selected SWIRE sources with similar X-ray fluxes.



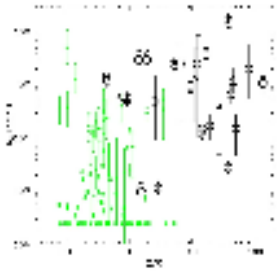
Source Type	Our Sample	Control Sample
Obscured (N_H>10^{22})	55-95%	20%
Unobscured	5-45%	80%
QSO2	40-55%	5%

Since there is a fraction of sources being undetected even in deep X-ray exposures with IR colors typical of obscured QSO that could likely be Compton-thick QSO, the number of discovered QSO2s should be considered a lower limit.

We have therefore demonstrated that our selection criteria results very efficient in finding out a large number of QSO2s at z ≥ 1 when applied to a wide-area survey like SWIRE.

X/O vs N_H

More than 50% of our sources have extreme F_X/F_O ratios (EXOs, F_X/F_O>10). High values of X/O suggest the presence of absorption and most of EXOs are obscured AGNs. Remarkably, in our sample all but one sources showing X/O > 10 have N_H>10^{22} cm^{-2}, i.e. they are obscured AGN. For comparison we show values obtained from a sample of Hard X-ray selected sources in the XMM-LSS survey *(green points, Garcet et al. 2008)*.



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