Dust Obscured Galaxies in COSMOS: Heavily obscured AGN?

Giorgio Lanzuisi
Enrico Piconcelli
Fabrizio Fiore
Cristian Vignali

IASF-Roma, OAR, OABo & COSMOS collaboration
Are (all) DOGs obscured AGN?

DOGs: Dust Obscured Galaxies, showing MIR/O > 1000, F$_{24}$ > 0.3 mJy, R-K > 4.5 (e.g. Dey+08,09, Desai+09)

- Powerful ULIRG (L$_{IR}$ > 10$^{45}$ erg s$^{-1}$) at high redshift (z = 1-2)

Key early phase of QSO/host galaxy co-evolution?

Basic issue: fraction of DOGs powered by AGN:
- MIR Bump DOGs (fainter F$_{24}$) SF dominated
- MIR Power-law DOGs (brighter F$_{24}$) AGN dominated

X-ray properties:
- in CDF-S and COSMOS, Stacking of undetected Fiore+08,09 found a “factor 2” population of CT AGN candidates at Log(L$_X$)=43-44

- SWIRE large area survey: X-ray detected Extreme DOGs (MIR/O>2000, F$_{24}$ > 1.3 mJy) >50% are heavily absorbed type2 QSO, high fraction of C-Thick QSO candidates (Lanzuisi+09)
The COSMOS survey

- 2 deg$^2$ of HST pointings (Scoville+07)

- $10^5$ galaxies detected

- Omni-wavelength coverage down to faint fluxes (Spitzer, Herschel, Subaru, ESO-VLT, VLA.....)

- Thousands of spectroscopic redshifts available (Lilli+07)

- Accurate photometric redshifts for all the sources ($\Delta z/(1+z) \sim 2\%$ for AGN, Ilbert+09, Salvato+09)

- Medium X-ray coverage with Chandra and XMM on large areas:
  - 1760 sources in 0.9 deg$^2$ with Chandra (Elvis+09)
  - 1887 sources in 2 deg$^2$ with XMM (Hasinger+07)
Sample Selection

X-ray detected DOGs (> 3 net counts)

- **A**: MIR/O > 1000, F$_{24}$ > 0.55 mJy
53 sources (22 with > 30 net counts)

- **B**: 300 < MIR/O < 1000, F$_{24}$ > 0.55 mJy
55 sources (20 with > 30 net counts)

- in cell A Log(< L$_{5.8}$ >) = 45.2
  and <z> = 1.8
- in cell B Log(< L$_{5.8}$ >) = 44.6
  and <z> = 1.1
The X-ray bright DOG sample

DOG samples with > 30 counts:
40% of the sources can be analyzed “one by one” (XMM spectra available, doubling the number of counts)
→ tip of the iceberg of the X-ray DOG population.

BUT: they are representative of the entire population in redshift and $L_{5.8}$ distribution
Spectral results for the X-ray bright DOG sample

- ~90% of sources are obscured (both in cell A and B)

- QSO2: 60% in cell A
  20% in cell B

The difference between $L_{\text{5.8}}$ and $L_X$ is consistent with the amount of absorption.

Relation from SWIRE (Lanzuisi+09) consistent with Fiore+09, Bauer+10....
Stacking Analysis for X-ray faint DOG sample

- 66 sources in A and B, with $3 < \text{counts} < 30$, stacked together in rest frame

- $\Gamma = 0.55$

- signatures of reflection-dominated/C-Thick absorbed spectra

- EW of Fe Kα = 1.25 ± 0.34 keV
Going down in Mid-IR flux

- **C cell**: 63 sources with $0.30 < F_{24} < 0.55$ mJy, MIR/O > 1000,
  $3 < \text{counts} < 30$
- **C cell**: 63 sources with $0.30 < F_{24} < 0.55$ mJy, MIR/O > 1000, $3 < \text{counts} < 30$

- EW of the Fe Kα < 200 eV (at 2 σ)

→ Composite SB+obscured AGN ?

- $\Gamma = 0.20$
The mean $L_{\text{X}}/L_{5.8}$ and $L_{\text{X}}$ of the stacked spectra of A and B, in 4 redshift bins, is consistent with CT obscuration.

The $L_{\text{X}}/L_{5.8}$ of stacked spectra from DOGs in the C cell suggests:

1) strong contribution from an AGN in X-rays ($L_{\text{X}} > 10^{42}$ erg s$^{-1}$)
2) strong contribution from SB in Mid-IR
The fraction of AGN in DOGs

Even if selected regions are contiguous in $F_{24}$, the median of $F_{24}$ distribution for each subsample are very different.
The fraction of AGN in DOGs strongly decrease with $F_{24}$.
Conclusions

A & B cell DOGs:

- Mid-IR bright \( (F_{24} > 0.55 \text{ mJy}) \) and X-ray bright DOGs result to be obscured AGN

- The cut at \( \text{MIR/O} = 1000 \) divides QSO-like from Seyfert-like AGN (MIR/O correlates with \( L_{58} \) and \( L_X \))

- The stacked spectrum of sources in A and B with < 30 counts show a strong Fe K\( \alpha \) line with \( \text{EW} \sim 1\text{keV} \) significant at > 4 \( \sigma \)
  The observed \( L_X \) is consistent with CT obscuration

C cell DOGs:

- The stacked X-ray spectrum of DOGs with \( 0.30 < F_{24} < 0.55 \text{ mJy} \) do not show any Fe K\( \alpha \) signature but the \( L_X > 10^{42} \text{ erg s}^{-1} \). (mix of SB/bump and AGN dominated DOGs?)

A large fraction of DOGs with X-ray detection (> 3 counts) are highly obscured AGN.