Powerful outflows in z~1.5 X-ray obscured QSOs

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- Perna, Brusa, Cresci, Comastri, Lanzuisi et al., A&A submitted
AGN in FEEDBACK/OUTFLOWS:
X-ray luminous, obscured and “dusty” at z=1-3

10 targets X-ray (Lx>44) and K-band (K<19) brightest objects at z ~ 1.25-1.72 observed in the VIS-NIR with VLT/X-shooter
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XMM-COSMOS obscured QSOs: single aperture Nuclear Spectra

simultaneous multi-component fit: systemic+BLR+outflow
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Simultaneous multi-component fit: systemic+BLR+outflow

BLR Hα (FWHM>2000 km/s) detected in 6/10

SMBHs with $M_{BH} = 10^8$-$10^{10}$ M$_\odot$ (massive!) (Bongiorno+ 2014)

Broad/shifted component (FWHM=900-1600 km/s) in forbidden lines ([OIII], [NII],[SII]) detected in 6/8 (75%) ascribed to outflows (Brusa+2014)
XMM-COSMOS obscured QSOs: single aperture Nuclear Spectra

Quantifying the OUTFLOW ENERGETICS:

\[ P_{K}^{\text{ion}} = 5.17 \cdot 10^{43} \frac{C L_{44}([OIII]) v_{0,3}^3}{n_{e3} R_{kpc} 10^{[O/H]}} \text{ erg s}^{-1} \]

Cano-Diaz+2012:

- only ionized component
- LOWER LIMIT

Estimates depend on radius, velocity, metallicity, density and [OIII] flux

Kinetic powers consistent to the 0.1-5% coupling efficiencies, similar to that predicted by AGN feedback models (King 2005)
XMM-COSMOS obscured QSOs: *slit-resolved spectroscopy*
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- \( N_H = 6-7 \times 10^{-22} \text{ cm}^{-2} \)
- \( \text{SFR} \approx 250 \text{ M}_\odot/\text{yr} \) (Main Sequence)
- \( E(B-V) \approx 0.9-1.0 \)
- \( L_{\text{bol}} = 2 \times 10^{46} \text{ erg/s} \)
- \( L_{\text{bol}}/L_{\text{Edd}} \approx 0.01-0.05 \) (\( \text{MBH} = 10^8-10^9 \text{ M}_\odot \))

\( N_H \) and \( L_{\text{bol}} \) are key parameters in understanding the properties of obscured QSOs. The high \( E(B-V) \) suggests significant dust extinction, while the high \( L_{\text{bol}} \) indicates a powerful source of energy. The \( L_{\text{bol}}/L_{\text{Edd}} \) ratio helps to classify the state of the QSO, with lower values indicating a quasar phase.
Evidences of large-scale outflows from X-shooter slit-resolved spectroscopy of two z~1.5 obscured QSO in COSMOS

HST-ACS I-band

UltraVista J-band

[XIII]5007 Å

(Flux (a.u.))

(kpc)

Obs wavelength (nm)

([XIII]5007 Å)
Evidences of large-scale outflows from X-shooter slit-resolved spectroscopy of two z~1.5 obscured QSO in COSMOS

HST-ACS I-band

UltraVista J-band

outflow extending beyond 10 kpc scale!
XMM-COSMOS obscured QSOs: **slit-resolved spectroscopy**

**Fluxes & Velocities:**
simultaneous multi-component fit: systemic+BLR+outflow

![Normalized Flux vs Rest Wavelength](image.png)
XMM-COSMOS obscured QSOs: *slit-resolved spectroscopy*

**Fluxes & Velocities:** simultaneous multi-component fit

BPT diagram

**AGN photoionization origin**

- **XID2028**
- **XID5321**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tr>
<td>[]</td>
<td>nuclear systemic</td>
</tr>
<tr>
<td>[ ]</td>
<td>nuclear non-systemic</td>
</tr>
<tr>
<td>[ ]</td>
<td>off-nuclear non-systemic</td>
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</tbody>
</table>

**Rest wavelength (Å)**

**log([NII]/Hα)**

**log(\([\text{OIII}]/\text{H}\beta]\))**
XMM-COSMOS obscured QSOs: **slit-resolved spectroscopy**

**Fluxes & Velocities:**
Non-parametric analysis

**XID2028**
- $v_{\text{max}} = -1350\pm50$ km/s
- DV = $-350\pm50$ km/s
- w80 = $980\pm40$ km/s

**XID5321**
- $v_{\text{max}} = 1730\pm20$ km/s
- DV = $500\pm20$ km/s
- w80 = $1450\pm25$ km/s

**Nuclear [OIII]5007**

**Off-Nuclear [OII]3727**

**Perna+2014**
Quantifying the outflow mass rate:

\[ M_{\text{out}}^{\text{ion}} = 5.33 \times 10^7 \frac{C L_{44}([\text{OIII}])}{\langle n_{e3} \rangle 10^{[O/H]}} \, \text{M}_\odot \]

Cano-Diaz+2012:

- only ionized component; \( L_{[\text{OIII}]} / L_{\text{H}\beta} \approx 10 \)
- \( L([\text{OIII}]) \) from nuclear & off-nuclear regions, and corrected for the extinction (Balmer decrements)
- \( N_{e3} = 120 \, \text{cm}^{-3}/10^3 \) from off-nuclear \([\text{SII}]\) emission
- \( v_0 = v_{\text{max}} \)
- Solar metallicity

\[ \dot{M} = 3 \, M_{\text{out}} \frac{v_0}{R} \]

\[ \dot{M}_{\text{out}}^{\text{ion}}(2028) \approx 550 \, \text{M}_\odot \, \text{yr}^{-1} \]

\[ \dot{M}_{\text{out}}^{\text{ion}}(5321) \approx 500 \, \text{M}_\odot \, \text{yr}^{-1} \]
Neutral component: sodium NaD$\lambda\lambda5890,5896$, magnesium MgII$\lambda\lambda2796,2803$ and MgI$\lambda2853$ absorption lines

All the absorption lines show shifts nearly like those observed in the emission lines.

$\dot{M}_{out}^{tot}(2028) > 630 \, M_\odot \, yr^{-1}$

$\dot{M}_{out}^{tot}(5321) > 535 \, M_\odot \, yr^{-1}$
(1) Selection does work!

large scale (>10 kpc) outflow present in X-ray luminous, obscured XMM-COSMOS QSOs

--- inferred for 6 sources from [OIII] widths & shifts in integrated X-shooter spectra

--- confirmed by X-shooter slit-resolved spectroscopy (XID5321, XID2028)

(and directly detected in SINFONI/IFU data (XID2028; Cresci et al. 2014)

(2) Outflows are most likely AGN-driven

--- “fiducial” outflow kinetic power exceeds kinetic output from SN winds

--- consistent with predictions in feedback models (5% of $L_{bol,AGN}$)

--- confirmed by BPT diagram and momentum fluxes (XID5321, XID2028), consistent with “momentum boost” observed in local ULIRGs dominated by AGN & in luminous QSO, and required to reproduce the normalization of the $M_{BH} - \sigma$ relation