The realm of hyperluminous quasars

Hunting for the most luminous quasars

Aim: probe and study the AGN-driven feedback phase

The most luminous QSOs at the epoch in which their activity peaks (2<z<4)

Obscured quasar
- Dust-enshrouded
- High obscuration
- High SFR

Unobscured QSO
- Blue
- Optically bright
- X-ray unobscured

Blow-out phase
AGN-driven winds
Feedback in action

The strength of outflows is proportional to $L_{bol}^{0.5-1.3}$

Adapted from Alexander & Hickox 2012
Hunting for the most luminous quasars

Efficient large-area IR selection: search for hyperluminous ($L_{bol}=10^{47-48}$ erg s$^{-1}$) dust-reddened IR bright 2<z<4 QSOs

**Hot DOGs:** W1W2-dropout $\rightarrow$ heavy obscuration (Eisenhardt+2012, Wu+2012)

**Red QSO:** NIR color (J-K>2) $\rightarrow$ dust-reddened sources (Glikman+2004, Banerji+2012, Ross+2015)

**WISSH QSOs:** WISE/SDSS $\rightarrow$~90 MIR-bright Type 1 AGN (Bischetti+2017, Vietri+2018, Duras+2017)
Signature of outflows in dust-reddened/obscured sources

Hot DOGs: Indication of molecular outflow

ALMA - CO(4-3)

Red QSOs in blow-out phase

\[ \text{Fan+2018} \]

\[ Glikman 2017 \]

\[ \lambda_{Edd} \]

\[ \log[N_H (\text{cm}^{-2})] \]

\[ \log[\lambda_{Edd}] \]
Pervasive outflows at all scales in the Type 1 WISSH QSOs

Remarkable nuclear winds (~70%): strong CIV blueshifts (up to 7000 km/s)

Powerful [OIII] kpc scales outflows (~30%) (v~1000-2000 km/s, $\dot{E}_{\text{kin}} \approx 0.01 \times L_{\text{bol}}$)

Vietri+18

Bischetti+17

Bruni+2019

Travascio, LZ et al. submitted
X-ray view of hyperluminous quasars

- X-ray nuclear properties for ~50% of WISSH quasars
- $N_H$ up to $\sim 5 \times 10^{23}$ cm$^{-2}$
- disk emission largely dominates over coronal
- little X-ray contribution wrt the bolometric output $k_{bol,X} \sim 300$ (~1 dex scatter)
Few examples of X-ray spectra

**WISSH-QSO**

XMM-PN/MOS1/MOS2
Chandra

Zappacosta et al. in prep.

**Red-QSO**

XMM-PN/MOS1/MOS2

Martocchia+2017

**WISSH-QSO**

Chandra

Martocchia+2017

**Hot DOG**

W1835+52
Zappacosta+2018
X-ray vs Mid IR

X-ray nuclear radiative output compared to larger-scale Mid-IR emission

Strong UV output → line driven winds → quenching of the X-ray coronal emission

(Proga 2003, 2005, 2007)
Wind regulated X-ray emission

- Relation between X-ray luminosity and CIV blueshifts
- No significant dependence at other wavelengths

Nuclear winds are likely quenching the coronal emission

Zappacosta et al. in prep.
Comparing X-ray emission to other wavelengths

- 1 dex dependence
- shrink scatter in this regime
- refinement of relations at the highest luminosities
The dust-driven blow-out phase

WISSH quasars and other hyperluminous quasars are mostly blowing out their obscuring medium.
Conclusions

• Hyperluminous QSOs exhibit pervasive signs of outflows

• The X-ray emission correlates over more than 1 dex with the velocity of the broad-line region winds
  – nuclear winds are likely quenching the corona
  – needs to refine $k_{bol,X}$, $L_{6\mu m}/L_X$, $\alpha_{ox}$ at the highest luminosities

• A large fraction of hyperluminous QSOs is blowing-out their surrounding obscuring medium

• Future perspective:
  – study the X-ray weakness - CIV velocity shift at lower $L_{bol}$
  – investigate mildly relativistic highly ionized SMBH winds with ATHENA
Nuclear winds in hyperluminous QSOs: the Athena perspective

X-IFU simulation

- WISSSH quasar at z=3.4
- Wind parameters:
  - $v_{\text{wind}}=0.15c$;
  - $\log(N_H/cm^2)=23.4$
  - $\log(U/\text{erg cm s}^{-1})=2.3$
  - $v_{\text{turb}}=5000 \text{ km/s}$
- 20 ks $\rightarrow$ 2500 counts
  - accuracy on 1%, 2% and 5% on $\log N_H$, $v_{\text{wind}}$ and $\log U$
- Variability studies on few hours time-scales

Figure: from Martocchia+2017, with updated X-IFU responses