The bolometric output of AGN in the XMM-COSMOS survey

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The X-ray Universe: Berlin, June 30 2011
Multi-wavelength database → statistically relevant sample of unobscured (Type 1, Lusso et al. 2010) and obscured (Type 2, Lusso et al., subm.) AGN.

- Broad band (from IR to X-rays) SED of Type-1/2 AGN.
- Robust estimate of the nuclear emission ($L_{bol}$, $k_{bol}$).
- $k_{bol}$ versus $L_{bol}$ at [0.5-2]keV and [2-10]keV.
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545 X-ray selected radio quiet Type 1 AGNs from the XMM-COSMOS wide field survey (2 deg$^2$, 1822 sources, $\langle t \rangle \sim 50$ ks, Brusa et al. 2010) → 322 spectroscopically identified
→ Additional 223 AGNs with a Type 1 SED from the photo-z sample (Salvato et al. 2009)
wide range of redshift $0.04 \leq z \leq 4.25$, wide range of X-ray luminosities $40.6 \leq \log L_{[2-10]keV} [\text{erg s}^{-1}] \leq 45.3$
UV to X-ray Properties

$\alpha_{\text{ox}}$ vs $L_{2500\text{Å}}$

- Red crosses = photometric sources
- Black circles = spectroscopic sources
- Slope = 0.14 for an optically selected sample (Steffen et al. 2006)
- Slope = 0.15 for our X-ray selected sample
- Highly significant correlation (17 $\sigma$ from Kendall-$\tau$)
- $\Delta \alpha_{\text{ox}} = \alpha_{\text{ox}} - \alpha_{\text{ox}}(L_{2500\text{Å}})$
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UV to X-ray Properties

$k_{\text{bol}} \text{ vs } \alpha_{\text{ox}}$

Log $k_{\text{bol}} = 1.561 - 1.853\alpha_{\text{ox}} + 1.226\alpha_{\text{ox}}^2$

- 343 Type 1 AGN with detection in both [0.5-2]keV and [2-10]keV
- $1\sigma = 0.078$
- $3\sigma = 0.234$
- $\alpha_{\text{ox}} \rightarrow$ estimate of $k_{\text{bol}}$
- if the $L_{[2-10]\text{keV}}$ is available (from X-ray spectra) $\Rightarrow$ compute $L_{\text{bol}}$
- no need of multiwavelength data and SED extrapolation
$k_{bol}$ vs $\lambda_{Edd}$ and $\alpha_{ox}$ vs $\lambda_{Edd}$

150 Type 1 AGN with BH mass estimate (using the Mg II line width)
red open circles: 25 Type 1 AGN from Vasudevan & Fabian (2009)
high accretion rate onto SMBH $\rightarrow$ efficient accretion disk $\rightarrow$ prominent UV bump $\rightarrow$ steep $\alpha_{ox}$
The data set

Type-2 AGN:

- **Hard X-ray sources:**
  \[ F_{[2-10]\text{keV}} \geq 2 \times 10^{-15} \text{[erg s}^{-1}\text{cm}^{-2}] \]
  \[ 41.06 \leq \log L_{[2-10]\text{keV}} \leq 45.02 \]
- **secure** optical counterpart
- **spectroscopic** redshift \( 0.045 \leq z \leq 3.524 \)

\[ \Rightarrow 255 \text{ Type-2 AGN} \]
Average SED (AGN+Host-galaxy)

- Multi-wavelength data:
  - SPITZER/MIPS: 160-70-24 $\mu$m
  - IRAC: 3.6 $\mu$m-4.5 $\mu$m-5.8 $\mu$m-8.0 $\mu$m
  - CFHT: J-K-i*-u*band
  - SUBARU, GALEX, XMM-Newton:[0.5 – 2]keV-[2 – 10]keV.
- Rest-frame data interpolation (linear+"smoothing")
- Normalize at 1 $\mu$m luminosity
- Binning & average each bin
**Average SED (AGN+Host-galaxy)**

- Flat average X-ray slope
  \[ \langle \Gamma_X \rangle = 1.12 \] (not corrected for \( N_H \))
- Optical-UV: dominant host-galaxy contribution
- near-IR to mid-IR: increasing contribution from the AGN,

but very few sources with detection at 160-70 \( \mu m \)...
...waiting for far-IR data from Herschel
same number of sources in each bin: 40 AGN per bin.
Binned average SED (AGN+Host-galaxy)

- low luminosity bins $\rightarrow$ SED "galaxy shape"
- high luminosity bins in near/mid-IR $\rightarrow$ flatter SEDs $\rightarrow$ AGN emission
Main goal:

to properly disentangle the emission associated to stellar light from that due to accretion.

1. Stellar mass
2. SFR
3. AGN bolometric luminosity and bolometric correction
SED-fitting

- AGN component: Silva et al. (2004)
Bolometric correction

- 240 Type-2 with $N_H$ and AGN best-fit.
- 109 AGN with $N_H$ from X-ray spectra
- 131 AGN with $N_H$ from HR.
- 306 Type-1 from Lusso et al. (2010).
Bolometric correction

AGN template spectrum from a set of power laws (enforce the relationship between the $\alpha_{\text{ox}}$ and luminosity (e.g., Vignali, Brandt and Schneider 2003)  → AGN bolometric luminosity function & BH mass function

Disadvantage: no window onto the actual variation of $k_{\text{bol}}$ in the real AGN population.

$$L_{\text{bol}} = 1.0 \times 10^{12} \ L_\odot$$

![Graph showing the bolometric correction and AGN spectrum with various power laws and luminosity functions.](image-url)
Bolometric correction

The bolometric output of AGN

Log $L_{[2-10] \text{keV}} = 43.30 \div 44.30$:

$\langle k_{\text{bol}} \rangle \sim 13 \pm 1$ Type-2

$\langle k_{\text{bol}} \rangle \sim 23 \pm 1$ Type-1

(significantly different at the 7$\sigma$ level)
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(significantly different at the 7$\sigma$ level)
Bolometric correction: Type-2 AGN (preliminary!!)

The bolometric output of AGN

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Bolometric correction: Type-1 AGN (preliminary!!)

The bolometric output of AGN

[0.5-2]keV

[2-10]keV
Bolometric correction: Type-1 vs. Type-2 AGN (preliminary!!)

The bolometric output of AGN
Summary & Conclusions

1. Significant correlation between $\alpha_{\text{ox}}$ and the UV luminosities.

2. Significant correlation between both $k_{\text{bol}}$ and $\alpha_{\text{ox}}$ with $\lambda_{\text{Edd}} = \frac{L_{\text{Bol,1\mu m}}}{L_{\text{Edd}}}$: high accretion rate $\Rightarrow$ large UV bump $\Rightarrow$ steep $\alpha_{\text{ox}}$.

3. Significant correlation between $k_{\text{bol}}$ and $\alpha_{\text{ox}}$: estimate of $L_{\text{bol}}$ without multiwavelength data.

4. Trend of smaller $k_{\text{bol}}$ for Type-2 AGN than Type-1 AGN at a given X–ray luminosity.

5. Correlation between $k_{\text{bol}}$ (at [0.5-2]keV and [2-10]keV) and $L_{\text{bol}}$ for both Type-1 and Type-2 AGN.