The Compton-thick growth of Supermassive Black Holes constrained

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SMBH growth

- Local Universe: $10^{6-10} M_\text{\textsc{x}}$ black holes
  - How and when did they get there?
  - Interaction with hosts? As gal-form tool
- Growth mode: AGN
  - Inflow, self-heating radiates as AGN, proportional
SMBH growth channels

- How to get 0.5% of bulge mass into <0.0001% of the volume?
  - Angular momentum problem
  - One efficient way: major mergers
  - In any case:
    
    *matter feeding* can be *matter obscuring*

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Alexander & Hickox 2012
Census of SMBH growth

Need census over cosmic time of AGN

- unobscured: \( N_H = 10^{20-22}/\text{cm}^2 \)
- mildly obscured: \( N_H = 10^{22-24}/\text{cm}^2 \)
- heavily obscured: \( N_H = 10^{24-26}/\text{cm}^2 \) (CTK)
X-ray Selection

- **Why?**
  - Fewer objects, longer exposures, but:
  - Selection function understood (photo-el. Abs.)
  - Little contamination from non-AGN
2-10keV Selection

at z=0: misses heavily obscured AGN

at z=1-3: use cosmic particle decelerator

largest (~100) sample of CTK AGN Brightman+14
Characterisation of AGN

- inflow rate
- inflow obscuration
- inflow time

\[ \text{Accretion luminosity intrinsic (abs.-corr.)} \leftrightarrow \text{LOS column density} \]

\[ \text{Redshift} \]
Redshift

- Not possible from X-ray alone
  see XZ: C. Simmonds

- Association with multi-λ: not trivial
  see NWAY talk: M. Salvato

- Redshift estimation
  - spec-z: expensive
  - photo-z: hard for AGN → M. Salvato, LT. Hsu

- How much to trust & when not to trust a z
  - z with uncertainties, propagate
  - include sources w/o redshift Aird+10
L, \( N_H \) from X-ray spectrum

Scattered Powerlaw component

CTK flat spectrum + FeK line
L, $N_H$ from X-ray spectrum
L, $N_H$ from X-ray spectrum

- **MCMC (emcee/GW)**
  - Simple fitting: One minimum
  - MCMC: One minimum
    - convergence tests can be fooled

- **Nested Sampling (BXA/Multinest)**
Population inference

X-ray point source spectra
Assumptions on LF shape

- Density $\varphi(L_x, z, N_H)$

- Shift in field to verify if
  - assumed double-PL evolution is simple
  - or complex (LDDE)

- Miyaji+15 split sample, check LF in bins
- Aird+10,+15 bending PL of obsc, unobsc evolution via polynomials
- Buchner+15 smooth fields fewest assumptions, large uncertainties
Compton-thick Luminosity Function

- Reconstruction of a smooth field
- Results insensitive to chosen smoothing length
  0.5 mag between bins
- Consistent Cthin total LF with Ueda+14, Aird+10, Buchner+15
Obscured fractions

Total number density

• Obscured fraction: \(77^{+4}_{-5}\%\)

• Compton-thick fraction: \(38^{+8}_{-7}\%\)

Ricci+16: Swift/BAT
Annuar in prep: NuSTAR z=0
Wilkes+13: Radio, z~2 CTK fraction < 40%
see talk Mateos+17 for upper limit z<1
Obscuration–Luminosity evolves

Consensus in works correcting for selection biases:

Evolution is not only L-dep Edd-rate-dep?

see Buchner+17b

Buchner+15

CTK L-dep in local Universe: Ricci+16
Total luminosity emitted

\[ L_{\text{total}} = \sum \text{unobscured} + \sum \text{CTK} + \sum \text{CTN obscured} + \sum \text{unobscured} \]
Black Hole Mass Accretion

Convert to mass flowing into BH
Accretion consistent with local BHMD

in prep., see also Merloni15

ε=10%

Bol. Corr.:
Marconi+04
not Hopkins+07
Mergers

![Graph showing the relationship between log (Lbol) [erg/s] and fraction of AGN in mergers.](Treister+12)

![Graph showing the cumulative BH growth (mergers/total).](Redshift)
Mergers
Summary

- CTK ~ 1/3 (in number and accretion)
- Obscured ~ 3/4 (in number and accretion)
- Mergers are majority growth mode

- Beware of pitfalls of simple methods
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- Impact of galaxy-scale gas on obscuration?
  - Poster, Buchner+17a,b

- Poster: New CLUMPY X-ray spectral model