Infrared Excess sources: Compton Thick QSOs at z~2?

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X-ray Background models

Compton Thick AGN \((N_H > 2 \times 10^{24} \text{cm}^{-2})\) required by models for the XRB
Finding Compton Thick AGN: X-ray vs mid-IR

Hard to detect below $\sim10$keV

mid-infrared (3-20µm): alternative wavelength regime for finding obscured AGN

$N_H = 2 \times 10^{24}$ cm$^{-2}$
Infra-Red EXcess source selection

- $f_{24\mu m}/f_R > 1000$
- $R-[3.6] > 3.7$
- mean redshift, $z \sim 2$

Daddi et al. 2007, Fiore et al. 2008, 2009 (IRX sources)
Dey et al. 2008 (DOGs)
IRX sources: Compton Thick QSOs?

X-ray stacking: hardness ratio consistent with Compton Thick AGN ($N_H > 2 \times 10^{24} \text{cm}^{-2}$).

X-ray faint: 2-3dex fainter than typical AGN. Evidence for CT QSOs ($L_X >> 10^{43} \text{erg/s}$).
IRX sources: Compton Thick QSOs?

X-ray stacking: hardness ratio consistent with Compton Thick AGN ($N_H > 2 \times 10^{24} \text{cm}^{-2}$).

X-ray faint: 2-3dex fainter than typical AGN. Evidence for CT QSOs ($L_X > > 10^{43} \text{erg/s}$).
IRX sources: Compton Thick QSOs?

X-ray stacking: hardness ratio also consistent with moderate obscured AGN ($N_H \sim 10^{23}\text{ cm}^{-2}$).

X-ray faint: also consistent with moderate/low luminosity AGN.
IRX sources: Compton Thick QSOs?

X-ray stacking: hardness ratio also consistent with moderate obscured AGN ($N_H \sim 10^{23} \text{cm}^{-2}$).

X-ray faint: also consistent with moderate/low luminosity AGN.
IRX sources: Compton Thick QSOs?

The nature of IRX sources is controversial:

Compton \textit{Thick} QSOs at z\sim 2 (Daddi07, Fiore08, 09)?

\textbf{OR}

Compton \textit{Thin} moderate-$L_X$ AGN
(Georgantopoulos08, Donley08, Pope09)?
Selection of z~1 sources with IRX SEDs

- AEGIS + CDF-North
- UV to far-IR photometry: RAINBOW* Database
- Select z~1 sources with SEDs that satisfy the IRX selection criteria at z=2:
  - $f_{24\mu m}/f_R>1000$
  - $R-[3.6]>3.7\text{mag}$

*http://guaix.fis.ucm.es/rainbow

Perez-Gonzalez et al. 2008
Selection of $z\sim1$ sources with IRX SEDs

- AEGIS + CDF-North
  - Total of 21 sources with far-UV to 70$\mu$m SEDs
  - 2-10keV counterparts for $9/21$ sources
X-ray detected IRX sources: X-ray spectral analysis

9 IRX sources have 2-10keV counterparts
- \( N_H \sim 10^{21} - 5 \times 10^{23}\text{cm}^{-2} \)
- \( L_X \sim 10^{42} - 2 \times 10^{44}\text{erg/s} \)
X-ray detected IRX sources: SED fits

9 IRX sources have 2-10keV counterparts:
- star-formation contributes to mid-IR
- AGN torus component is required for all X-ray detected IRXs with $L_X > 10^{43}$ erg/s

Fit models to SED: Rowan-Robinson et al. 2005, 2008
X-ray detected IRX sources: SED fits

9 IRX sources have 2-10keV counterparts
- star-formation contributes to mid-IR
- QSO torus component is required for all X-ray detected IRXs with $L_X > 10^{43}\text{erg/s}$
IRX sources w/o X-ray counterparts

12 IRX sources w/o X-ray detection
- SEDs consistent with starburst activity
- No evidence for AGN component at mid-IR
- AGN intrinsic luminosity $<10^{43}$ erg/s
Conclusions

• z~1 sources with IRX SEDs: no evidence for luminous \((L_X>10^{43}\text{erg/s})\) Compton Thick \((N_H>2\times10^{24}\text{cm}^{-2})\) AGN.
  – X-ray spectra consistent with moderate column densities \((N_H\sim10^{23}\text{cm}^{-2})\)
  – Star-formation contributes/dominates the mid-IR.

• The population of IRX sources at z~2 is likely to be dominated by Compton thin, moderate/low luminosity AGN.