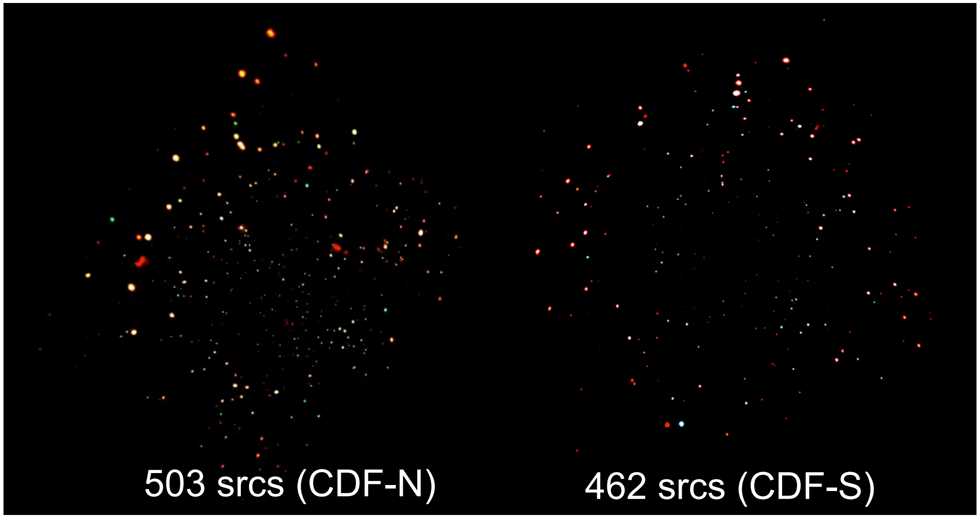
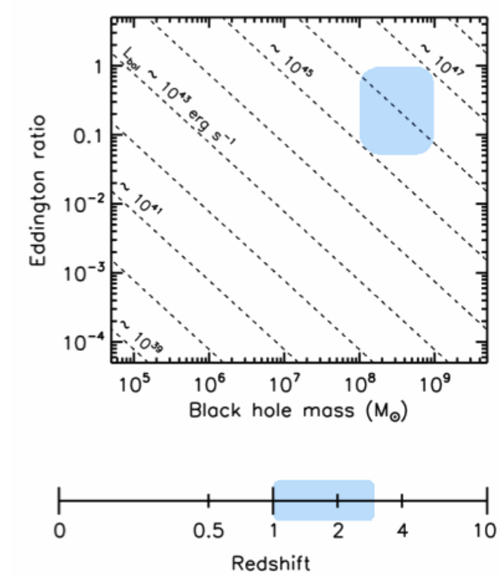
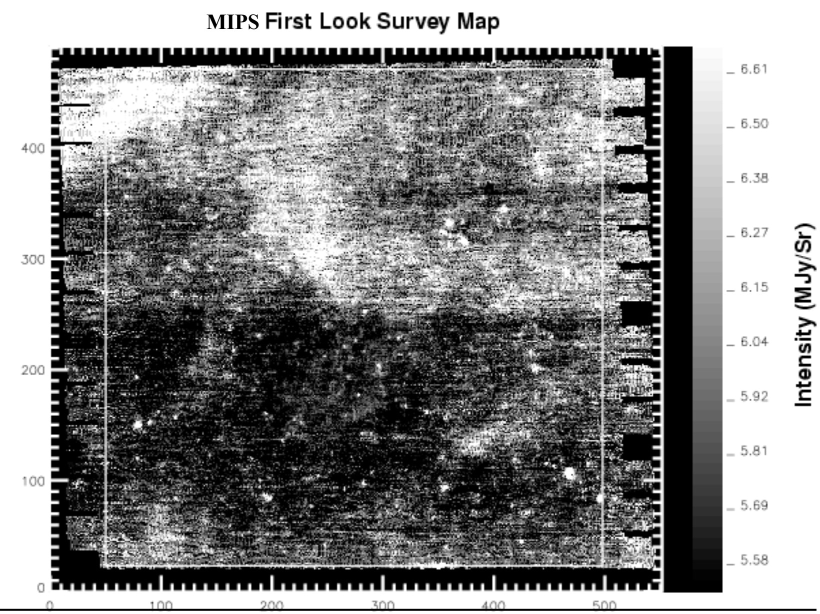
Assessing Obscured Quasars at $z \sim 2$







Franz Bauer (SSI, PUC),
D. Alexander (Durham),
A. Sajina (SSC),
L. Yan (SSC),
+ CDF-S 2Ms team

Abstract

To explain many of the characteristics of modern-day galaxies, successful models of galaxy formation and evolution must typically invoke some form of self-regulated heating or feedback. Although the precise physical mechanisms by while such feedback can be transferred from its sources to sinks is still a matter of debate, powerful active galactic nuclei remain one of the most obvious and viable candidates. Among AGN, Compton-thick quasars are duly considered one of the most likely possibilities for harnessing the AGN power as feedback for galaxy evolution, but have been to date relatively difficult to find. We present here recent estimates of the obscured quasar number density from deep X-ray and IR spectroscopic surveys

Some Issues

Successful models of galaxy formation and evolution need some form of self-regulated heating or feedback to achieve consistency with observations. AGN accretion energy is debated as the best choice for feedback because it can act on galaxy *and* cluster scales. Yet the form of this feedback is not observationally well-determined. While outflows in a few X-ray broad-absorption line quasars may provide sufficient feedback energy required by the above models (e.g., Chartas et al. 2009), but outflows from more common local AGN fall well short by ~1-2 orders of magnitude (e.g., Krongold et al. 2007). **Thus we appear to need quasar-mode accretion. A partially or fully-obscured phase may be preferred to transfer more momentum.**

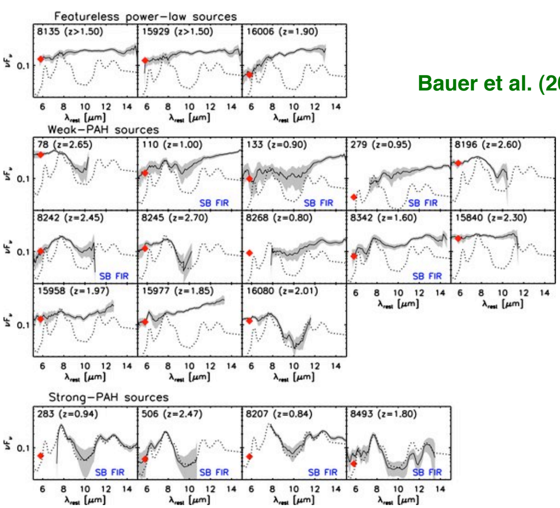
Quasars are the only large AGN population that appear to be accreting close their Eddington limits, providing rapid growth of their SMBHs. Most AGN (i.e., Seyfert-luminosity) accrete well below this, implying any major growth period for them was much earlier, perhaps as quasars. Quasars lifetimes, however, appear to be pretty short (~10^7 yrs), and **thus it is uncertain how/when SMBHs were grown so large. A longer, obscured phase where SMBHs are hidden would help (e.g., Page et al. 2004).**

Finally, the space density of luminous quasars peaks at high redshifts (i.e., z~2), often dubbed cosmic downsizing of AGN. This should thus be the epoch of strongest feedback, where many observational relationships (e.g., M_{BH} vs M_{Bulge} vs σ) are established. Quasar space densities are well-constrained at this epoch, but obscured quasar space densities are not. **To place better constraints on the total SMBH growth occurring, we need to constrain the space densities of obscured quasars.**

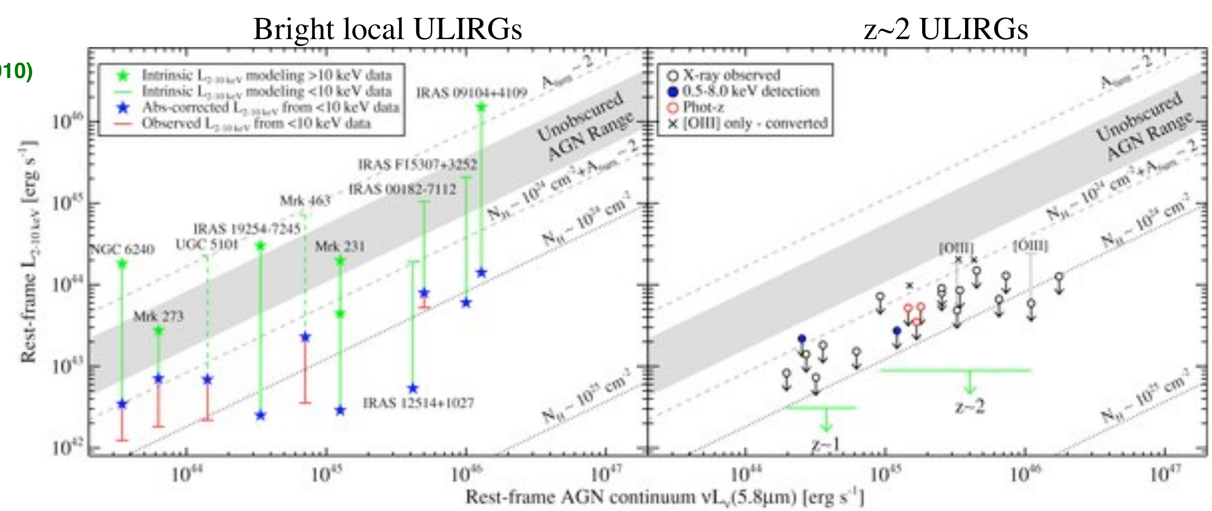
We present here recent estimates of the obscured quasar space density from deep X-ray and IR spectroscopic surveys...

Mid-IR Selected Obscured Quasars at z~2

ULIRGs have long stood out as candidates for highly obscured accretion onto SMBHs (e.g., Sanders & Mirabel 1996), with many now confirmed as Compton-thick AGN (below middle). Because *Spitzer* can observe ULIRGs out to z~3-4, they offer a natural obscured complement to quasars. Here we study 20 out of 50 ULIRGs identified from the *Spitzer* First Look Survey (xFLS) with f_ν(24 μm)>0.9 mJy, νf_ν(24 μm)/νf_ν(R)>10, and νf_ν(24 μm)/νf_ν(8 μm)>3 (Yan et al. 2007, Sajina et al. 2007, 2008, Bauer et al. 2010). These heavily obscured objects are unique, all having: optical spectra IDs, *Spitzer* IRS spectra (below left) with deconvolved starburst and AGN continuum components, radio and X-ray constraints (below right). The sample is dominated by weak-PAH ULIRGs with hot-dust continua, characteristic of AGN activity, with AGN bolometric luminosities of 10^{45}-10^{47} erg s^{-1} comparable to powerful quasars. Nearly all lack any detectable X-ray emission, however, even when stacked (green limits). Using the IRS-derived 5.8 μm AGN continuum luminosity as a proxy for L_X, coupled with high IR-to-optical ratios and often significant silicate absorption, strongly argues that the majority, if not all, are likely to be at least mildly Compton-thick (N_H >10^{24} cm^{-2}), comparable to local equivalents.

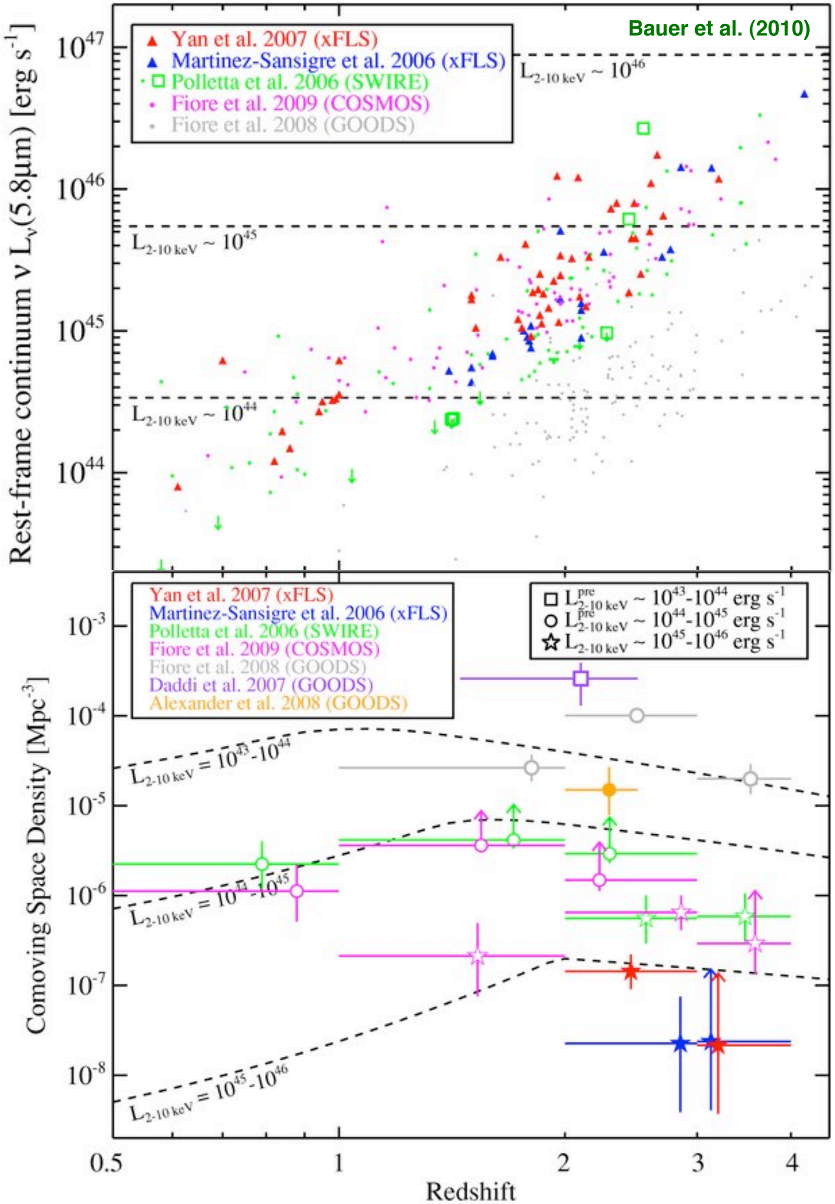


Bauer et al. (2010)



Tuesday, July 27, 2010

Mid-IR Selected Obscured Quasars at z~2

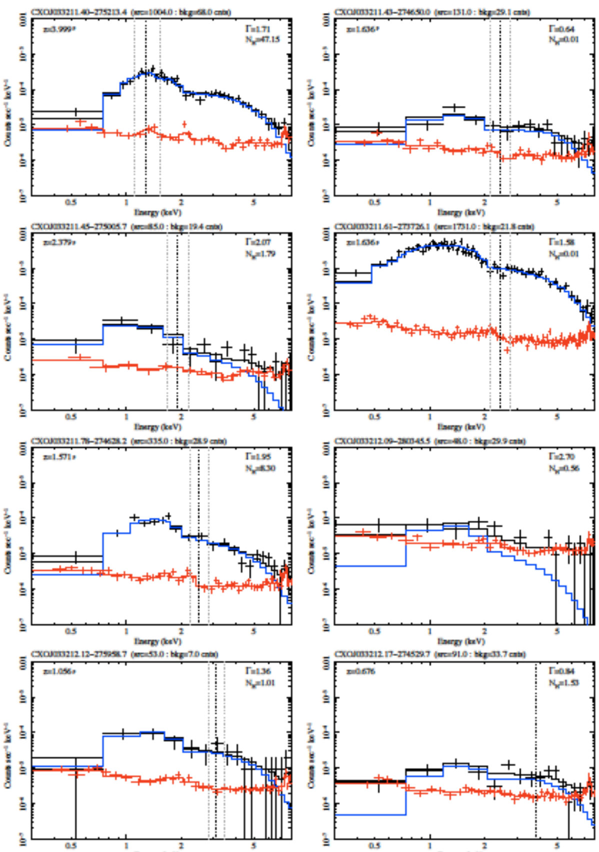


The xFLS ULIRGs are comparable to the most luminous ULIRGs from larger or deeper mid-IR surveys (top left). Thus they provide well-observed templates to aid in the interpretation of similar objects from these photometric-only samples, where considerable uncertainty about source properties remains (e.g., AGN fractions) and comparable follow-up is not yet feasible. Unfortunately, the relatively high flux cutoff of the xFLS sample means it is highly incomplete except in the highest L_X bin (dashed lines).

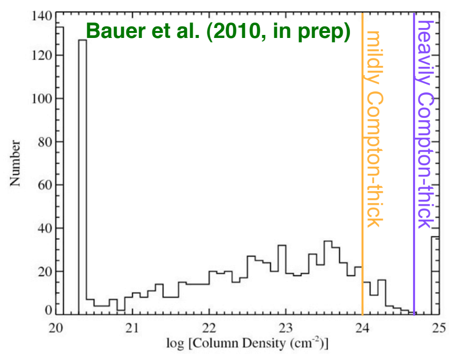
Selected space densities for the various ULIRG samples (lower left). The xFLS primarily samples highly-luminous Compton-thick QSOs, while fainter samples probe more common moderate L_X quasars and Seyferts. At face value, mid-IR derived Compton-thick AGN rates are already crudely in line with CXRB models (dashed lines; Gilli et al. 2007), although these could be considered lower limits since mid-IR extinction and incompleteness are not corrected. On the other hand, low-luminosity mid-IR selected “AGN” probably suffer from heavy star formation contamination/bias and are overestimated.

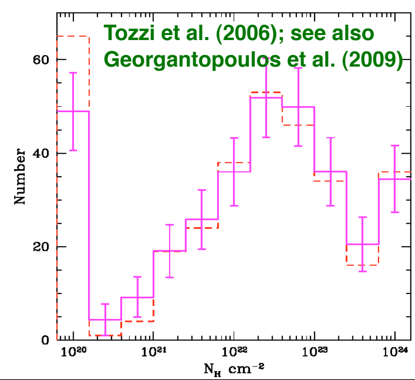
X-ray Spectra-Selected Obscured Quasars at z~2

X-ray spectroscopic sample of ~950 objects from 2Ms Chandra Deep Fields North/South. There are IDs and redshifts for 98% of sample. Example spectral fits are below.

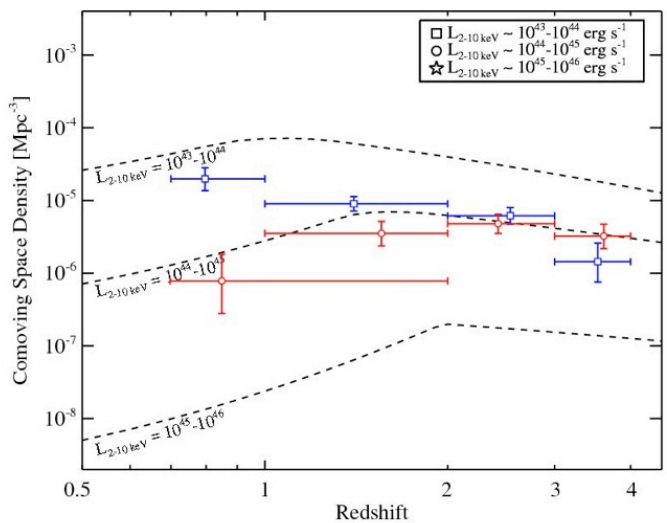


Preliminary: N_H distribution from simple absorbed powerlaw to data, with high-confidence pure $\Gamma<1$ reflection objects considered heavily Compton-thick with ~4% reflection fraction (previous work below).





Preliminary: space densities for only the Compton-thick (>10^{24} cm^{-2}) AGN among the CDF sample. We are still biased against low-reflection fraction objects (i.e., most obscured, which we hope show up in mid-IR). In the Lx=10^{44} -10^{45} erg/s bin from z=1-4, where X-ray surveys appear most complete, the data match recent CXRB model estimates (Gilli et al. 2007).



Some Conclusions

* The deep mid-IR and X-ray surveys have begun to yield highly-obscured AGN in large numbers.

* Combining the observed mid-IR and X-ray space densities, for which the amount of source overlap appears small, we arrive at space densities of roughly the same order of magnitude as model predictions now (perhaps a factor of 1.5-2 higher) across most relevant probed redshifts. *A strong caveat here is that there are still factor of ~2 uncertainties, on one side in terms of mid-IR and X-ray sample incompleteness and mid-IR extinction, and on the other in terms of mid-IR flux contamination by star formation.*

* It remains to be seen how/when SMBHs grow most rapidly, but it is encouraging that we now have sizable samples of obscured quasars, at what we believe is the peak accretion epoch, that we can target for further investigation of their feedback signatures.