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• Which QSOs do we need to look at?
• Submm emission in QSOs
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• Winds from nearby AGN: we need the physics as well.
The black hole/bulge mass relation tells us that the formation of spheroids and black holes are intimately linked.

QSOs had their heyday at $z \sim 2$.
- Most vigorous period of black hole growth.
- If black holes and stars grow together, QSOs should also be forming stars rapidly.

Peak of star formation rate also at $1 < z < 3$.

Boyle et al. 1988, MNRAS 235, 935:


Most of the accretion luminosity comes from close to the knee in L.F.
• Drew samples of QSOs
  – 1<z<3
  – close to L*
  – that we ought to be able to detect with SCUBA.

• Two samples of QSOs:
  – X-ray unabsorbed
  – X-ray absorbed
X-ray absorbed and X-ray unabsorbed QSOs are completely different in submm, i.e. star formation.

Page et al. 2001, Science, 294, 2516
What does this mean?

• X-ray absorbed QSOs are ULIRGs/hyperLIRGs
  – The objects have $L_{\text{FIR}}$ between 1 and 4 times $L_{\text{AGN}}$ – must be star powered.
  – Can’t be to do with orientation.
• Therefore they probably form part of an evolutionary sequence.
  – Bulge not finished yet - earlier than typical QSOs.
  – Black holes already large - must be later than typical submillimetre galaxies.
  – Only about 10% as numerous as normal QSOs.

X-ray absorbed QSOs are a brief transition stage between the ultraluminous starburst and the unobscured QSO phase.
XMM-Newton spectra

What is the absorption? cold gas or ionised gas?

- Cold absorbers:
  - $\chi^2/\nu$ is OK, but funny residuals, abnormal distribution of $\Gamma$
  - Underlying spectra would not be normal for QSOs!

- Ionised absorbers:
  - Reasonable fits, reasonable $\Gamma$, no funny residuals.

$\Gamma=1.3 +/- 0.1$  $\Gamma=1.4 +/- 0.1$  $\Gamma=1.4 +/- 0.1$

Tells us: The absorbers are probably ionized
We need much better X-ray spectra

Ionised winds and QSOs

- RGS on XMM-Newton has told us:
  - AGN ionised absorbers are almost always winds.
  - They contain little dust - probably sublimated as it joins outflow.
  - Most of the absorbing gas seen only in the X-ray.
  - Even the weedy Seyferts of today can have large mass outflow rates $M_{\text{out}} > M_{\text{acc}}$.
- QSOs with ionised winds are rapidly forming stars.
- The winds are probably scaled up versions of Seyfert winds.
- Winds look to be very important in the evolutionary connection between AGN and galaxy formation.

These winds can eject a lot of material, so could they be fundamental to QSO evolution in general?
Completely different angle on importance of ionized winds in QSOs:

- UV BALs in 15% of QSOs
- Extremely faint in X-rays: heavily absorbed
- CIV 6x more common than MgII
- Higher ionisation lines only visible in X-rays
- Huge discovery potential for IXO

For all we know, the other 85% of QSOs could have fast outflows at higher ionisation, only detectable in X-rays
We won’t find out what ionized winds do in QSOs until IXO.

- Take a “typical” QSO, simulate an IXO spectrum with a toy model.
- $z=2$, $L=10^{44.5}$ (0.5-2 keV), Galactic column of $2 \times 10^{20}$ cm$^{-2}$
- Add absorption lines from OVII, Fe
- Assume saturated lines with FWHM = 3000 km/s
- Include Fe UTA and 6.9 keV lines at similar to those in NGC3783.
- Illustrative only - no edges, very few abs lines, no emission lines, power law continuum.
- Guilty confession*: simulated with TES response matrix from an ESA/JAXA mission beginning with X, 100ks exposure

* But you’ll get the point.
The results:

Fe UTA is easy

Other lines possible if broad

We can get the dynamics, column densities, outflow rates, abundances, etc for QSO outflows!
What about the Fe K lines?:

Fe K absorption lines almost impossible

We really need the low energy response on IXO!
BUT!
We also need something else to understand ionized outflows in QSOs.

- We need to understand the **physics** of AGN outflows in bright, nearby AGN before we can apply it to our z=2 observations.
- Fantastic advances in the last 10 years, but our understanding is still terribly limited.
- **Fundamental** problem is that we have never had X-ray spectra with high enough resolution.
The best studied AGN warm absorber: NGC3783

Today’s resolution

Tomorrow’s resolution

This is our current estimate of what the spectrum actually looks like.

Only the IXO XGS tells us what the spectrum actually does look like.
• Today, we don’t resolve the X-ray absorption line profiles in any AGN with any instrument.
  – We don’t know if the X-ray source is fully covered.
  – We don’t know what the velocity dispersions of the outflows are, or whether they consist of multiple components.
  – We don’t know where they come from.
  – We can’t be certain how much mass or energy is carried in the outflows.
  – We don’t know how they are driven.
  – We don’t know what they do to the AGN or to the surrounding galaxy.

• We need to resolve the absorption lines to answer all these fundamental questions.
Conclusions

• X-ray absorbed QSOs at z=2 have ionized winds, and are hosted by ultraluminous galaxies with huge star formation rates.
• The absorbed QSOs appear to represent a transitional phase between submillimetre galaxies and QSOs.
• These winds could be the terminators of star formation and accretion.
• Incidence of UV broad absorption lines as a function of ionization also shows that highly ionized X-ray absorbing winds could be very important in the evolution of QSOs.
• Huge discovery space for IXO in understanding the role of winds in QSO evolution.
• The IXO grating spectrometer is fundamental to show us how AGN winds work.
• Soft X-ray response of cryogenic spectrometer is very important to tell us about z~2, the epoch of galaxy formation.