Connecting Galaxy Evolution, Star Formation and the X-ray Background

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The redshift distribution of the sources peak at $z \lesssim 1$.

Quasars, the most powerful AGN, are mostly found at $z \sim 2-3$.
The sources typically have X-ray luminosities < \(10^{44}\) erg/s

Again much less than quasars (> \(10^{45}\) erg/s)
Connection to Star-Formation History?

Juneau et al. (2005)
The peak in the XRB z dist’n is close to where the cosmic SFR reaches its max

The sources which produce the XRB are mostly obscured Seyfert-like AGN

Hypothesis:

- The increase in obscured AGN to z~1 is directly related to the increase in the cosmic SFR
- i.e., the obscuration around the AGN is regulated by the host galaxy SFR -> it must evolve with z

Prediction:

- a Type 2/Type 1 ratio that evolves with z
Barger et al. (2005)
Testing the model

- Compute an XRB synthesis model and determine if there is a model that can simultaneously account for
  - the spectrum of the XRB
  - the number counts of X-ray sources in the 0.5-2 and 2-8 keV bands
  - the Broad-Line AGN fractions measured by Barger et al.
Ueda et al. (2003)
The $N_H$ Distribution

- Need to specify what fraction of AGN are absorbed by a specific column
  - in general, will be a function of $z$ and $L$
  - only observed constraints are local
- Define AGN absorbed by columns with $N_H < 10^{22}$ cm$^{-2}$ as Type 1; otherwise, Type 2
- 10 $N_H$ bins are defined: $\log N_H = 20, 20.5, \ldots, 24, 24.5$
- As a first try use a flat distribution
  - also used the Risaliti et al. (1999) dist’n where 50% of all Sy 2s are Compton thick
Methodology

- First search for an evolution in the AGN Type-2/Type-1 ratio, $R$, that best accounts for the Barger et al. data
  - four different (arbitrary) parameterizations are used
  - all have a $(1+z)$-term
  - $z$ evolution is halted at $z=1$

- One other free parameter is the value of $R$ at $z_{\text{min}}$ and $L_{\text{min}}$, $R_0$
  - consider models with $R_0$ varying from 1,2,..,9,10
Results

$R_0 = 6$

Type 1 fract. $\propto (1+z)^{-1.9}$

Ballantyne et al. (2005)
$R_0=6$

Type 1 fract. $\propto (1+z)^{-1.9}$

Ballantyne et al. (2005)
Results

$R_0=4$ (cf., Maiolino & Rieke 1995)

Type 2 fract. $\propto (1+z)^{0.3}$

Ballantyne et al. (2005)
$R_0=4$ (cf., Maiolino & Rieke 1995)

Type 2 fract. $\propto (1+z)^{0.3}$
Results

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Ballantyne et al. (2005)
Implications

The absorbing gas around an AGN is regulated by SF processes in the host galaxy. The obscuring medium could be spread over a range of radii.

MCG-6-30-15; Malkan et al. (1998)
Implications

- The star formation and AGN in these galaxies are fueled by interactions and minor mergers.
- Seyferts are distinct from quasars in more than their luminosity!

NGC 1531 & 1532
Conclusions

- The Barger et al. (2005) Type 1 fractions indicate that $z$ evolution of $R$ is required
- A model which can account for the Barger data, the CXRB spectrum and number counts has $R_0 = 4$
  - The Type 2 fraction in this model evolves as $(1+z)^{0.3}$
- A simple, non-evolving torus cannot alone provide the AGN obscuration over all cosmic time
  - the shape of the CXRB spectrum is due to obscuration correlated with the SFR in the host galaxy
- Seyfert galaxies, which mainly produce the CXRB, are likely fueled by minor mergers and interactions
  - there may be a sig. delay b/w the interaction and the subsequent ignition of the AGN
Results

$R_0=1$ (Hao et al. 2005)
Type 2 fract. $\propto (1+z)^{0.9}$
Results

$R_0=1$ (Hao et al. 2005)

Type 2 fract. $\propto (1+z)^{0.9}$