AGN variability and the links between star formation and black hole growth

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Illustration courtesy NASA
Do all star-forming galaxies host AGN?
Differences between AGN hosts and other comparable galaxies appear to be **small**

**Colors**

- (a) $0.0 < z < 1.0$, mass-matched
- (d) $1.0 < z < 2.0$, mass-matched

**Morphologies**

- F775W ($i$ vs. $H$)
- Spheroids
- Disks
- Mergers / Interactions

**Clustering**

- (b) $0.0 < z < 1.0$, mass-matched
- (e) $1.0 < z < 2.0$, mass-matched

- AGN fraction
- $10^{41.9-43.6}$
- $10^{43.0-43.7}$

- (c) $0.0 < z < 1.0$, mass-matched
- (f) $1.0 < z < 2.0$, mass-matched

- Fraction (%)
- Pure Disk
- All Disks
- Pure Spheroid
- All Spheroids
- Irr/Pec
- Point-Like
- Disturbed I
- Disturbed II
- Companion
- Undisturbed

**e.g.,** Xue et al. (2010)

**e.g.,** Kocevski et al. (2012)

**e.g.** Hickox et al. (2009)
Little clear connection between AGN luminosity and star formation rate?

\[ \text{e.g. Rosario et al. (2012)} \]
BUT......

1. AGN and SF have qualitatively similar *cosmic* evolution

AND

2. Both require a supply of cold gas

How to reconcile these?

Galaxies have **a wide range of accretion rates**:
Hopkins et al. (2009) Aird et al. (2012), Bongiorno’s talk
These differences can be caused by variability!

Muno et al. (2007), Ponti et al. (2010)

Schawinski et al. (2010)
What does it mean for an AGN to be “on”?

A fluorescent bulb at 1000 frames per second (http://www.youtube.com/watch?v=5pNtjOYkAbA)
AGN vary much faster than star formation

Novak et al. (2011)
Variation over many orders of magnitude
BUT...

NOT observable as "variability"

Wang et al. (2010)
A simple ansatz:

Average BH accretion is perfectly correlated to global star formation

What would this actually look like?
INGREDIENTS

1. Observed infrared luminosity function (Rodighiero et al. 2010)

2. Average BH accretion rate = SFR / 1000
   (motivated by Magorrian et al. 1998)

3. Instantaneous AGN luminosity follows a distribution from the model of Novak et al. (2011)

4. $L_{\text{AGN}} = 0.1 \times \text{BHAR} \times c^2$

5. Kennicutt (1998) relation between SFR to $L_{\text{IR}}$
Increase with $z$ of SFR in massive galaxies

$L_{\text{SF}} \propto L_{\text{AGN}}^{0.8}$

Shao et al. (2010)
This is observed!

Chen et al. (see poster)

Mullaney et al. (2012)
The AGN luminosity function

Convolve scaled IR LF with the model instantaneous accretion rate distribution

Aird et al. (2010)

Rodighiero et al. (2009)
Full disclosure

- Observed AGN LF
  - Hopkins et al. (2007)
  - Aird et al. (2010)

- Scaled IR LF (SF)?
  - Rodhiero et al. (2010)

- AGN variability model

$z = 2.0$
CONCLUSION:

To first order (and on galaxy evolution timescales) these are the same objects
OPEN QUESTIONS

Is there a **universal accretion rate distribution**? Can we accurately measure it? What produces it?

**AGN in “passive” galaxies?** Is this a different mode of accretion (i.e. not fueled by cold gas?) How common are these?
CONCLUSION:

“AGN” = “Normal”?