Investigating the AGN-Merger Connection at z~2 with CANDELS

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with
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Mergers have long been an attractive AGN fueling mechanism. Would help explain scaling relations between BH mass and bulge mass and velocity dispersion. Previous searches failed to find a convincing AGN-merger connection out to z~1. Especially true for moderate-luminosity AGN, many of which are found in normal spirals.
Two fueling modes: merger-driven accretion & stochastic accretion

Frequency of merger-driven accretion evolves rapidly with redshift. At z~2, mergers expected to be dominant fueling mode.
Wide Field Camera 3

Rest-Frame UV  

V  z  Y  J  H

z=1.55  Rest-Frame Optical
X-ray AGN in GOODS-S

- Selected z~2 AGN using:
  - CANDELS WFC3 H-band imaging.
  - Chandra 4 Msec dataset in CDFS. Deepest X-ray data available.

- Nandra et al. 4Ms source catalog contains 569 sources in CDFS.

- Likelihood Matched to WFC3 H-band catalogs.

- Redshift Determination:
  - Silverman et al. (2010) – Spect-z
  - Wuyts et al. (2010) – Photo-z

- Results in 72 AGN at 1.5 > z > 2.5.
X-ray Luminosity Distribution

Luminosity limit at z~2: $L_x \sim 10^{42}$ erg/s
Host Morphologies

- F160W (H)
- F775W (i)
- Spheroids
- Disks
- Mergers / Interactions
- Rest-Frame Optical
- Rest-Frame UV
- z=1.55
- V, z, Y, J, H
Visual Classifications

Disk    Spheroid    Irr / Pec    Compact

Merger    Interaction    Disturbed    2x Nuclei    Close Pair

Classifiers:
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Mass-Matched Control Sample

* Compared against 216 mass-matched control galaxies: \( M_{\text{Host}}/2 < M_{\text{Gal}} < 2M_{\text{Host}} \).
Classification Results

- No excess of disturbed morphs among AGN hosts vs control.
- Majority of hosts undisturbed.
- Disk most common single morphology for AGN hosts.
- AGN associated with spheroids more often control galaxies.
AGN Still Favor Spheroids

* Even in an era where the mass-morphology relationship appears to break down, AGN still preferentially found in spheroidal systems.
Standard Caveats

* May miss AGN-merger connection because:
  * Obscuration
  * Time delay between merger and AGN activity

* Alternative Triggering Mech:
  * Violent disk instabilities (i.e. clumpy disks)
  * Secular processes
  * Minor Mergers

* It appears stochastic accretion plays a larger role in triggering AGN activity at $z \sim 2$ than previously thought.
Morphologies of Compton Thick AGN

- Can test obscuration bias by examining morphs of Compton thick sources.
- Alexander et al. (2011) find 11 sources in CDFS at z~2 with reflection dominated X-ray spectra, suggesting extreme column densities ($N_H > 10^{24}$ cm$^{-2}$).
- Morphology of these sources do not appear considerably different than entire sample.
Constraints on Time Delay Caveat

- May miss AGN-merger connection because:
  - Time delay between merger and AGN activity

- Morphologies:
  - 51% found in Disks (17% bulgeless)
  - 28% found in Spheroids
  - 17% have irregular morphs
  - More bulge-dominated than non-active, massive galaxies.

- Disks may survive major mergers, when gas rich, but unlikely (Bournaud et al. 2011).

- If spheroids = triggered by past major mergers, disks = fed by secular processes, then we find far too little merger activity.
Implications for AGN Fueling Models

- Number density of stochastically fed AGN rival merger-triggered AGN roughly 2 orders of mag below knee.
- Knee in XLF: $L_x \sim 10^{44}$ erg/s (2-10 keV)
- We find 50% disk-like fraction at $L_x \sim 10^{43}$ erg/s
- Implies stochastic accretion plays a larger role in triggering AGN activity at $z \sim 2$ than prev thought.
Alternatives to Mergers

* May miss AGN-merger connection because:
  * Obscuration
  * Time delay between merger and AGN activity

* Alternative Triggering Mech:
  * Violent disk instabilities (i.e. clumpy disks)
  * Secular processes
  * Minor Mergers
Clumpy Disks Among AGN Hosts

* Visually classified the “clumpiness” of AGN hosts from $z=0.5-2.5$.
* Classifications done at same rest wavelength using $i, z, J, H$ bands.
* ACS imaging smoothed to match WFC3 resolution
Clumpy Disks Among AGN Hosts

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Clumpy Disks Among AGN Hosts

Mild increase in frequency of clumpy AGN hosts at $z \sim 2$. 
Clumpy Disks Among AGN Hosts

- Mild increase in frequency of clumpy AGN hosts at z~2.
- Greater increase in clumpy fraction among control population.
Clumpy Disks Among AGN Hosts

- Violent disk instabilities should be visible as clumpy disk morphs.

Control Galaxies

- Some evidence clumpy disks more prevalent among non-active galaxies.
Alternatives to Mergers

- May miss AGN-merger connection because:
  - Obscuration
  - Time delay between merger and AGN activity

- Alternative Triggering Mech:
  - Violent disk instabilities (i.e. clumpy disks)
  - Secular processes
  - Minor Mergers

- It appears stochastic accretion plays a larger role in triggering AGN activity at z~2 than previously thought.
Conclusions

- AGN hosts at z~2 do not show irregular morphs more often than mass-matched non-active control galaxies.
- Undisturbed disks most common morphology
- If disks have not experienced major merger in recent past: stochastic accretion must play a greater role in fueling AGN activity at z~2 than expected.
- Cannot rule out minor mergers.
- Kocevski et al. (2011) – Submitted
CANDELS: THE AGN-MERGER CONNECTION AT Z \sim 2


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ABSTRACT

Using HST/WFC3 imaging taken as part of the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS), we examine the role that major galaxy mergers play in triggering active galactic nuclei (AGN) activity at z \sim 2; the first such analysis at this redshift. Employing visual classifications, we have analyzed the the rest-frame optical morphologies of 72 galaxies at 1.5 < z < 2.5 which host moderate-luminosity (L_X \sim 10^{42-44} \text{ erg s}^{-1}), X-ray selected AGN in the Chandra Deep Field South. To determine if the AGN host galaxies show merger signatures more often than similar non-active galaxies, we compare their morphologies to a sample of 216 mass-matched control galaxies at the same redshift. We find that a majority of the AGN reside in late-type galaxies (51.4%), while a smaller percentage are found in early-type hosts (27.8%) and systems with irregular morphologies (16.7%). Despite the high disk fraction, the AGN hosts are more often associated with spheroids than non-active galaxies of similar mass. Roughly 16.7% of the AGN hosts have highly disturbed morphologies and appear to be involved in a major merger or interaction, while the majority of hosts (55.6%) instead appear relatively relaxed and undisturbed. These fractions are statistically consistent with the fraction of control galaxies that show similar morphological disturbances. Our results suggest that the hosts of moderate-luminosity AGN are no more likely to be involved in an ongoing merger or interaction relative to non-active galaxies of similar mass at z \sim 2. Furthermore, the high disk fraction observed among the AGN hosts appears to be at odds with predictions that merger-driven accretion should be the dominant AGN fueling mode at z \sim 2, even at moderate X-ray luminosities. The presence of a large population of relatively undisturbed late-type hosts suggests that secular evolution and the stochastic accretion of gas plays a greater role in triggering AGN activity at these redshifts than previously thought.

Subject headings: galaxies: active — galaxies: evolution — X-rays: galaxies

Kocevski et al. (2011)

Submitted – on astro-ph soon