No Accounting for Taste: Black Holes Will Eat Anything

Jillian Bellovary
Vanderbilt University
What do Black Holes Eat?

Gas!

• Where does it come from?
• How does it get to the black hole?
Trace accreted gas backwards to determine its origins.
How do galaxies get their gas?

Gas enters the virial radius, shocks, and falls in to the disk.

e.g. White & Rees 78, Keres +05,09, and especially Brooks et al. 2009
How do galaxies get their gas?

Low-mass galaxies simply accrete cold gas.
How do galaxies get their gas?

Even when a shock develops, cold filaments can penetrate the shock.
How do galaxies get their gas?

Of course, mergers deliver gas as well (clumpy)
How do galaxies get their gas?

- **Cold** accretion
  - low mass, filaments
- **Shock**ed accretion
  - high mass
- **Clump**y accretion
  - mergers
How do Black Holes get their gas?

- **Cold** accretion
  - low mass, filaments
- **Shocked** accretion
  - high mass
- **Clumpy** accretion
  - mergers
$z = 4$ simulated galaxies
**z = 4 Galaxy Properties**

<table>
<thead>
<tr>
<th></th>
<th>hz2</th>
<th>hz3</th>
<th>hz4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stellar mass</td>
<td>$1.63 \times 10^{10}$</td>
<td>$2.06 \times 10^{10}$</td>
<td>$9.64 \times 10^{8}$</td>
</tr>
<tr>
<td>Gas mass</td>
<td>$2.36 \times 10^{10}$</td>
<td>$3.62 \times 10^{10}$</td>
<td>$7.53 \times 10^{9}$</td>
</tr>
<tr>
<td>Rest frame B magnitude</td>
<td>-23.6</td>
<td>-24.0</td>
<td>-20.9</td>
</tr>
</tbody>
</table>
Are they visible as AGN?

Nope.

Major mergers

Minor mergers

Kevin’s soft X-ray upper limits

Bolometric Luminosity (erg/s)

Redshift

Time (Gyr)

Minor mergers

Major mergers

Kevin’s soft X-ray upper limits

Bolometric Luminosity (erg/s)
Cold Flows Dominate SMBH Accretion
Composition of galaxy = composition of SMBH
What does it all mean...

<table>
<thead>
<tr>
<th></th>
<th>hz2 halo</th>
<th>hz2 BH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold</td>
<td>62%</td>
<td>66%</td>
</tr>
<tr>
<td>Clumpy</td>
<td>25%</td>
<td>21%</td>
</tr>
<tr>
<td>shocked</td>
<td>13%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Black holes are not picky
Incoming angular momentum matters more!
The Main Points

• Massive-ish $z=4$ galaxies may not have tons of SMBH activity
• SMBHs and their host galaxies have the same composition
• Incoming angular momentum likely critical
Open Questions

• What happens during $0 < z < 4$?
• Where do Kevin’s galaxies fit in?
• What is the angular momentum evolution of the gas as it approaches the SMBH?
• Are there any observational signatures of these growth modes?
• What are the repercussions for $M-\sigma$?
The $z = 4 \ M-\sigma$ relation...

(Proceed with caution)
$z = 3.5$ relation from Moster+ 2010
Composition of young central stars ~
composition of SMBH

- 50 Myr time bins
- Stars formed in central 0.5 kpc
- Gas accreted by SMBH during that time