Growing Black Holes in Galaxy Mergers

Mike Koss  Eureka Scientific

Claudio Ricci (UDP, Chile), Benny Trakhtenbrot (ETH Zürich/Tel Aviv), Kevin Schawinski, Laura Blecha (UF), Richard Mushotzky, Daniel Stern, Meg Urry, Ezequiel Treister, Fiona Harrison, Sylvain Veilleux, and the Swift BAT Team
1. Are galaxy mergers linked to BH growth?

2. Dual Black Holes- Simulations and Observations

3. Sub-kpc mergers
Nearby galaxy mergers are very clear in imaging.
Nearby X-ray Selected AGN show a clear excess of mergers over matched inactive galaxies.

Koss et al. 2010
Highly obscured AGN tend to be preferentially in mergers.

Kocevski et al. 2015
Obscuration peaks at later stages (<10 kpc).

Ricci et al. 2017, see also Koss et al. 2016b.
Luminous AGN show excess of mergers.
Mergers are less numerous, but larger percentage of total black hole growth.

Treister et al. 2012
High resolution X-ray imaging is critical for dual AGN.

Secondary AGN not detected in emission line diagnostics or in radio (VLA) Luminous ($L_{2-10 \text{ keV}}=10^{43}$ and $10^{42}$ erg/s) X-ray Point Sources Likely SF and obscuration hides AGN

NGC 6240 is a very similar case (Komossa et al. 2002)
Large study of 167 galaxies for dual AGN.

Koss et al. 2012
Dual AGN fraction and luminosity increase with separation.

Dual AGN Activity Increases at Closer Separations
X-ray luminosity increases dramatically at small separations (< 5 kpc)
Dual AGN fraction was 10/100x larger than from SDSS
Typical luminosity ratio of ~10

Simulations broadly agree with observations.

Smoothed particle hydrodynamics simulations-Gasoline

Capelo et al. 2017
Eagle Simulations, increasing dual AGN fractions with redshift, offset from observations.
Eagle simulations suggest higher fractions at larger separations because of projections.

Much higher fractions at larger separations than observed. Differing gas fractions?

Rosas-Guevara et al. 2018
Eagle simulations show dual AGN with similar brightness.

Typical luminosity ratio for dual AGN in our sample was 11.

Rosas-Guevara et al. 2018
Most observational studies are limited to scales of several kpc, but greatest activity is in final phase.

Van Wassenhove et al. (2012)
Studying AGN mergers at kpc separations is important to constrain final dynamical friction phase. Backer et al. 2003 gives a prediction about locations of typical black hole binaries/rates mergers.
Large samples of high resolution images of nearby galaxies in the NIR now exist within HST archive.

Most galaxies show boring bulges.
~17% of obscured luminous AGN show hidden mergers
Are these obscured AGN with nuclear mergers the prototypes for GW sources?
Significant excess in luminous obscured AGN
Observations roughly agree with simulations matched in stellar mass, gas fraction, Eddington ratio.
Future approaches to surveying dual AGN, mergers, and black hole growth.
Key Questions:
How does the AGN accretion rate, black hole mass ratios, and obscuration change with merger stage?
How are environments of dual AGN different?
Uses large survey of molecular gases and black hole masses (Palomar/xshooter).
Summary: Galaxy Mergers and Dual AGN

- Mergers linked to black growth across redshifts in luminous AGN
- Black hole growth, obscuration, dual AGN, and mergers consistent with simulations
- Large X-ray and optical surveys necessary to interpret results
- Hidden population kpc scale mergers in obscured AGN in NIR
- Precursor population of SMBH mergers