Quasars, Mergers, and the Formation of Elliptical Galaxies

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Motivation QUASARS AND SPHEROID FORMATION



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"Transition" vs.

- Move mass from Blue to Red
- Rapid
- Small scales
- "Quasar" mode (high mdot)
- Morphological Transformation
- Gas-rich/Dissipational Mergers



"Maintenance"

- Keep it Red
- Long-lived (~Hubble time)
- Large (~halo) scales
- "Radio" mode (low mdot)
- Subtle morphological change
- "Dry"/Dissipationless Mergers



NO reason these should be the same mechanisms



Tuesday, December 25, 12

T = 0 Myr

Gas





Motivation

QUASARS AS PROBES OF GALAXY FORMATION?

- What can we learn from quasar populations?
 - Are they indeed tracing the "transition"?



Hopkins, Richards, & Hernquist 06

LF vs. Redshift UV THROUGH IR



LF vs. Redshift UV THROUGH IR



What Do We Learn? "FIRST ORDER"



What Do We Learn? **"FIRST ORDER"**

- Little ambiguity in L-M mapping
 - **Model-independent**



Tuesday, December 25, 12

Probability (Arbitrary Scale)

0.001

What Do We Learn? "FIRST ORDER"

- Little ambiguity in interpretation at z < 2</p>
 - High-z can't get bigger
 - Observed mdot
 - Observed clustering
 - Local BHMF





What Do We Learn?

WHAT DOES THIS TELL US ABOUT MASSIVE GALAXY FORMATION?



* Observed **Eddington Ratios** * Simulation Quasar Lightcurves * Merloni et al. (BH "fundamental plane") * Yu & Tremaine, Marconi et al., Shankar et al. (simple ~constant Eddington ratios)

Hopkins, Coil, Myers, Lidz, et al.

What Do We Learn? WHAT DOES THIS TELL US ABOUT MASSIVE GALAXY FORMATION?



What Do We Learn?

WHAT DOES THIS TELL US ABOUT MASSIVE GALAXY FORMATION?

Know quasar clustering(z) & z=0 hosts of these BHs:



9.5

9.0

8.5

8.0

7.5

log('Active' M_{BH}) [M_®]

Quasar Luminosity Function Defines a Characteristic "Forming" Mass(z)

Compare that M_BH(z) with the z=0 hosts' formation times



Spheroid Formation Times:

Quasar Luminosity Function Defines a Characteristic "Forming" Mass(z)

Compare that M_BH(z) with the z=0 hosts' formation times





Local Early-Type Clustering, Extrapolated to the Star-Formation Time for each M_gal



Local Early-Type Clustering, Extrapolated to the Star-Formation Time for each M_gal

Observed Quasar Clustering at each z

Where Is This Happening? EMPIRICAL TESTS OF QUASAR FUELING MECHANISMS

Doesn't *generically* trace star formation



Where Is This Happening? EMPIRICAL TESTS OF QUASAR FUELING MECHANISMS



A "Generic" Sequence? EMPIRICAL TESTS OF QUASAR FUELING MECHANISMS



A "Generic" Sequence? EMPIRICAL TESTS OF QUASAR FUELING MECHANISMS



More Detailed Comparison USING SIMULATIONS TO MAP QUASARS <> SPHEROIDS



Hopkins, Somerville, Hernquist+06

(see also Fontanot et al. 2006, Malbon et al. 2006, Volonteri et al. 2006)



Ueda+



Observed RS Buildup to z>~1 = Expectation if *all* new mass to the RS "transitions" in a quasar-producing merger





The Role of "Quasar" Feedback CORRELATION VS. CAUSALITY?





Summary

- There really does appear to be a strong association between quasars, mergers, and the buildup of the red sequence
 - Non-merger driven models (while almost certainly dominant at low L & low z) just don't work

It is possible to "map" between populations

- Quasars have a lot to tell us about spheroid formation:
 - Where stars formed? When?
 - Downsizing?
 - When is formation gas rich / gas poor?
- Open questions:
 - "Maintenance" : smooth mapping from quasar to "radio" modes?
 - How much work does the *quasar* do?