Uniting Mergers, Quasars, and Elliptical Galaxies

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Do Observed Populations Bear This Out?

DO THE NATURE & EVOLUTION OF THE CORRESPONDING LUMINOSITY FUNCTIONS SUPPORT THIS MERGER HYPOTHESIS?

Many detailed studies on individual objects/transitions & their correlations (e.g. Lake & Dressler, Genzel+, Rothberg & Joseph)



What about the populations/distributions?

Downsizing Happens BUT WHAT DOES THAT MEAN?





Dissipationless ("red"/ "dry") vs. Gas-rich ("wet") mergers?

Downsizing Happens BUT WHAT DOES THAT MEAN?



Empirical Comparisons WHAT CAN WE LEARN BEFORE INVOKING THE MODELS?

- Global Spheroid & BH growth co-evolve
- But are the sites of growth the same?
- How to extend to mergers?



Empirical Comparisons HOW ARE SPHEROID POPULATIONS BUILDING UP?



Red Mass Functions with Redshift

CAN WE OBSERVATIONALLY IDENTIFY WHERE SPHEROIDS ARE BEING FORMED?



Red Mass Functions with Redshift

CAN WE OBSERVATIONALLY IDENTIFY WHERE SPHEROIDS ARE BEING FORMED?



Downsizing and the "Transition" Mass WHAT DOES THIS MASS MEAN?

Xu+ 04 Wolf+ 05 Bundy+ 05

2006



- Merger mass functions trace the buildup of spheroids
 - Independent of timescales, rates, etc.
- Dry mergers can't help at low-M

Downsizing and the "Transition" Mass WHAT ABOUT MERGER RATES/FRACTIONS?



Downsizing and the "Transition" Mass WHAT DOES THIS MASS MEAN?

Extend this to where we just have merger mass densities...



Downsizing and the "Transition" Mass COMPARISON TO QUASAR EVOLUTION



Downsizing and the "Transition" Mass COMPARISON TO QUASAR EVOLUTION



Clustering of Quasars, Mergers, & "Transition" Mass Galaxies

AN INDEPENDENT TEST





More Detailed Comparisons GETTING MORE OUT OF THE DATA

- If spheroids & quasars are formed in mergers, the full mass/luminosity functions of all three populations must be self-consistent!
- What's the best approach? SAMs?
- How to "map"?
 - Quasar Luminosities/Accretion Rates
 - Galaxy Luminosities: Star Formation & Dust
 - > Observability
 - Morphology
- Galaxy Merger Simulations



The Simulations

- Generally spiral-spiral major mergers
- Gadget-2 (Springel et al. 2005)
 - Bondi-Hoyle accretion: 20 pc resolution
 - ~5% radiated energy couples to local ISM
- Multi-phase ISM for star formation (Springel & Hernquist 2003)
 - Variable equation of state: increase/decrease thermal impact of SF feedback
 - +/- Stellar winds
- Several hundred simulations (Robertson et al. 2005, Cox 2004):
 - Progenitor masses, velocities, orbits, orientations, redshifts, gas fractions, ISM EOS, mass ratios, feedback coupling, bulge fractions, gas physics

T = 0 Myr

Gas





Mergers Drive Strong Gas Inflows, Fueling Starbursts and BH Growth SYSTEM CHANGES RAPIDLY; BUT STATISTICS ARE WELL-BEHAVED







Quasars Are Self-Consistently Generated LIKEWISE, QUANTIFY THEIR STATISTICS & OBSERVABILITY



Feedback Can Have Important Effects

ALTER COLOR EVOLUTION; CHANGE AGN LIGHT CURVE/SELF-REGULATION



Tuesday, December 25, 12

Given the Conditional Quasar Lifetime, De-Convolve the QLF QUANTIFIED IN THIS MANNER, UNIQUELY DETERMINES THE RATE OF "TRIGGERING"

$$\phi(L) \equiv \frac{d\Phi}{d\log L}(L) = \int \frac{dt(L, L_{peak})}{d\log(L)} i(L_{peak}) d\log(L_{peak}).$$
Simple quasar
lifetimes
$$2 \int \frac{\Phi}{d\log(L)} d\log(L) d\log(L_{peak}) d\log(L_{peak}) d\log(L_{peak}).$$



If lightcurves/lifetimes were trivial, this would be a simple rescaling of units

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- Feedback-regulated lifetime drives a given QSO to lower L after blowout, and spends more time at low-L
- Much stronger turnover in formation/merger rate
- Same process, but distributions have different shapes





Testing These Mappings



Apply This Mapping to Ongoing Mergers TEST STATISTICS OF QUASAR, RED GALAXY, & MERGER POPULATIONS



Ongoing Mergers: Luminosity Density USE QUASARS TO PREDICT THE MERGER LUMINOSITY DENSITY

Also, e.g.:

- number densities
- color-magnitude relations
- color-color relations
- dust distributions



Ongoing Mergers: Merger-Induced Star Formation Rates APPLY AN IDENTICAL FORMALISM TO THE SFR DISTRIBUTION TO MAP FROM QUASARS





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Spheroid Buildup Mapped out By Quasars BACK TO WHERE WE STARTED



Luminosity Function (NUV,U,B,V,R,I,K; 0<z<6)



Multiple Age & Structure Measurements to Compare



Multiple Age & Structure Measurements to Compare



Extend to High Redshifts & New Wavelengths PROBING THE EPOCHS OF MAJOR INTERACTIONS



Li et al. (in prep)





Narayanan et al.

(in prep)

Summary

- Quasars, Mergers, and the Buildup of Spheroid MFs appear to trace one other
 - Extend to higher redshifts
 - Better merger statistics
 - Independent tests
- The statistics of these distributions are self-consistent as predicted by the "strong" merger hypothesis
 - It is possible to "map" between populations
 - QLF >> Merger LF/MF >> Spheroid MFs >> QLF
 - A large number of properties can be predicted with these mappings; conversely, used to test this self-consistency
- Much to do:
 - Extend to IR populations : ULIRGs/SMGs/SCUBA
 - Full cosmological models
 - Test different feedback/accretion/star formation models

Thanks!