Ultra-DEEP Keck spectroscopy of z~1 E/S0s in GOODS-N

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Aims and motivations

1. Redshift $0<z<1$ is important to quantify continued formation of “normal E+S0” galaxies

2. Dynamical information to clarify the star formation history of E+S0 galaxies as a function of a galaxy mass

3. Large well-defined sample to address controversial results (field vs cluster; old vs young)
The Fundamental Plane: star formation history at given mass

- Empirical correlation between size, luminosity and velocity dispersion
- Gives “effective M/L” at “effective mass”

Dressler et al. 1987; Djorgovski & Davis 1987; Bender Burstein & Faber 1992; Jorgensen et al. 1996
The evolution of M/L: field

- FP exists in the field to z~0.7
- Evolution in the field is faster than in clusters.
- Not as much as in models!

Treu et al. 1999, 2001a,b;2002

Fundamental Plane: M/L Evolution for Field Spheroidals
Correlation of residuals with morphological anomalies

• Most HDF spheroidals follow the track consistent with $z_{\text{SF}} > 2$
• Possible anomalies in M/L may be associated with WFPC-2 asymmetries?

Van dokkum & Ellis 2003
The evolution of M/L: towards a precision measurements

Larger samples show that error bars are still large enough to allow for a variety of interpretations. Is it local density, mass, selection effects?

Gebhardt et al. 2003
E+S0 in GOODS-N
Sample definition

• GOODS epoch 1 v0.5 z(AB)<22.5

• Morphological classification in z band:
  – Approximately B rest frame at z~1
  – High-priority: compact, E, S0
    • Conservative classification on v0.5 data including bulge-dominated Sabs
    • Verified on v1.0 data

• NO COLOR SELECTION!

• 6-12 hrs integrations with DEIMOS on Keck-II (April 2003)

Treu et al. 2004
Tally of observed objects

- 26 stars
- 163 early-types (E+S0, compact)
- 61 early-spirals (Sa+b)
- 23 late-spirals (Sc+d)
Examples of targets: E+S0
Examples of targets: spirals
Example of objects: blue core E+S0s

14/163 E+S0 have blue cores, i.e. rest frame d(B-V)<-0.2
High Quality Spectra
The evolution of the FP. I

\[ 1.25 \log \sigma + 0.32 \text{SB}_{\text{B}} + 8.895 \]

\(~80\%\) of the total sample
The evolution of the FP. II
The evolution of the FP. III
The evolution of the FP. IV
The evolution of the FP. V
The evolution of the FP. VI
The evolution of the FP. VII
The evolution of the FP. VI

• Smaller galaxies evolve faster!
• Smaller mass to light ratio correlates with independent indicators of younger stellar populations (Hd and colors)
Conclusions

• The most massive E+S0s (groups/poor clusters?) are “old and dead” to z~1

• In the mass range $10^{10}$-10$^{11}$ solar masses E+S0s are not old and dead, as indicated by M/L, H_, and colors, but they are accreting mass

• Mass assembly in early-type galaxies continues to relatively recent times, moving to smaller mass scales.

• Environment might be playing a role but the dominant variable appears to be mass.
Quantitative results depend on selection effects!!! In progress..
The end