Nearby Galaxies in High-$z$ Surveys

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\( \mu(V) < 21.5 \)

Mihos et al. 2005
DATA REDUCTION MATTERS

The famous UDS spiral (in the K-band)

HyperSuprimeCam Strategic Programme
DR2 i-band data (Aihara+2019)

SWarp (Euclid VIS sims)

Improved sky background correction
HUDF 2012
(Ellis+13, Koekemoer+13, McLure+13)
ABYSS
(Borlaff+19)

https://www.iac.es/proyecto/abyss/
Borlaff+19

Kpc

Buitrago+17
10 arcsec ~ 70 kpc

* Buitrago+17
** Borlaff+19
Development of Massive Elliptical Galaxies

1. TODAY
   13.7 billion years
   Local elliptical galaxy

2. 5 billion years
   Merging galaxies

3. 3 billion years
   Compact galaxy

4. 2 billion years
   Quasar

5. 1.5 billion years
   Dusty starburst galaxy

6. 1 billion years
   Merger

BIG BANG
Massive ETGs should grow an extended stellar envelope across cosmic time. Two phase formation scenario: inside-out growth vs in-situ component.

Accreted component

Great work by simulations: Hopkins+09, Oser+10, Hilz+13, Cooper+13, Zolotov+15, Wellons+16, etc; and so many others.

Plenty of observational evidence: Bezanson+09, Van Dokkum+10, Trujillo+11, Huertas-Company+13, FB+14, Williams+14, Ferreras+14,
Development of Massive Elliptical Galaxies

- Relic in a low-density environment
- Massive Ultracompact Galaxy
- Red nuggets
- Perseus cluster
- Relic in a high-density environment
- Ultramassive galaxies
- Relic in a low-density environment
- Massive Ultracompact Galaxy
Incredible properties: übermassive black holes (Van den Bosch+12), bottom-heavy IMF at all radii (Martín-Navarro+15), uni-modal GC population (Beasley+18)
Buitrago+17
Based on the seminal work of Trujillo & Bakos 2013

Galaxies are affected by surface brightness dimming

Selection criteria:
-> Stellar mass \( > 5 \times 10^{10} \, M_\odot \)
-> \( z_{\text{spec}} < 1 \)

=> Early-type galaxies down to 29 mag arcsec\(^2\) restframe at median redshift \( z = 0.65 \)!!!
PROGRESSIVE DEVELOPMENT FOR ETG STELLAR HALOES OVER REDSHIFT

- Buitrago et al. (2017)
RELATIVE IMPORTANCE OF STELLAR HALOES FOR ETGs OVER REDSHIFT

From Cooper+13 simulations
RELATIVE IMPORTANCE OF STELLAR HALOES FOR ETGs OVER REDSHIFTS

\[ \text{Relative Importance} \]

\[ \left. \frac{M_{\text{stellar}}}{M_{\odot}} \right|_{R > 5 R_\odot} \]

\[ \text{ETGs at } <z> = 2 \]
\[ \text{ETGs at } <z> = 0.65 \]
\[ \text{Mean ETGs at } <z> = 2 \]
\[ \text{Mean ETGs at } <z> = 0.65 \]
\[ \text{Mean ETGs at } <z> = 0.1 \]

\[ \text{Galaxy Mass} / M_{\odot} \]

\[ 10^{11} \]

\[ 2 \times 10^{11} \]

\[ M_{\text{stellar}} / M_{\odot} \]

\[ 10^{10} \]

\[ 10^{11} \]

\[ 10^{12} \]

\[ 10^{13} \]

\[ 10^{14} \]

\[ \text{UGC00180} \]

\[ \text{M31} \]

\[ \text{NGC 1042} \]

\[ \text{NGC 1068} \]

\[ \text{NGC 253} \]

\[ \text{NGC 3351} \]

\[ \text{NGC 3370} \]

\[ \text{NGC 4258} \]

\[ \text{NGC 4220} \]

\[ \text{NGC 1084} \]

Comparison of stellar mass to galaxy mass for ETGs at different redshifts.
MASSIVE GALAXIES IN CANDELS @ Z < 0.5

See also Buitrago+13

Reis, FB+19 (in press)
Center of the Abell 2029 cluster

- $R_e = 64 \pm 12$ kpc (Fisher+1995)

- Searching for similar objects in KiDS with C. Tortora | Stellar populations w/ FADO by S. Reis and J.M. Gomes

New $r_e = 42\pm4$ kpc (but probably much less)

IC1101

Just google this name...

HST WFPC2 2-color composite
IC1101

Exposure time 3.83h in the OGS telescope (1m)

R band: 28.01 mag/arcsec²
V band: 28.39 mag/arcsec²
B band: 29.24 mag/arcsec²

(3σ, 10x10 arcsec)

10 arcsec = 14.74 kpc
IC1101_1000x1000pix

B OGS
V OGS
R OGS

500 kpc
10 arcsec ≈ 14.74 kpc
• Work in progress!
• Is this galaxy light or is it ICL?
• Fossil group? Cluster merger?
• Integrated mass $3.4 \pm 0.5 \times 10^{12} M_\odot$
• If taking the Galaxy mass function at $z = 0$ (Baldry+2012)...

Is $\Lambda$CDM accounting for these objects?
MUSE FoV, PI Buitrago
NEW GENERATION TELESCOPES’ CAPABILITIES

Provided an adequate data reduction, good observing strategy and good PSF knowledge
Limiting Surface brightness given as 3σ detections in 10x10 arcsec boxes

• JWST
  ➢ 30.5 mag arcsec^{-2} (1h) and 31.8 mag arcsec^{-2} (10h)

• Euclid
  ➢ Wide survey: 28.7 mag arcsec^{-2}, Drilling fields: 29.7 mag arcsec^{-2}

• LSST
  ➢ 26.5 (15 sec) => SDSS Stripe 82 for 25000 deg^2 each 3d!, 30.5 (3.5h)

• 30-m telescopes
  ➢ 31.2 mag arcsec^{-2} (1h) and 32.5 mag arcsec^{-2} (10h)

• MESSIER spacecraft
  ➢ Whole sky: 34 mag arcsec^{-2}, Drilling fields: 36 mag arcsec^{-2}
SUMMARY

• Massive **elliptical galaxies** grow **stellar haloes** to account for their size and mass evolution, and they host 5-20% of the stellar mass (vs < 5% for LTGs)

• Massive galaxies are privileged testbeds for galaxy evolution and their different **flavours** imply (and help discerning) different physical mechanisms at play

• Next generation telescopes and surveys will systematically find many low- to intermediate-redshift galaxies, and **LSB** is key to fully understand galaxies (beware cosmological dimming!)

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