THE EFFECTS OF CLUSTER ENVIRONMENTS ON THE STELLAR- MASS – SIZE RELATION*

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HAEUSSLER, MOUSTAKAS, FORMICULA, ROSATI, BALESTRA, CLASH-VLT, CLASH

*from observations
A.

THE STELLAR-MASS – SIZE RELATION
The stellar mass – size relation

- Galaxy size scales with luminosity/stellar mass
- Different tracks depending on MORPHOLOGY and STAR-FORMATION ACTIVITY
- At given luminosity/size: fairly broad, flat/steep distribution
  - $R[kpc] \sim M_*^{0.26}$
  - $R[kpc] \sim M_*^{0.65}$

Present day stellar mass size relation Shen+ 03 SDSS
What governs size evolution?

In-situ: Stellar Mass

Ex-situ: Environment

Puffing up-scenarios:

• **AGN activities** (Croton+06, Fan+08,+10, Ragone-Figueroa&Franato+11)

• **SN-winds** (Damjanov+09)
What governs size evolution?

In-situ: Stellar Mass
Puffing up-scenarios:
• **AGN activities** (Croton+06, Fan+08,+10, Ragone-Figueroa&Franato+11)
• **SN-winds** (Damjanov+09)
• Mergers cause an increase in stellar mass

Ex-situ: Environment
Accretion scenarios:
• **Major merger**
• **Minor merger**

Stripping of stellar/gaseous material:
• **Tidal stripping**: low-speed galaxy encounters that do not result in a merger event.
• **Galaxy harassment**: multiple high-speed encounters between galaxies in the cluster environment
• **Tidal truncation** of the outer galactic regions
B.
SAMPLE OVERVIEW, MEASUREMENTS
Survey, Data, Sample

P.I. Postman
P.I. Rosati

25 mass-selected, relaxed clusters, 0.2<z<0.9
Campaign includes photometry from HST, Subaru, Spitzer, Chandra

CLASH-VLT spectroscopic follow-up from VIMOS-VLT, P.I. Rosati
500-1000 members for 13 southern clusters

MACSJ 1206.2 – 0847 at z=0.45
CLAsh HSt COVERAGE

the central 4.07 sq.arcmin (~ 3 Mpc regions)

CLAsh SUBARu COVERAGE

30x30 arcmin\(^2\)

Excellent resolution:
Used for robustness check of structures

Large field of view:
Used to look for environmental effect

HST 16 filters

Subaru 5 filters
**Measurements**

Sizes from **Sérsic fits** to the radial intensity profile using **Galapagos-2**: each standard GALFIT parameter replaced by a polynomial function of wavelength (GALFITEM).

**MegaMorph**  S. Bamford, B. Häußler, M. Vika

\[ I(r) = I_e \exp(-b_n [(r/r_e)^{1/n} - 1] \]

\[ I_e(\lambda) \quad r_e(\lambda) \quad n(\lambda) \]

On GITHUB: expand, fix, adapt
Morphological classification

The **Sérsic index** correlates with the **morphology** of the galaxy $n < 2.5$

Andredakis, Peletier & Balcells 95, Ravindranath+04

Sérsic index establishes only ONE classification scheme. Even though it is in good agreement with morphology, there are several ways to classify.

$n$: Error in ★ / ★ classification HST/Subaru: 15%

B/T: Error in ★ / ★ classification HST/Subaru: 10%

Sizes: 85% within 1kpc variation

Masses: B&C+03 models to B,V,R,I,z
C.
RESULTS:
what effects of the global environment on the stellar-mass – size relation can we measure with our sample?
Projected phase space: CLASH MACS1206 z=0.45 spectroscopic members and infalling galaxies, divided by Sérsic index and in 3 size bins, SIS* analysis, Carlberg, Yee & Ellingson95

*”useful starting point”

+ (expected) higher masses → greater size?

+ masses Bias?
CLASH MACS1206 spectroscopic members in 3 radial bins

“How important are cluster-specific phenomenon in the overall picture?”

“Optical morphologies are not enough to point directly to one process.”

Deviation in velocity space

ICM-dominated core within R500

Tidally active region within R200

Infall region out to 3 virial radii
Environment

Phase Space divided into 3 environmental bins:
R < R500, R500 < R < R200, R > R200

SELECTION FUNCTION CORRECTED
Environment

Phase Space divided into 3 environmental bins:

- R < R500
- R500 < R < R200
- R > R200

Selection Function Corrected

\[ \sum_{n=1}^{3} \text{normalized #} \]

- n vs. R
- r_{eff}[pix]
- B/T
- log[M/M_{\odot}]

Disks
Environment

Phase Space divided into 3 environmental bins:
R< R500, R500<R<R200, R>R200

Enhancement of low mass objects in outer regions → low mass objects should have smaller $r_e$

Enhancement of high mass objects in the center → high mass objects should have larger $r_e$

Size depends on morphology

<table>
<thead>
<tr>
<th>Environment disks</th>
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<tbody>
<tr>
<td>R&gt;R200</td>
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Selection Function Corrected
Environment

spheroids

Phase Space divided into 3 environmental bins:
R< R500, R500<R<R200, R>R200

SELECTION FUNCTION CORRECTED
Size depends on morphology

Enhancement of high mass objects in the center ➔ high mass objects should have larger $r_e$

Enhancement of low mass objects in outer regions ➔ low mass objects should have smaller $r_e$
Stellar-mass – size relation: cluster-field

Mass-Size relation MACS 1206 for disk-like/spheroidal cluster galaxies

median residuals to field, sf galaxies:
8.5 < log(M*) < 9.5
-0.124
9.5 < log(M*) < 10.5
-1.758
10.5 < log(M*) < 11.5
-3.224

Van der Wel+14 field relations

Cluster relation

Field relation vDW
Mass-size relation in different environments

- environments using the phase space
- Sérsic n-division for disk/spheroidals

Inside R500
Mass-size relation in different environments

• environments using the phase space
• Sérsic n-division for disk/spheroidals
Mass-size relation in different environments

- environments using the phase space
- Sérsic n-division for disk/spheroidals
Blue spheroids
About **75% of all passive galaxies have an early-type morphology** at all stellar masses (similar to e.g. Huertas-Company+12 who finds this at all redshifts from $z \sim 1$). The remaining $\sim 25\%$ are essentially early-type spirals + S0. Therefore, studying the population of passive galaxies as a whole mixes different morphological populations which do not necessarily share the same evolutions.
Mass-size relation in different environments

- environments using the phase space
- color-color – division for sf/quiescent
Mass-size relation in different environments

- environments using the phase space
- color-color – division for sf/quiescent

Between R500 and R200
Mass-size relation in different environments

- environments using the phase space
- color-color – division for sf/quiescent

![Mass-Size relation MACS 1206 for star-forming/quiescent cluster galaxies](image)
D.

SUMMARY, CHALLENGES
WE STUDY THE DISTRIBUTION OF GALAXIES IN THE STELLAR MASS-SIZE PLANE IN A VERY MASSIVE CLUSTER AT Z~0.45

AT FIXED MASS WE FIND A REDUCTION OF SIZE FOR DISKS/SFG IN COMPARISON TO A FIELD SAMPLE BY VDW BY UP TO 20% - WITH SUBTLE EVIDENCE THAT THIS DEPENDS ON THE LOCATION INSIDE THE CLUSTER (HOWEVER LESS CLEAR WHEN COMPARED DIRECTLY)

THIS IS COMPATIBLE WITH OTHER FINDINGS E.G. FERNANDO LORENZO+13, CEBRIÁN+14
ANALYSIS DOES NOT SHOW ANY SIGNIFICANT ENVIRONMENTAL DEPENDENCE OF THE SIZES OF ET/QUIESCENT GALAXIES AT FIXED STELLAR MASS AT Z~0.45 AND SEEMS TO BE INDEPENDENT OF THE POSITION (IN PHASE-SPACE) OF THE GALAXY IN THAT CLUSTER HALO

THE RESULT IS ROBUST TO DIFFERENT GALAXY SELECTIONS BASED ON STAR–FORMATION, MORPHOLOGY. (SEE HUERTAS-COMPANY+13 FOR Z~0)
ESTIMATION OF GALAXY STELLAR MASSES CAN BE BIASED UP TO 0.2DEX DUE TO DIFFERENT ESTIMATOR AND STELLAR POPULATION MODELS (BERNARDI+10, RAICHOOR, MEI+11)

FIT WITH A SINGLE SERSIC PROFILE OF A GALAXY THAT HAS AN EXPONENTIAL COMPONENT CAN BIAS THE SIZE AND THE MASS ESTIMATION UP TO 20%/0.2 DEX, RESPECTIVELY (BERNARDI +13A,B)

FOLDING IN LOCAL DENSITIES THROUGH NEAREST NEIGHBORS
WE’VE ONLY JUST STARTED TO CONNECT THE DOTS. THANK YOU.