The impact of "pre-processing" on the galaxy mass-size scaling relation

Massive CLASH cluster
$M_{200} \sim 10^{15} \, M_\odot$

infalling galaxies

- Gas accretion
- Star forming galaxies
- No more inflow, star formation continues with available gas
- Gas removal, star formation stops

$t_Q \, \text{slow}$  $t_Q \, \text{fast}$
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- morphology/structure: CLASH, EUCLID, WEAVE, ..
- gas metallicity: CLASH-VLT
- star formation rates: CLASH, EUCLID, WEAVE, ..
The evolutionary status of a galaxy is indicated by its position in the color-mass and mass-size diagrams.
Galaxy color and morphology are correlated, but not equivalent.

Colour = star formation history, Morphology = dynamical history.
Clusters host a significant population of transitioning galaxies. Why?

560 spec members of CLASH Cluster MACS1206, z=0.45, 3xR200

Kuchner+17
Red disks are undisturbed morphologically, but disturbed kinematically.

Galaxy harassment, strangulation, suppressed accretion and ram pressure stripping:
gas of the galaxy halo or disk are either pushed out or quickly used up, essentially removing the reservoir of fuel necessary to form stars.
Transition objects become important in clusters.

Galaxy abundance and diversity is imprinted on the stellar-mass-size plane.

What may be responsible for the decreasing sizes of transition galaxies?

reasons for a decrease in size: bulge is growing or disk is shrinking
The strength of the bulge influences the location of the galaxy in the mass-size plane.

A prominent bulge leads to smaller sizes.

Continuous + smooth trend unifying LTGs and ETGs.
The strength of the bulge influences the location of the galaxy in the mass-size plane.

A prominent bulge leads to smaller sizes.

Continuous + smooth trend unifying LTGs and ETGs
Bulge dominance alone cannot explain smaller sizes for early types.

Are disk components of quenched galaxies affected by the cluster environment?
We see some evidence for smaller disk sizes in quiescent galaxies.

- Disk sizes of quiescent galaxies become smaller.

- Gas stripping is more effective in the fragile outskirts of galactic disks (Bekki+09).

- Is this outer disk fading / suppression of SF in the outskirts due to cluster mechanisms?

- Comparing with CANDELS: this is not seen in the field (Dimauro+ in prep.)
What do we mean by environment?
The cluster environment is the result of hierarchical assembly.
Does the size of a galaxy depend on their location in a cluster?

ICM dominated core | tidally active region | infalling galaxies

**Red disks**: same size as red spheroids, but at different location
At $R_{200}$, an increasingly important population of red disk galaxies is responsible for a decrease in size of disk-dominated galaxies.

Outer regions of disks fade and the spheroid component becomes more dominant.
How long do galaxies continue to form stars after their accretion into a cluster?

Satellite SFR Evolution: Delayed-then-Rapid Quenching

- Central galaxy: \( \tau_{\text{cen}} = 2 - 4 \text{ Gyr} \)
- Satellite galaxy

- \( t_{Q,\text{delay}} = 2 - 4 \text{ Gyr} \)
- \( t_{Q,\text{fade}} = 0.2 - 0.8 \text{ Gyr} \)

Bamford+09, Haines+13: massive galaxies: slow quenching, low mass galaxies: rapid

50% of late type galaxies show tails of ionised gas (e.g. Boselli & Gavazzi14): Ram pressure stripping

MSR: mix of progenitors formed at different quenching epochs

Wetzel+13
Assemble studies show that clusters accrete up to 50% of their galaxies via groups. Dressler+13

pre-processing: the idea that a galaxy might experience considerable environmental effects before being accreted onto a cluster.
WEAVE Wide Field Cluster Survey

Deep spectroscopy of galaxies in the infall regime of a sample of 16 WINGS clusters reaching ~ 5 virial radius

- WEAVE is the next-generation survey facility for the William Herschel Telescope
- provides a dedicated wide-field optical spectroscopic (MOS) instrument in the Northern Hemisphere: Low-res mode: R = 5000, blue arm 366 - 606 nm, red arm 579 - 959 nm, Multiplex: 950 fibres per plate
- obtain ~2500 spectra per cluster structure, with ~1000-1500 in infall region
- map and understand filamentary nature of LSS
The Three Hundred Project:
Pre-processing and defining filaments in simulations

Gas particles

Halo catalogues

DisPerSE (Sousbie+11,13)

z=0

Courtesy: Jake Arthrur, Meghan Gray, Charlotte Welker
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19 07 18 | Ulrike Kuchner | University of Nottingham
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HST FF campaign, Monica LoCasio
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HST FF campaign, Monica LoCasio
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19 07 18 | Ulrike Kuchner | University of Nottingham
Alfonso Aragon-Salamanca, Jake Arthur, Steven Bamford, Meghan Gray, Boris Hauessler, Frazer Pearce, Miguel Verdugo, Bodo Ziegler*

*(alphabetical)
The quenched fraction correlates with environment and stellar mass.

(also: e.g. Kauffman+04, Baldry+06, Peng+10, Wetzel+12, Muzzin+12, Kodama for high z)

Stronger trends than for early type fraction
Bamford+09

Haines+07
The early-type fraction correlates with environment and stellar mass.
Morphology-Density relation Dressler 80
Structural parameters were measured with the automated tool GALAPAGOS-2 using GALFITM.

S. Bamford, B. Häußler, M. Vika+

The code provides

- **Sizes** from Sérsic fits to the radial intensity profiles
- **Bulge/disk** decompositions
Structural parameters were measured using the automated tool GALAPAGOS-2
The sample of 560 galaxies in MACS1206 encompasses the entire galaxy population.
In accordance with the comparison sample, members are divided based on their colors.

BRI-selected quiescent members
BRI-selected star forming members
The different tracks depend on star-formation activity.
How long do galaxies continue to form stars after their accretion into a cluster?
Velocity dispersions trace the mix of virialized and unvirialized populations.

Because it's the ultimate test.