The morphology-density relation in distant galaxy clusters

Liza Sazonova

K. Alatalo, J. Lotz, K. Rowlands, G. Snyder, V. Rodriguez-Gomez et al.

How do galaxies evolve...
In densest cosmic environments – galaxy clusters

Abell 370 cluster – NASA/ESA/Hubble

Galaxy clusters host 100s of galaxies and are an important factor governing galaxy evolution.

Nearby Universe [$z = 0$] – Morphology-Density Relation

Galaxies in nearby clusters do not form stars (quenched/quiescent) and are centrally concentrated (bulge-dominated morphology).

Caused by environmental quenching mechanisms: removal of the star-forming gas fuel of infalling galaxies, e.g. via ram pressure stripping
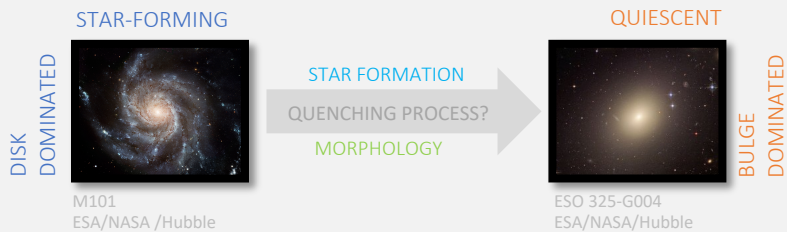
Early Universe [$z > 1$][8 Gyr ago] – ???

When do cluster galaxies become more bulge-dominated?

How do they transform? What is the quenching mechanism?

We answer this with galaxy morphology!

Study morphology of galaxies in 4 clusters in the early Universe (1<z<2) to see if they are structurally different to non-cluster (field) galaxies.

STAR-FORMING

QUIESCENT

DISK DOMINATED

BULGE DOMINATED

STAR FORMATION

QUENCHING PROCESS?

MORPHOLOGY

M101
ESA/NASA /Hubble

ESO 325-G004
ESA/NASA/Hubble

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1 **Find cluster members**

J1426.5+3508 - Hubble

Redshift [a.k.a. distance] photometric redshifts from NDWFS and Spitzer data

Membership probability a galaxy is a cluster member using its position and redshift

Imaging data deep *Hubble* rest-frame optical data (F160W/F140W)

Membership catalogs: Brodwin et al. 2013

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2 **Get a control sample**

CANDELS galaxies

Cluster KDE
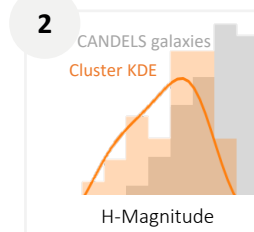
H-Magnitude

Data deep *Hubble* CANDELS field (F160W)

Redshift bias match field galaxies to cluster redshift within $\Delta z = 0.25$

Mass bias select field galaxies matching cluster H-magnitude distribution as a proxy for mass

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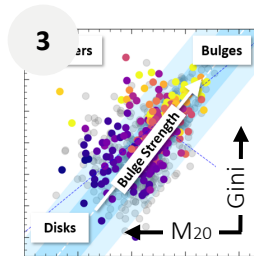
3 **Measure galaxy morphology**

Stars   Bulges

Bulge Strength

Gini

Disks M_{20}

Parameters Bulge strength, compactness, disturbance and Sérsic Index

Tools Open-source morphology code STATMORPH

Rodriguez-Gomez et al. 2019

Principal Component Analysis

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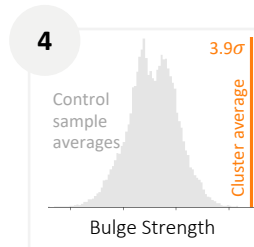
4 **Cluster vs field populations: Monte Carlo analysis**

3.9σ

Control sample averages

Cluster average

Bulge Strength

Monte Carlo Find median value in control and cluster samples for a given morphological parameter

Repeat for **40,000** subsamples of field galaxies

Significance What is the likelihood the cluster sample was drawn from field?

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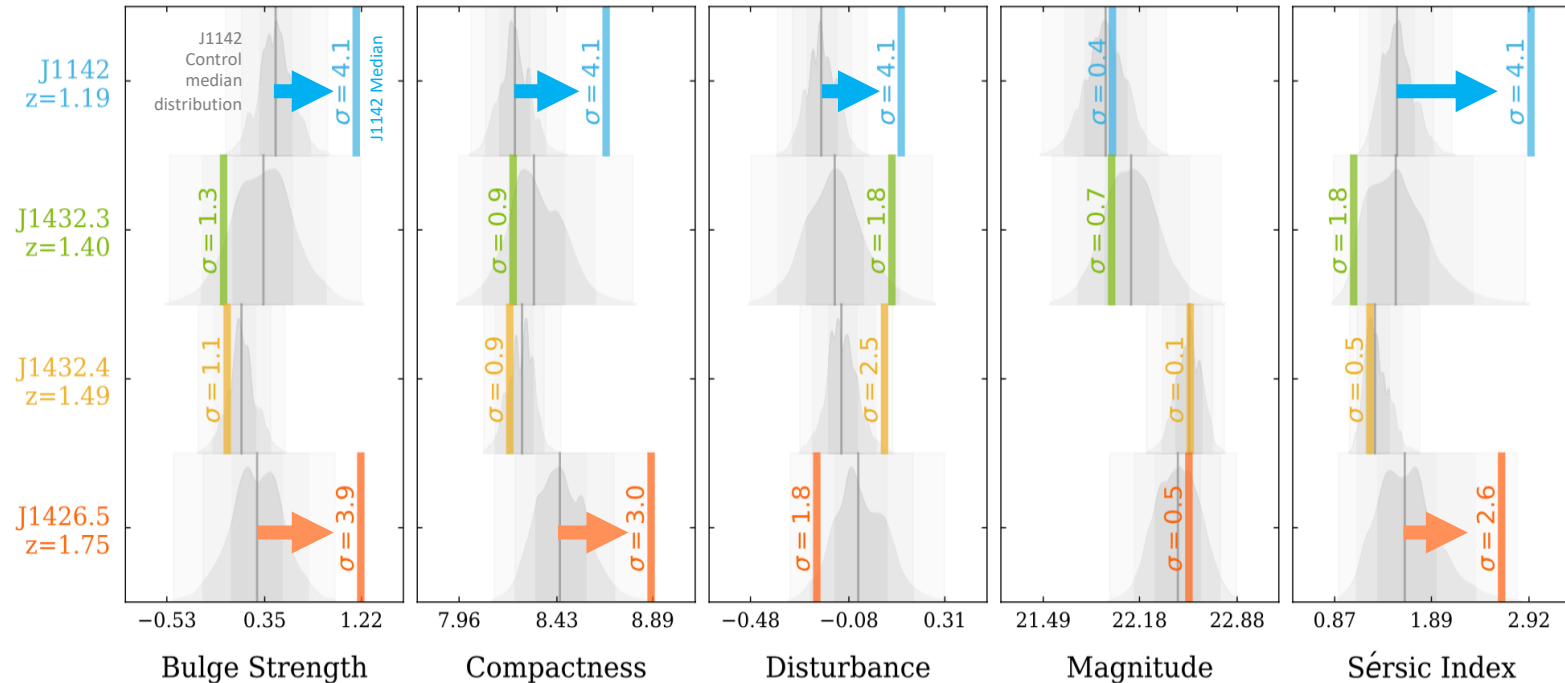
Compared to the morphology of CANDELS field galaxies...

2 out of 4 clusters host mainly bulge-dominated, compact galaxies

Bulge-Dominated — Established morphology-density relationship

Compact — Gas is driven inwards, not just removed like in ram pressure stripping scenario
Mergers or tidal interactions?

Highest significance for low mass galaxies (log M < 10.5)

[Q] What about the other 2 clusters?

[Q] How does this depend on the galaxy **mass**, morphological **type** or **distance** from the cluster center?

[A] More in the paper! arXiv:2007.03698

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Learn more! https://astro-nova.github.io