Galaxy evolution in the full range of cosmic densities

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Open Questions
Among many other things …

- Which DM halo for which type of galaxy?
- Growth of DM vs baryonic structures?
- Morphological transformations: when, where, how
- Origin of the star formation quenching
- Time evolution of cosmic baryonic structures: groups and clusters
- The fraction of star forming galaxies increases with time both in the field and in clusters.
- Galaxies are quenched as far out as 3-5 virial radii.
The efficiency of this environmental quenching rises with redshift, from **15% at z\textasciitilde1.6 to \textasciitilde70% below z\textasciitilde1** (Nantais et al., 2017).

Suggested physical processes include

- **ram-pressure stripping** (disc gas removal due to the rapid motion of the galaxy within the intra-cluster medium)
- **harassment** (multiple high-speed encounters between galaxies)
- **starvation** (stripping of the galaxy gas envelope supplying star formation).

Relative efficiency and sphere of influence, their action timescales are still debated (Haines et al., 2015; Fillingham et al., 2015; Balogh et al., 2016; Wagner et al., 2017).

Long-standing **tension** between the relatively short transition time-scales derived from the abundance of post-starburst galaxies (e.g., Dressler et al. 2013) and the non negligible fraction of star-forming systems in clusters and groups which implies a much longer time between accretion and star formation shut-off (e.g., McGee et, 2011; Cantale et al. 2016).
Hydrodynamical as well as semi-analytical simulations are still facing challenges
i) decoupling between baryonic processes and dark matter growth via feedback
processes which are still poorly constrained;
ii) parametric solutions to prevent satellite galaxies to be quenched too quickly

Observational constraints are very seriously needed.
Density maps

- preferential directions
- spatially correlated groups/associations
- cluster-cluster variation

SEEDiSCS
At any given cluster-centric distance, a large range of local densities ...

Rérat et al., in prep
What are filament (group)-like densities?

\[
\text{Log } \Sigma_{30} \quad \text{Log } \Sigma_{10}
\]

\( >2\sigma \quad 1\sigma \) above the mean density

Transition between large and local scales
Intermediate mass galaxies are sensitive to the local density, massive ones are much less so

At all densities, the smallest galaxies have the lowest fraction of red sequence members

Rérat et al., in prep
From voids to filaments

Kuutma et al., 2017
Access to the galaxy morphology is important

Cantale et al. 2016
We are looking for

- SFR indicators
- Gas (fuel) measurements: HI + H₂
A new observing window

Virgo
Coma cluster and super cluster

LoCuSS
Jablonka et al.

CL 0024+16
Geach et al. 2009, 2011

CL 0926+1242
Jablonka et al. 2013

ISCS J1432
Wagg et al. 2012

CL1416+4446
Jablonka et al. 2013

SEEDisCS
M0717
Jablonka et al.
$t_{\text{depl}} = \frac{M_{\text{gas}}}{\text{SFR}}$

$\text{SFR} = \frac{\text{SFR}}{M_{\text{star}}}$ normalized to the main-sequence
Cosmic variation of the gas

Blyth et al. 2014
SKA

SKA + Euclid ?
How do DM halos assemble?

**Figure 7.** The fraction of particles in a series of spherical shells that were accreted smoothly (black circles – solid line), by minor mergers (starred symbols – dotted) and by major mergers (open triangles – dashed). The distinction between minor and major mergers is made at a mass ratio of 10:1. Fractions are averaged over all six level-2 Aquarius haloes and error bars show the rms scatter among haloes. Despite substantial scatter, the trends are clear. Major mergers contribute to the inner regions, and diffuse accretion and minor mergers mainly to the outer regions which contain the bulk of the mass.

**Figure 10.** Total mass enclosed within different physical radii, $M(<r)$, for $r = 1, 2, 8$ and $32$ kpc, as a function of cosmic time. Different colours correspond to different haloes, as labelled in the figure. Masses in each panel are normalized to their values at $z = 0$. Time is labelled at the bottom and redshift at the top. Except for halo Aq-F, which is the remnant of a recent major merger, the inner mass profile of Aquarius haloes has been very stable for the past $5-6$ Gyr, a period comparable to the age of the Solar system.
SKA + Euclid

- photometry
- morphology
- $1.8 \times 10^4$ $z > 1$ clusters
- SED fitted; Halpha SFRs
The added value of SKA

**SFR**: free free emission from HII regions ($\leq 2$GHz), synchrotron radiation from e- from SN remnants (10-100GHz)

Seymour et al., 2008

Ciliegi & Bardelli et al., 2008
The added value of SKA

$H_2$
The added value of SKA

HI

SKA 1: Capability to image galaxies at reasonable linear resolution and good column density sensitivity @ 0.2 < z < 1.7

SKA 2: —> z = 2

Figure 3: Three examples of possible accretion of H\textsubscript{I} in nearby spirals indicated by the presence of gas complexes at anomalous velocities: M 101 (van der Hulst & Sancisi (1988)), NGC 2403 (Fraternali et al. (2002)), and M 33 (Sancisi et al. (2008)).

accretion?