Tracing the transition from active to passive galaxies in groups

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Cosmological interest of groups

~60% of galaxies in the nearby Universe are group members

\[ \sigma_{\text{group}} \approx \sigma_{\text{galaxy}} \]

coevolution of galaxy members and groups
May we rank groups evolutionary phase i.e. place groups in a cosmological context?

this means to ....

understand member evolutionary paths

role of the environment: strangulation, ram pressure ....
role of the interaction: merger, accretion, SF quenching...
secular evolution: bars, lenses, rings....

in groups with different density and galaxy population through...

methods

- dynamical analysis: membership, sub-structures ....
- multi-tech approach: 2D kinematics, line-strength indices
- photometric analysis: multi-λ, SED, CDMs ....
- structural analysis: bulge/disk, fine structures ....

interpretation tools

Chemo-photometric SPH simulations
Multi-\(\lambda\) morphological analysis of members

- Evidence of distortions/asymmetries
- Prominent Star Formation (SF) regions
- Age of stellar populations from \(~2\)Myr to \(~7\)Gyrs
- \(M_\odot\) of the group \(~10^{11}\)M\(\odot\)
Dynamical analysis of groups
<table>
<thead>
<tr>
<th>group</th>
<th>$\sigma$ [km/s]</th>
<th>$R_H$ [Mpc]</th>
<th>$t_c H_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>U268</td>
<td>63</td>
<td>0.31</td>
<td>0.77</td>
</tr>
<tr>
<td>LGG225</td>
<td>118</td>
<td>0.45</td>
<td>0.41</td>
</tr>
<tr>
<td>U376</td>
<td>225</td>
<td>0.21</td>
<td>0.13</td>
</tr>
<tr>
<td>U677</td>
<td>327</td>
<td>0.35</td>
<td>0.12</td>
</tr>
</tbody>
</table>

\[
R_H = \frac{\sum_i \sum_{ij} (w_i w_j) (r_i - r_j)}{\sum_i \sum_{ij} w_i w_{j;i}} \frac{1}{t_c} \]

\[
t_c = \frac{\langle r \rangle}{\langle v \rangle}
\]
Photometric analysis of groups

USGC U268
Leo II

USGC U376
Leo II

USGC U677
Leo II

LGG 225
Leo II
Interpretation tool


Inputs:
1) collapsing triaxial halos of DM + gas in different proportions and of different total masses.
2) recipe includes self-gravity of the gas, stars and DM, radiative cooling, hydrodynamical pressure, shock heating, viscosity, SF, feedback (from evolved stars and type II SNae, chemical enrichment)

Outputs:
1) Synthetic SED at each evolutionary stage i.e. snapshot (37 Myr). The SED accounts for chemical evolution, stellar emission, internal extinction and re-emission by dust in a self-consistent way
2) Morphological, dynamical chemo-photometric evolution

Resolution:
1) the initial particle number is 0.6 - 1.2 $10^5$ (initial conditions 3-6 $10^4$ particle of gas and DM).
2) The gravitational softenings are 1 (DM), 0.5 (gas) and 0.05 (stellar particles) kpc.

From the grid of simulations we isolate those simultaneously best-fitting the galaxy global properties: the total SED, the morphology and the gas + stars kinematics.

We trace back in the (NUV-r) vs. Mr CMD the transition from red to the blue sequences, following the galaxy transformation.
Chemo-photometric SPH simulations

Matching morphology, the light profile and SED

NGC 3626  2-MASS J  Simulated map

Following members transformation

SED  J-band brightness profile

Bulge  Inner disk  Outer disk
Chemo-photometric SPH simulations
Matching the morphology and SED

Galaxy age  13.7 Gyr
Stellar age ~ 3.7 Gyr
Total Mass  $4.9 \times 10^{10} M_{\odot}$
Gas Mass  $1 \times 10^{10} M_{\odot}$
SFR ~ 0.14 $M_{\odot}$/yr

The merger begins 3.5 Gyr after the onset of the SFR.
Rings/arms like features arise in the latter stages of the merger episode, when the galaxy is almost 8 Gyr old as a consequence of the head-on collision.

Mazzei, Marino, Rampazzo et al. 2013, ASR, in press
Chemo-photometric SPH simulations

- Matching Rotation curves of gas and stars

Mazzei, Marino et al. 2013, Advances Space Research
Chemo-photometric SPH simulations - Predicting the galaxy transformation in the CMD
**Conclusions**

**Galaxy transformation Sp-S0**: the major merging of two halos, initially just composed of DM and gas, may account for transient structures in gas-rich S0s. The residual star formation today “rejuvenating” the ring/arm like structures in S0s, as well as the gas vs. stars peculiar kinematics, may then be a mere consequence of a major merger, i.e. this is a phase during the merger episode.

The evolution of S0s with FUV rings in groups is not necessarily driven by secular evolution.

**(NUV-r) vs. Mr CDM as transformation diagnostic**: gas-rich S0s cross the green valley in the NUV-r vs. Mr colour magnitude diagram, in about 3–5 Gyrs, before reaching their current position in the red sequence.

**Evolution of ETGs members**: ETGs brighter than Mr = −21mag (TODAY) are older than 13 Gyr and spend up to 10 Gyr of their overall evolutionary time in the blue cloud before they reach the red sequence migrating through the green valley. Fainter ETGs are younger, of ≈ 2 Gyr on average, and evolve for about 7-8 Gyr along the blue cloud. The turn-off occurs at z ≈ 0.3 – 0.4.

ETGs members of these groups evolved toward the red sequence before and during the group collapse phase.

**Galaxies today fainter than MV = -21 mag strongly oscillates in the green valley**

**Group evolution**: Es in LGG 225 are younger than those in U376 of 1 Gyr at least, in agreement with the fact that LGG 225 seems less virialized than U376. NGC 3457 is the result of a galaxy encounter while NGC 3522 originates from a major merger.

All Es in U376 originates from a major merger and are older than 13 Gyr.

**Group evolution**: SPH simulations suggest that ETGs members of these groups evolved toward the red sequence before and during the group collapse phase consistently with the dynamical analysis of both groups showing that they are not yet virialized.
Future prospects

Enlarge both data and simulations to the entire set of late-types in U376