Environmental imprints in field and cluster dwarf early-types as seen by SAURON

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in collaboration with:

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Galaxy classification schemes

From purely morphological classification to systems reflecting true physical properties of galaxies:

↑ Hubble 1926
Kormendy+ 2012 ↗
Cappellari+ 2013 →
Dwarf early-types: more complex than we used to think

Wealth of substructure:
- spiral arms, bars, disks, lenses, nuclei
- kinematically decoupled cores, rotating & non-rotating
- spread in ages and metallicities

Shallow potential wells (low masses and densities)
- important testbeds for theories of galaxy formation & evolution

Lisker + 2006
Galaxy harassment
- high-speed encounters with other galaxies & tidal heating resulting from the interactions with the cluster’s potential well
- can remove stellar and (more efficiently) dark mass
- can change morphology
- lowers angular momentum

Ram-pressure stripping
- interactions between galaxies and the intergalactic medium
- quickly removes gas & quenches star formation
- preserves angular momentum
dEs – finding progenitors

Not a straightforward task:

- observed nearby – *present-day* analogs of dE progenitors
- high-z observations too demanding for these low SB systems
- detailed studies of cluster dEs long hampered by the lack of high-quality data

Recent advances in studies of early-type galaxies

- giant early-types studied in detail in 3D by the SAURON / ATLAS3D teams
- logical next step was to extend this analysis to low-mass systems
Our sample: 12 Virgo and field dEs

- Virgo Cluster: closest large concentration of dEs
- Bright dEs of varying $\epsilon$, level of substructure, local density
- Most with long-slit data already available
- Covered a range of $\epsilon$ and (projected) distances from M87
Stellar velocity maps - diversity everywhere

- **kinematic twist**
- **round rotator**
- **flat non-rotator**
- **round non-rotator**
- **flattened disky rotator**
- **kinematically decoupled core**

(Ryś+ 2013b)
Angular momentum of dEs is much lower than of their presumed late-type progenitors

(Ryś+ 2014)
Rotation curves of dEs are much steeper than those of late-type galaxies

\[ \frac{V_{\text{circ}}}{V_{\text{H\alpha}}} \]

\[ \frac{r}{R_{\text{opt}}} \]

\[ V_{\text{circ}} \text{ or } V_{\text{H\alpha}} \text{ (km/s)} \]

\[ 0.0 \quad 0.2 \quad 0.4 \quad 0.6 \quad 0.8 \quad 1.0 \]

\[ Catinella+06, V_{\text{H\alpha}} \]

\[ this \ work, V_{\text{circ}} \]

\[ Swaters+09, V_{\text{HII}} \]

\[ this \ work, V_{\text{star}} \]

\[ dE V_{\text{circ}} \text{ & late-type } V_{\text{H\alpha}} \]

\[ dE V_{\text{circ}} \text{ & dIrr } V_{\text{HI}} \text{ profiles} \]

(Ryś+ 2014)
variety of properties suggests formation/evolution scenario acting stochastically

dE have lower $\lambda_R$ and steeper dE $V_{\text{circ}}$ profiles than the present-day analogues of their presumed late-type progenitors,

transformation mechanism needed that is able to lower angular momentum + account for increased stellar concentration,

transformation due to tidal harassment – unless the dE progenitors were already compact and had lower angular momenta at higher redshifts.
Ages, $Z$, mass & light weights of both young and old components:
- old component present in most galaxies
- younger component typically more centrally concentrated than the old one

→ some dwarfs could have contributed to the build-up of massive galaxies’ stellar haloes
→ secondary burst of SF or SF still strong at $\sim$ a few Gyr

(Å. Ryś+ 2015)
VCC 1431 - a genuinely old galaxy?

- no evidence for populations $\sim<10$ Gyr
- no substructure (Janz+ 2013) $\rightarrow$ no tell-tale sign of interactions
- centrally located in Virgo
- lowest $\lambda_R$ and steepest $V_{circ}$ profile

If infallen:

- gas stripped before entering the cluster (in group?) $\rightarrow$ SF quenched
- then tidally harrassed $\rightarrow$ made more compact & had its $\lambda_R$ lowered

(Agnieszka Ryś 2015)
ID 0918 - a merger remnant?

- break in young and old population profiles at KDC radius
- merger, gas lost earlier – no further SF
- isolated location – encounter highly improbable

\[ \Gamma_y = 0.21^{+0.39}_{-0.39} \]
\[ \Gamma_o = 0.12^{+0.13}_{-0.13} \]

\[ \Gamma_y = 1.01^{+0.51}_{-0.51} \]
\[ \Gamma_o = -0.37^{+0.56}_{-0.56} \]

(Ryś+ 2015)
we are able to recover 2-SSP SFHs from the limited SAURON λ range thanks to high data quality

for the majority of objects SF either still strong at a few Gyr of age or secondary SF burst ~at that age

in agreement with the proposed dE formation scenario where tidal harassment drives the remaining gas inwards and induces a secondary star formation episode.

we find a candidate "relic" galaxy + an object where kinematic and stellar population properties are correlated (merger remnant?) – illustration of the SFH variety of dEs
Summary

we confirm & add to the variety of dE kinematic and stellar population properties,

we show that dynamical properties of dEs favor the tidal harassment scenario (able to increase compactness, lower angular momentum & DM fraction)

we see that SF activity was still strong a few Gyr ago or that the galaxies experienced a secondary SF burst, compatible with the above scenario
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Future work

Doubled SAURON Virgo sample
- stronger constraints wrt dwarf-giant scaling relations

Expanding the sample to different environments
- cosmic voids
- other nearby clusters (Fornax, Coma)

Making simulations and observations meet:
- looking “through the eye of SAURON” at a new suite of high-resolution simulations of dEs in the Virgo cluster
- → come and see my talk @ 12:15 on Thursday (Symposium 2)