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Dwarf ellipticals in the eye of SAURON: dynamical & stellar population analysis in 3D

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Abstract. We present the dynamical and stellar population analysis of 12 dwarf elliptical galaxies (dEs) observed using the SAURON IFU (WHT, La Palma). We demonstrate that dEs have lower angular momenta than their presumed late-type progenitors and we show that dE circular velocity curves are steeper than the rotation curves of galaxies with equal and up to an order of magnitude higher luminosity. Transformation due to tidal harassment is able to explain all of the above, unless the dE progenitors were already compact and had lower angular momenta at higher redshifts. We then look at the star formation histories (SFHs) of our galaxies and find that for the majority of them star formation activity was either still strong at a few Gyr of age or they experienced a secondary burst of star formation roughly at that time. This latter possibility would be in agreement with the scenario where tidal harassment drives the remaining gas inwards and induces a secondary star formation episode. Finally, one of our galaxies appears to be composed exclusively of an old population ($\gtrsim$12 Gyr). Combining this with our earlier dynamical results, we conclude that it either was ram-pressure stripped early on in its evolution in a group environment and subsequently tidally heated (which lowered its angular momentum and increased compactness), or that it evolved *in situ* in the cluster's central parts, compact enough to avoid tidal disruption.

Keywords. galaxies: elliptical and lenticular, dwarf - galaxies: evolution - galaxies: formation

1. Introduction

dEs are the most common galaxy class in dense environments, outnumbering all other classes combined. Their low masses make them ideal test beds for studying different mechanisms that shape galaxies, since both external influences and internal feedback mechanisms are far more extreme in dwarfs than in massive galaxies. They also make them challenging to observe. dEs are a surprisingly inhomogeneous class, which has made it difficult to relate different dE subtypes to each other, as well as to place the whole class in the larger context of galaxy assembly and (trans)formation processes.

The idea behind the present project (Ryś *et al.* 2013) was to obtain large-scale two-dimensional *maps* of kinematic and stellar population properties for objects for which (with very few and small-scale exceptions) only one-dimensional profiles were available before. With integral-field data it is possible not only to reduce the uncertainties on radial properties, but also to characterize potential substructures far more accurately, and to provide detailed information on the dynamical structure of observed systems.

2. Results

We find that the specific angular momenta of dEs are significantly lower than those of the late-type galaxies of the CALIFA survey (Sánchez *et al.* 2012). This leads to the conclusion that when designing possible transformation paths we need to include processes that lower stellar angular momentum. We compare our dEs circular velocity profiles to those of massive (Catinella *et al.* 2006) and dwarf (Swaters *et al.* 2009) late-type galaxies and find that dE curves are steeper and their absolute values higher than those of late-type galaxies of comparable luminosity. Therefore, we need to account for this increase in concentration in our search for late-to-early type transformation mechanisms. Furthermore, we investigate whether any correlation exists between the dark matter fraction and the 3D (i.e. intrinsic) clustrocentric distance and we find that galaxies in the cluster outskirts tend to have higher dark-to-stellar matter ratios. All this implies that processes like ram-pressure stripping (Gunn & Gott 1972) alone are not able to explain the observed characteristics of the dE class. Tidal harassment (Moore *et al.* 1998) is currently the only available scenario with which we can explain the above findings, unless the dE progenitors were already compact and had lower angular momenta at high redshift (Ryś *et al.* 2014).

We look at resolved star formation histories of our galaxies and find that the majority of them either still exhibited strong star formation (SF) at a few Gyr ago or they experienced a secondary burst of SF that occured roughly at that time. We interpret this as a tentative piece of evidence in favor of the harassment scenario, where such episodes of SF are expected as the remaining gas is driven inwards as a result of tidal forces. We also find that the old populations of dEs are roughly coeval with those of giant ETGs, in principle making it possible for dEs to be the builing blocks of the outskirts of massive galaxies.

3. Conclusions and future work

We have presented the analysis of stellar kinematic and absorption line-strength maps for a sample of 12 Virgo Cluster and field dwarf elliptical galaxies. This is to date the largest sample of dEs for which integral-field data is available, and offers the largest spatial coverage so far. Nevertheless, we hope that once large samples for environments of varying density have been analyzed, the findings presented here will be strengthened/confirmed. It will also be of vital importance to be able to test our observational results against a larger suite of simulations of enough spatial resolution, going down to masses we require – and testing a range of initial conditions (orbits, masses, angular momenta, galaxy types and infall epochs) as well as interaction types. In this way observations could be interpreted against a more robust theoretical backbone.

References

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