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The Quest for Relics: Massive compact galaxies in the local Universe

F. S. Lohmann, A. Schnorr-Müller, M. Trevisan, R. Riffel, N. Mallmann, Ana L. Chies-Santos and C. Furlanetto

Departamento de Astronomia, Universidade Federal do Rio Grande do Sul,
PO Box 15051, 91501-970 Porto Alegre, Brazil
emails: felipe.s.lohmann@gmail.com, allan.schnorr@ufrgs.br,
marina.trevisan@ufrgs.br, riffel@ufrgs.br, nicolas.fisica@gmail.com,
ana.chies@ufrgs.br, cristina.furlanetto@ufrgs.br

Abstract. Observations at high redshift reveal that a population of massive, quiescent galaxies (called red nuggets) already existed 10 Gyr ago. These objects undergo a significant size evolution over time, likely due to minor mergers. In this work we present an analysis of local massive compact galaxies to assess if their properties are consistent with what is expected for unevolved red nuggets (relic galaxies). Using integral field spectroscopy (IFS) data from the MaNGA survey from the Sloan Digital Sky Survey (SDSS), we characterized the kinematics and properties of stellar populations of massive compact galaxies, and find that these objects exhibit, on average, a higher rotational support than a control sample of average sized early-type galaxies. This is in agreement with a scenario in which these objects have a quiet accretion history, rendering them candidates for relic galaxies.

Keywords. Galaxies: evolution, Galaxies: formation, Galaxies: kinematics and dynamics

1. Introduction

Observations of the high redshift Universe revealed that a population of massive quiescent galaxies (called red nuggets) already existed 10 billion years ago. These galaxies are thought to be the progenitors of local massive quiescent galaxies. However, compared to their local Universe counterparts, these objects show significant distinctions: they are very compact, more elongated and many have disks, suggesting that they undergo a significant size evolution over time (Trujillo *et al.* 2007). Simulations suggest that this evolution in size is mainly due to minor mergers (Naab *et al.* 2009). Thus, the study of these objects is crucial to understand the formation of massive galaxies. However, spatially resolved spectroscopic studies of large samples of red nuggets are not feasible with the current generation of telescopes. Since mergers occur in a stochastic manner, it is expected that there exists a population of galaxies in the local Universe that have not gone through these processes since they became quiescent. These galaxies, called relic galaxies, are local analogues of the high redshift red nuggets. Studying these objects can provide hints on the formation of massive quiescent galaxies at high redshift and how they transform into local early-type galaxies.

The aim of this work is to characterize the kinematics and the stellar populations of a sample of massive compact galaxies in the local Universe. The work focuses on the following items:

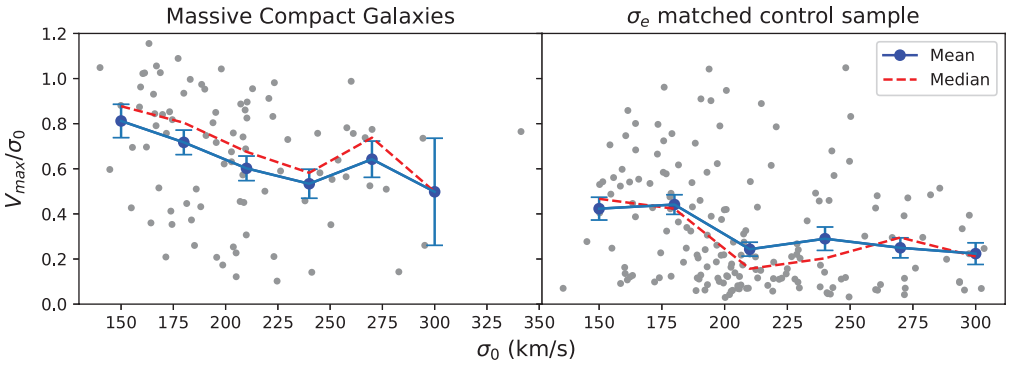

Figure 1. Distribution of $V_{\rm max}/\sigma_0$, the ratio between the maximum velocity along the major axis ($V_{\rm max}$) and the central velocity dispersion (σ_0, defined as the velocity dispersion measured in the central pixel), for both samples.

• Determine which galaxies have properties consistent with relic galaxies and understand their importance in the formation and evolution of massive galaxies;

• Investigate formation and evolution scenarios for these objects, as well as their relationship with local massive elliptical galaxies.

2. Methodology

We studied a sample of 87 galaxies selected from the MaNGA survey based on the following criteria:

(a) Stellar mass: $10^{10.5} M_\odot < M_\star < 10^{11.5} M_\odot$;

(b) The size of the semimajor axis of the half-light ellipse is at least 1σ below the value predicted by the local mass-size relation for early-type galaxies (van der Wel *et al.* 2014).

In order to verify if massive compact galaxies have different kinematics from massive average-sized galaxies, we defined a control sample with 174 objects with half-light radii within 1σ of the median size for a given mass. The samples were matched by σ_e, defined as the velocity dispersion measured in an effective radius aperture R_e, and by specific star formation rate. Using integral field spectroscopy data, velocity maps (V), velocity dispersion (σ) and Gauss-Hermite parameters h_3 and h_4 were obtained using the pPXF code (Cappellari 2017). The Gauss-Hermite h_3 parameter is of interest for this work as it is linked to the galaxy assembly history: simulations revealed that fast-rotators with a gas rich merger history show an anti-correlation between h_3 and V/σ, while fast-rotators with a gas poor merger history do not (Naab *et al.* 2014).

3. Conclusions

• The compact galaxy sample has, on average, a higher rotational support than the control sample (Fig. 1). This difference is driven mainly by a significant fraction of slow rotators in the control sample. This is in agreement with a scenario in which these objects did not go through gas-poor major mergers since their formation;

• Several objects in the compact galaxy sample (∼80%) present a strong anti-correlation between h_3 and V/σ. This anti-correlation indicates that these objects have a gas-rich merger history;

• However, to confirm whether these objects are indeed relics, further studies of their stellar populations - to constrain the time of their formation - and of the stellar kinematics on their outskirts - to rule out a significant contribution of accreted stars - are necessary.

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References

Cappellari, M. 2017, *MNRAS*, 466, 798
Naab, T., Johansson, P. H., & Ostriker, J. P. 2009, *ApJ* (Letters), 699, L178
Naab, T., Oser, L., Emsellem, E., *et al.* 2014, *MNRAS*, 444, 3357
Trujillo, I., Conselice, C. J., Bundy, K., *et al.* 2007, *MNRAS*, 382, 109
van der Wel, A., Franx, M., van Dokkum, P. G., *et al.* 2009, *ApJ*, 788, 28

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