The growth of massive galaxies due to merging since z~1 is size independent

L.A. Díaz-García[1], E. Mármol-Queraltó[2,3], I. Trujillo[2,3], A.J. Cenarro[1], C. López-Sanjuan[1], P.G. Pérez-González[4,5], G. Barro[6]

[1] *Centro de Estudios de Física del Cosmos de Aragón (CEFCA), Plaza San Juan, 1, Planta-2, E-44001, Teruel, Spain*
[2] *Instituto de Astrofísica de Canarias, c/ Vía Láctea s/n, E-38205, La Laguna, Tenerife, Spain*
[3] *Departamento de Astrofísica, Universidad de La Laguna, E-38205, La Laguna, Tenerife, Spain*
[4] *Departamento de Astrofísica, Facultad de CC. Físicas, Universidad Complutense de Madrid, E-28040, Spain*
[5] *Associated Astronomer at Steward Observatory, The University of Arizona*
[6] *UCO/LICK Observatory, University of California, Santa Cruz, CA 95064*

1. Abstract

Using a large compilation of massive (stellar mass $M \gtrsim 10^{11} M_\odot$) early-type galaxies (ETGs), we have probed, up to z~1, whether the presence of satellites within a projected distance of 100 kpc of these objects depends on the size of the host massive galaxies. We do not find any evidence for satellites with a mass ratio down to 1:10 neither down to 1:100 to be preferentially located around compact or extended massive ellipticals. This suggests that, at least since z~1, the merger activity in these objects is rather homogeneous across the whole population.

2. Introduction

At a fixed stellar mass, the size of low redshift ETGs is found to be a factor of two larger than their counterparts at z~1 and there is not any significant drop in the density of ETGs since z~1. The main mechanisms suggested to produce this growth in size since that epoch is the continuous bombardment of smaller pieces into the main objects leading to merging process (e.g., López-Sanjuan et al. 2012).

A proxy to measure the merging activity since z~1 is to study the frequency of satellites around the massive galaxies. In particular, we study whether the satellites are preferentially located around galaxies with a specific size in the stellar mass – size relation or whether they are homogeneously distributed among the galaxy population independently of their stellar mass and size.

3. The data

As the reference catalog for the central galaxies we have used the compilation of massive objects published by Trujillo et al. (2007). This catalog comprises massive galaxies with spectroscopic and photometric redshifts, stellar masses, half-light radius and Sérsic indices.

To compile the sample of satellite galaxies around our massive objects we have used the EGS IRAC-selected galaxy sample from the Rainbow Cosmological Database (https://rainbowx.fis.ucm.es/Rainbow_Database/). This database provides photometric redshifts and stellar masses.

In the redshift range 0<z<1.4 there are 378 massive ETGs for which we can probe satellites with a mass fraction compared to their central objects of 1:10. There are 145 massive ETGs in the redshift range 0<z<1.1 that are able to explore the presence of satellites down to mass range of 1:100 assuring that the fraction of galaxies is not biased by the stellar mass completeness limit on the Rainbow database.

4. Detection of satellites

The criteria to search for satellites around massive ETGs is based in Mármol-Queraltó et al. (2012): a galaxy is considered as a potential satellite if the redshift difference between the object and the main host is less than 1σ uncertainty in the estimation of the Rainbow redshifts within a projected radial distance of 100 kpc. Finally, we only consider satellite objects with a mass range 1:10 up to z=1.4 and 1:100 up to z<1.1.

Parameter b [10^{-6}kpc]			
Mass ratio 1 : 10			
Redshift	With Satellites	No Satellites	Global
$0.0 < z < 0.5$	2.57 ± 0.10	3.03 ± 0.19	2.91 ± 0.17
$0.5 < z < 0.8$	2.28 ± 0.30	2.01 ± 0.08	2.10 ± 0.06
$0.8 < z < 1.1$	1.52 ± 0.12	1.56 ± 0.08	1.56 ± 0.06
$1.1 < z < 1.4$	1.01 ± 0.23	1.17 ± 0.10	1.15 ± 0.09
Mass ratio 1 : 100			
Redshift	With Satellites	No Satellites	Global
$0.0 < z < 0.5$	2.94 ± 0.26	2.86 ± 0.20	2.91 ± 0.17
$0.5 < z < 0.8$	2.17 ± 0.10	1.97 ± 0.10	2.07 ± 0.06
$0.8 < z < 1.1$	1.42 ± 0.18	1.37 ± 0.20	1.41 ± 0.09

Table 1. The best fitting parameter b to the stellar mass – size distribution of massive ETGs for different redshift bins and mass ratios.

% Percentage (p-value < 0.9)		
Mass ratio 1 : 10		
Redshift	KS-test	TS-test
$0.0 < z < 0.5$	89.26	96.45
$0.5 < z < 0.8$	89.48	83.33
$0.8 < z < 1.1$	99.88	99.99
$1.1 < z < 1.4$	98.40	98.67
Mass ratio 1 : 100		
Redshift	KS-test	TS-test
$0.0 < z < 0.5$	97.07	99.60
$0.5 < z < 0.8$	96.15	91.14
$0.8 < z < 1.1$	93.39	100.0

Table 2. Percentage of the Monte Carlo methods for which the size distribution of galaxies with and without satellites is the same.

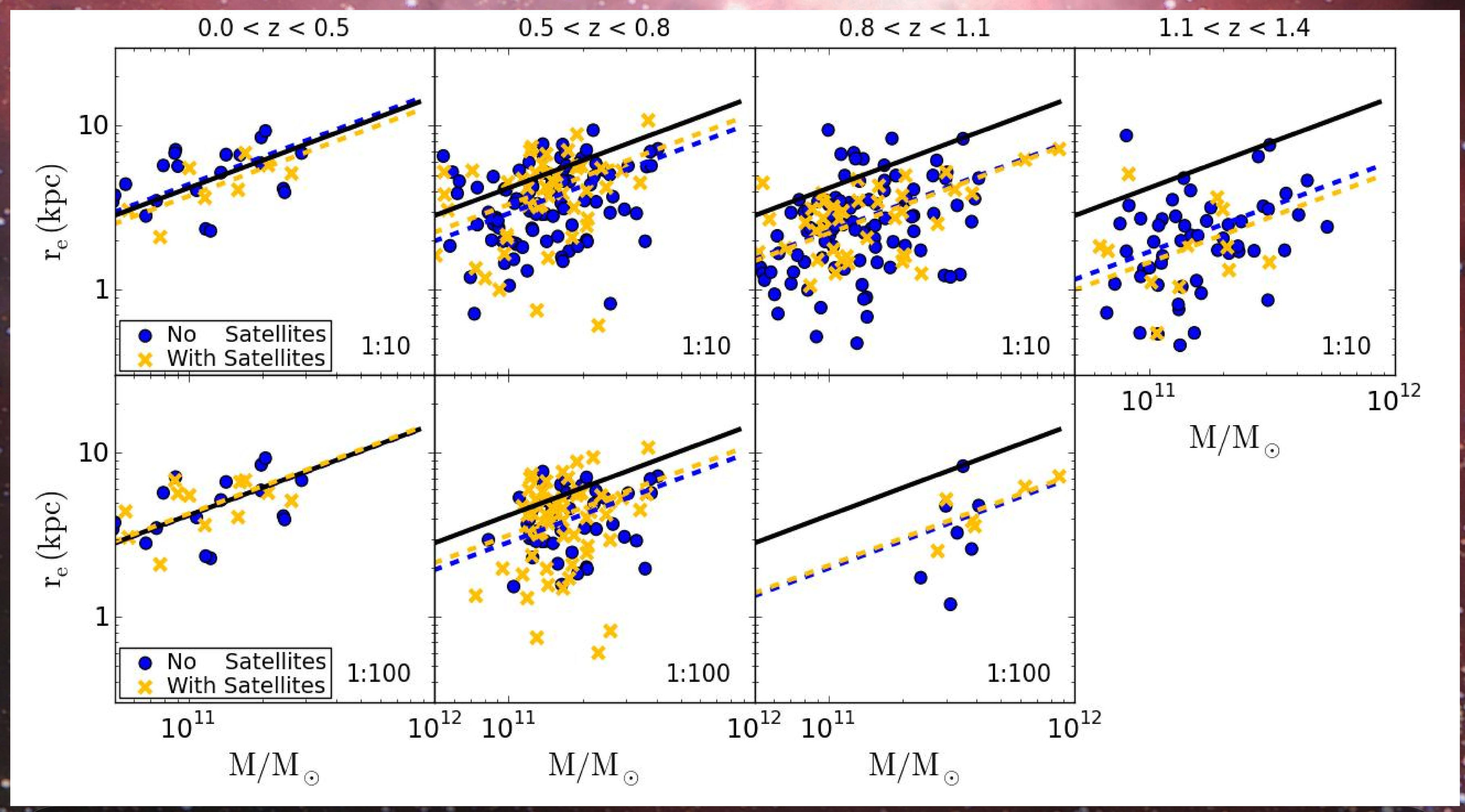

Figure 1. Stellar mass – size relation of ETGs in different redshift bins. In the upper row, we present massive galaxies with and without satellites down to a mass ratio of 1:10. In the bottom row, we present massive galaxies with and without satellites down to a mass ratio of 1:100. Blue dots indicate galaxies without the presence of satellites whereas yellow crosses represent massive galaxies with at least one satellite identified within a projected distance of 100 kpc. The black line represents the local stellar mass – size relation (see Shen et al. 2003) for ETGs. For every redshift bin, dashed yellow and blue lines show the best fitting to the distribution of galaxies with and without satellites.

5. Analysis and conclusions

A quick look to Fig.1 shows that galaxies with satellites are distributed homogeneously through the stellar mass – size relation at all redshifts in the 1:10 and 1:100 mass ranges. To explore the mean size of the populations, we fit the distributions using:

$$r_e(kpc) = b\left(\frac{M}{M_\odot}\right)^a$$

For ETGs Shen et al. (2003) found a=0.56 and b=2.88*10^{-6} in the local Universe. For the fittings we fix a=0.56 and b is left free. In Fig. 1, the dashed lines are the best results for the fittings of the distributions. The b values for the best fittings are in Table 1.

To assure that the size distribution of massive galaxies is or not related to the presence of satellites we performed a Kolmogorov-Smirnov(KS) and a T-Student (TS) test over the distributions getting that both distributions are not different.

Mármol-Queraltó et al. (2012) shows that the contamination of fake galaxies due to the uncertainty of the redshift and clustering effect can be up to ~30% in 1:10 and ~50% in 1:100. We can not correct the contamination of central galaxies individually, so we instead adopt a statistical Monte Carlo approach dropping out randomly galaxies with satellites to the sample without satellites until we recover the fraction of galaxies having satellites after the contamination correction. We repeat this process one million times.

For every Monte Carlo we compute a KS and TS test and we get that for more than 95% of the times the size distributions of massive galaxies with and without satellites are the same, see Table 2.

There is no hint for galaxies having satellites to be more compact or extended than galaxies without satellites. The fraction of galaxies having satellites in their surroundings are independent of their size. In Table 1 and Fig. 1 we can see that the massive galaxies evolve in size independently whether have satellites or not, moreover, the evolution in size is the same for massive galaxies with satellites and without satellites.

6. References

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diaz@cefca.es