The growth of massive galaxies due to merging since \( z \approx 1 \) is size independent

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1. Abstract

Using a large compilation of massive (stellar mass \( M > 10^{11} M_\odot \)) early-type galaxies (ETGs) at low redshift, \( z < 1 \), we determine the fraction of ETGs with satellites (excluding those within a projected distance of 100 kpc) with a mass ratio down to 1:100. We do not find any evidence for satellites with a mass ratio down to 1:100 to be preferentially located around compact or extended massive ellipticals. This suggests that at least since \( z \approx 1 \), 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 \( z \approx 1 \) and there is not any significant drop in the density of ETGs since \( z \approx 1 \). 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 \( z \approx 1 \) 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 < \( z < 1.1 \) 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 lower than 1/100. We do not find any evidence for satellites with a mass ratio down to 1:100 to be preferentially located around compact or extended massive ellipticals. This suggests that at least since \( z \approx 1 \), the merger activity in these objects is rather homogeneous across the whole population.

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:

\[
 r_\text{[kpc]} = b \frac{M}{M_\odot}^a
\]

For ETGs Shen et al. (2003) found \( a=0.56 \) and \( b=2.88 \times 10^6 \) 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 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 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 and without satellites.

6. References


Table 1. The best fitting parameters to the stellar mass - size distributions of massive ETGs for different redshift bins and mass ratios.

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