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Structure and morphology of relic galaxies in the Local Universe

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Introduction

Considering the two phase galaxy formation scenario of massive early type galaxies (Huang et al. 2016), the compact core forms first (at z > 3), followed by the growth of mass and size through mergers with other galaxies (from z < 2). Given the stochastic nature of the mergers, we can expect that some compact seeds of galaxies that form in the beginning of the Universe are left almost untouched until today. Thus, we expect to find them in the Local Universe (Beasley et al. 2018). These objects found at high redshift called Red Nuggets are compact (R_e < 2.5 kpc) massive galaxies (M $\sim 10^{11}$ M$\odot$) with old stellar populations. Objects with such features found in the Local Universe are considered relics and can help us to understand the formation and evolution of massive elliptical galaxies. The main goal of this project is to characterize the structure and morphology of candidates and confirmed relic galaxies in the Local Universe. In the near future, we plan to search for similar objects in cosmological simulations and understand their paths of formation and evolution.

Data

The first sample studied was composed of 16 galaxies with images from the Hubble Space Telescope (HST) in H and I bands, that were first selected and analyzed by Yildirim et al. 2018. In this project, the data was gathered from the Hubble Legacy Archive.

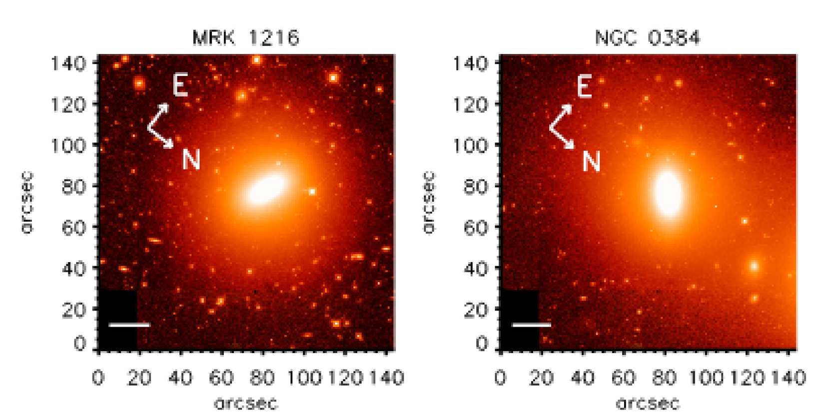

Figure 1: HST imaging of 2 galaxies from the first sample (Yildirim et al. 2018.)

The second sample being studied is composed of 87 candidate relic galaxies with images from the Sloan Digital Sky Survey (SDSS) in *g*,*r* and *i* bands. The objects were select as outliers in terms of their radii from the galaxy mass-size distribution at z=0.25 (van der Wel et al. 2014). A secondary control sample was built using galaxies with similar central dispersion velocities to those of the relic candidates. The imaging data of the relic candidates and the control sample were obtained from the SDSS Science Archive Server.

Method

To characterize the structure of the galaxies studied, we used the Sérsic profile (Sérsic 1963), which can be described by the following expression (Graham & Driver 2005):

$$I(R) = I_e exp\left\{-b_n\left[\left(\frac{R}{R_e}\right)^{1/n} - 1\right]\right\} \quad (1)$$

Where I(R) is the galaxy intensity as a funtion of its radius R, R_e is the effective radius that encloses half of the total light from the model, I_e is the intensity at R_e, n is the Sérsic index and b_n is a parameter determined in terms of n.

We performed single and double 2D Sérsic profile fitting with the software IMFIT (Erwin 2015) for all the galaxies in both samples (example on Fig. 2). The model selection was carried out considering reasonable physical arguments, analysis of the residual images and statistics of the fittings.

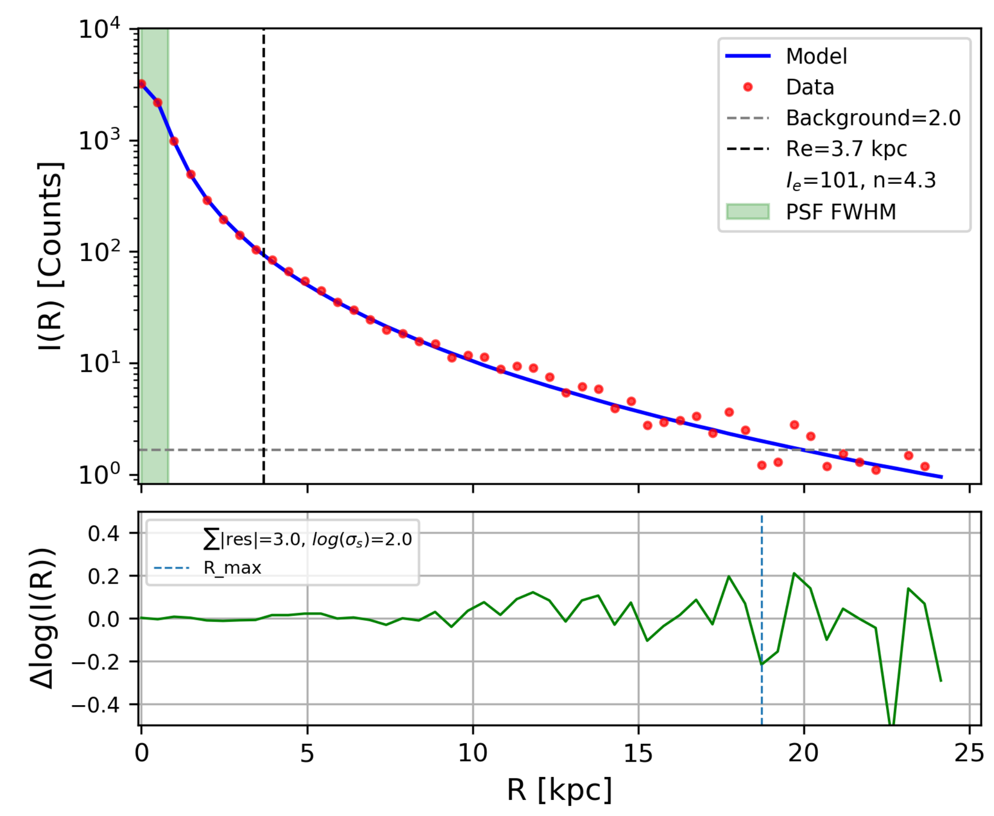

Figure 2: Light profile fitting (r-band) for the galaxy 1-48084 of the SDSS sample.

Results

The main results of the project for now are the Sérsic indexes and effective radii, presented below for both samples:

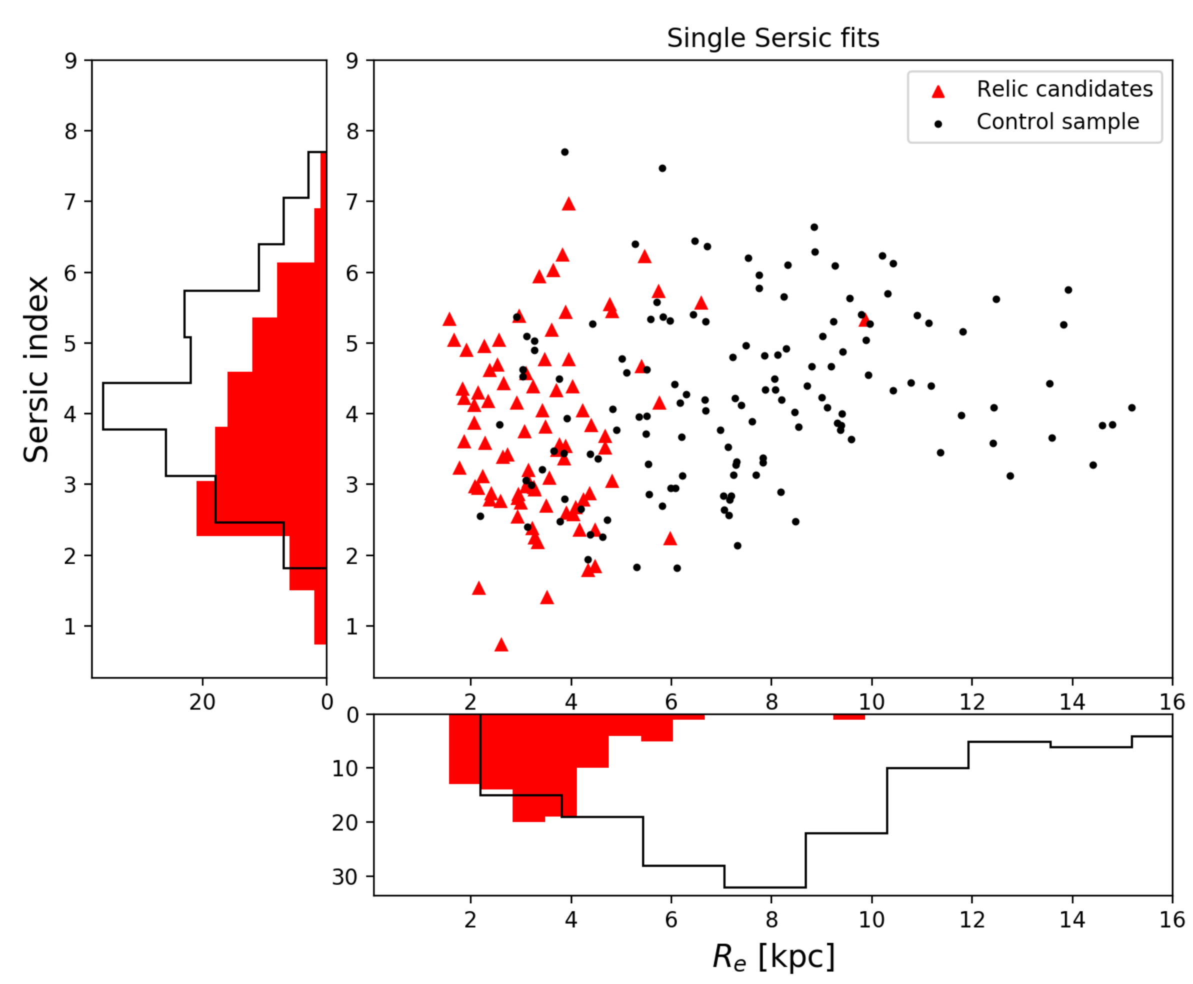

Figure 3: Results of the single Sérsic profile fitting applied on r-band images for 70 galaxies of the relic candidates sample. Red triangles represent the candidates and black dots represent the objects of the control sample.

Conclusions

From the double Sérsic fitting on the HST images we have that most of the 16 galaxies can be well modeled with a small (R_e < 2 kpc) and very compact component plus a larger component with low Sérsic index (n ≤ 1). From the single Sérsic fitting (Fig. 3) on the relic candidates of SDSS r-band images we can say that many objects have Sérsic index n ∼ 2.5, and effective radii R_e ∼ 3.0 kpc, while the cotrol sample seems to have different peaks in the distribution of the same parameters (Fig. 3).

References

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