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Morphological and non-parametric properties of clusters: Abell 1644 and Abell 3158

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Abstract. This project aims to contribute to the understanding of the formation and evolution of the universe through the study of galaxy clusters, the largest gravitationally bound systems in the Universe. A study is conducted on the morphological and nonparametric parameters of galaxies in the Abell 1644 and Abell 3158 clusters. We are specially interested in analysing the so-called Jellyfish (or Ram-Pressure Stripped) galaxies, studying its position within the cluster.

Resumo. Este projeto busca contribuir no entendimento da formação e evolução do universo através do estudo de aglomerados de galáxias, os maiores sistemas gravitacionalmente ligados do Universo. Nesse sentido, conduz-se um estudo dos parâmetros morfológicos e não paramétricos das galáxias nos aglomerados Abell 1644 e Abell 3158. Estamos especialmente interessados em analisar as chamadas galáxias Jellyfish (ou galáxias resultantes de pressão de ram), estudando suas posições dentro do aglomerado.

Keywords. Galaxies: clusters: general – Galaxies: fundamental parameters – Galaxies: photometry

1. Introduction

Galaxy clusters are the largest gravitationally bound systems that have reached, at least marginally, a state of dynamical equilibrium. Its process of formation involves complex phenomena, such as massive mergers, the accretion of galaxy groups, and interactions of galaxies with the interstellar medium as well as with other galaxies. Therefore, they play a central role in understanding the evolution of the Universe. Thus, it is important to highlight the study of the so-called Jellyfish (or Ram-Pressure Stripped) galaxies, which present a unidirectional tail as a result of its interaction with the intracluster medium. This mechanism is responsible for driving the rapid evolution of galaxies in dense environments, such as clusters. Therefore, the aim of this work is to contribute to such study through the analysis of structural and morphological properties of galaxies, correlating its parametric and non-parametric parameters with their respective positions within these clusters.

2. Materials and Methods

The sample studied is composed of 2 galaxy clusters: Abell 1644 (redshift of 0.047 and 574 galaxies) and Abell 3158 (redshift of 0.059 and 168 galaxies), which were selected for being non-relaxed clusters. The selection of galaxies in each cluster was carried out using data from the Southern Photometric Local Universe Survey (SPLUS DR4,Herpich et al. (2024)), while the analysis was performed with images in the g band from the Legacy DESI survey. As for the measurements, the software Astromorphlib was used, which can automatically download such images, providing routines for performing photometric analysis. This program also calculates a 2D sky background model and generates accurate segmentation maps of the galaxies in the image field. In Figure 1, an example of the fitting for a galaxy from Abell 1644 can be seen.

3. Results

Through the use of the Astromorphlib software (Hernandez-Jimenez & Krabbe 2022), it was possible to obtain parameters such as asymmetry (A), concentration (C), Sérsic index (n), and bulge strength parameters F(G,M20), which, according to Krabbe et al. (2024), present a high correlation with the JClass classification. Based on these indices, three graphics were constructed for the Abell 1644 cluster. According to Krabbe et al. (2024), morphologically disturbed galaxies — which include interacting galaxies and Jellyfish galaxies — occupy a region distant from undisturbed field galaxies. In Figure 1, this separation is highlighted by the black line in both panels, to the right of which lie the morphologically disturbed galaxies.

Subsequently, in order to select candidate Jellyfish galaxies, a visual and individual analysis of the galaxies located in the region defined as the morphological disturbance zone was performed. For this inspection, two main criteria were adopted: (i) the presence of a unidirectional tail, a distinctive feature of Jellyfish galaxies, and (ii) the absence of companion galaxies, to exclude those whose morphological disturbances could be caused by the gravitational influence of neighbors. As a result, a map of Abell 1644 was created showing the positions of all member galaxies (in blue) and the candidate Jellyfish galaxies (in pink) within a radius of 5R200 (Figure 2).

4. Conclusion

Thus, of the 82 galaxies in the Abell 1644 cluster located within the morphological disturbance zone, 20 were identified as candidate Jellyfish galaxies. According to Figure 2, these candidates are well distributed throughout the cluster's radius—5 of them are located within the substructure observed in the upper right region of the map. It is worth noting that this work includes future steps, which involve analyzing data from the Abell 3158 cluster, studying the galaxy environment, and conducting new measurements using the Galfitm software.

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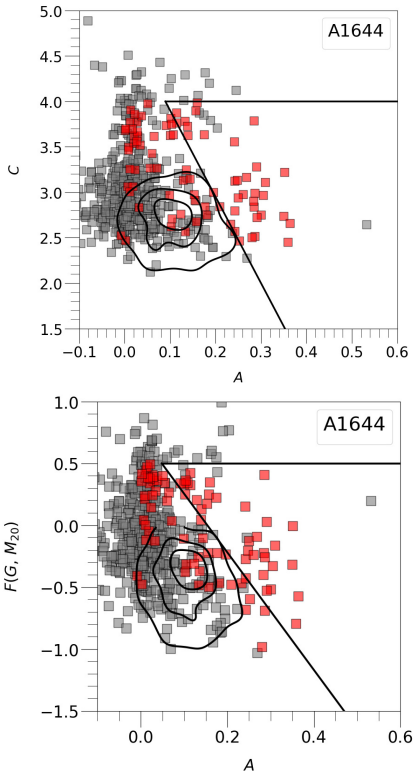

Figure 1. The distribution of galaxies in the Abell 1644 cluster is shown in the A versus C graph (top panel) and in the A versus F(G, M20) (bottom panel). The solid black lines delineate the boundaries of the morphological transition zone. In red are the galaxies that are within the morphological transition zones in all three graphs: A versus C, A versus F(G, M20) and A versus n, (not shown here).

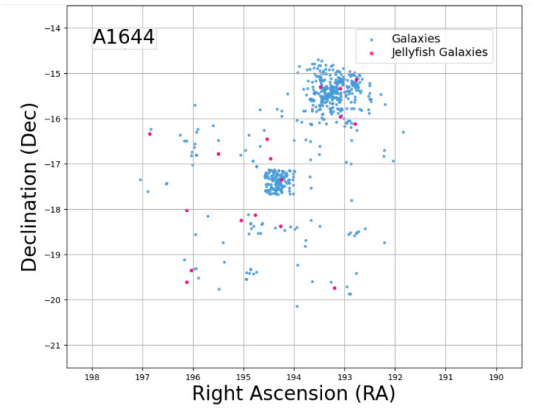

Figure 2. The spatial distribution of the members of the Abell 1644 cluster. The candidate Jellyfish galaxies are shown in pink.

References

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