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Dynamical analysis of galaxy populations in clusters

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We analyze the velocity anisotropy profile, projected numerical density, and projected velocity dispersion profiles of four galaxy populations classified with respect to the main source of gas ionization: quiescent (Q), star-forming (SF), optical active galactic nuclei (AGN), and transition objects (T). Our results reveal that the Q population exhibits the highest degree of virialization, followed by AGN and T populations. In contrast, the SF population displays the most pronounced indicators of non-equilibrium.

Galaxies inhabit diverse environments, ranging from cosmic voids to dense galaxy clusters. It is well known that several galaxy properties vary according to the galaxy environment. In order to explain this observational trend various environmentally-drawn evolution mechanisms have been proposed in the literature (for a review, see Boselli & Gavazzi, 2006). The dynamics of galaxies within clusters provide insights into the relative efficiency of these processes. This analysis can be conducted using the Jeans equations, which allows one to access to the velocity anisotropy parameter, β, thereby offering information about the orbits of galaxies.

In this work, we analyze the $\beta(r)$ profile and the projected profiles of the numerical density $I(R)$ and velocity dispersion $\sigma_P(R)$ of four galaxy populations classified with respect to the main source of gas ionization. To accomplish this, we selected a sample of 143 galaxy clusters with $M_{200} \geq 10^{14.0} M_\odot$ and Gaussian velocity distribution in the line-of-sight, drawn from de Carvalho et al. (2017), including a total of 10974 galaxies with $0.03 \leq z \leq 0.1$ and $m_r < 17.78$. After creating an ensemble cluster with all galaxies, we utilize both the BPT (Baldwin et al., 1981) and WHAN (Cid Fernandes et al., 2011) optical diagnostic diagrams for the classification of galaxies into the following populations: star-forming (SF), optical active galactic nuclei (AGN), composite or transition objects (T, SF+AGN ionization), and quiescent (Q). The $\beta(r)$ profile is determined using both the MAMPOSSt code (Mamon et al., 2013) and the method of Solanes & Salvador-Sole (1990).

We find that galaxies belonging to the Q population exhibit the clearest indications of equilibrium within their respective clusters. Within this population, we observe the lowest values of velocity dispersion and clustercentric distances. The $\beta(r)$ profile for the Q population suggests a transition from more isotropic orbits near the center to increasingly radial orbits in the outskirts. On the other hand, the results for the SF population are consistent with a non-virialized population. SF galaxies tend to be situated in the outskirts, with this population displaying the highest values of velocity dispersion. In addition, the MAMPOSSt fails to identify an equilibrium solution for the $\beta(r)$ profile capable of reproducing the observed $\sigma_P(R)$ profile for SF galaxies.

The AGN and T populations exhibit comparable $\sigma_P(R)$ profiles, with AGN galaxies located in closer proximity to the central regions than T galaxies. The $\beta(r)$ profile for both populations indicates a transition from more isotropic orbits near the center to increasingly radial orbits. Moreover, MAMPOSSt's solution for the $\beta(r)$ profile effectively reproduces the $\sigma_P(R)$ profile of the AGN population and approximately that of the T population. These observations suggest that these populations are in a more advanced state of virialization in comparison to the SF population.

Our results are consistent with a scenario in which an infalling population composed of SF galaxies is affected by environmental mechanisms that remove their gas and redistribute their mechanical energy. This leads to the transformation of an outer SF population into a more central quiescent one. In this context, the T and AGN populations represent intermediate stages of this evolutionary process.

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