Galaxy Evolution and Feedback across Different Environments
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The co-responsibility of mass and environment in the formation of lenticular galaxies

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Abstract. We present the latest data release of the Planetary Nebulae Spectrograph Survey (PNS) of ten lenticular galaxies and two spiral galaxies. With this data set we are able to recover the galaxies' kinematics out to several effective radii. We use a maximum likelihood method to decompose the disk and spheroid kinematics and we compare it with the kinematics of spiral and elliptical galaxies. We build the Tully- Fisher (TF) relation for these galaxies and we compare with data from the literature and simulations. We find that the disks of lenticular galaxies are hotter than the disks of spiral galaxies at low redshifts, but still dominated by rotation velocity. The mechanism responsible for the formation of these lenticular galaxies is neither major mergers, nor a gentle quenching driven by stripping or Active Galactic Nuclei (AGN) feedback.

Keywords. galaxies: elliptical and lenticular, cD, galaxies: evolution, galaxies: kinematics and dynamics

1. Introduction

Lenticular or S0 galaxies form a composite class of objects, whose evolutionary path appears to be driven by their mass. They are composed of a disk and a spheroid, and might present several subcomponents. The best way to recover lenticular galaxies' formation histories is to study the evolution of their disks and spheroids in different environments. If the progenitors of S0 galaxies are spiral galaxies whose gas was gently stripped or consumed, their disk kinematics would be similar to the kinematics of the disks of spiral galaxies. Their spheroid, though, might have been enhanced by a last sparkle of star formation, triggered by the infall of the stripped material onto the spheroid. On the other hand, S0 galaxies could be the result of mergers or interactions; in this case the disk kinematics would be hotter than in spiral galaxies. Higher random motion than in spiral galaxies disks might also be explained by clumpy disk formation. It is particularly promising to combine photometric and kinematic information to break the degeneracies in disentangling the spheroid and disk components, but for early type galaxies it is rather difficult to get kinematics information at large radii due to the steep decrease of the galaxy luminosity and the lack of a stable gaseous disk. Only discrete

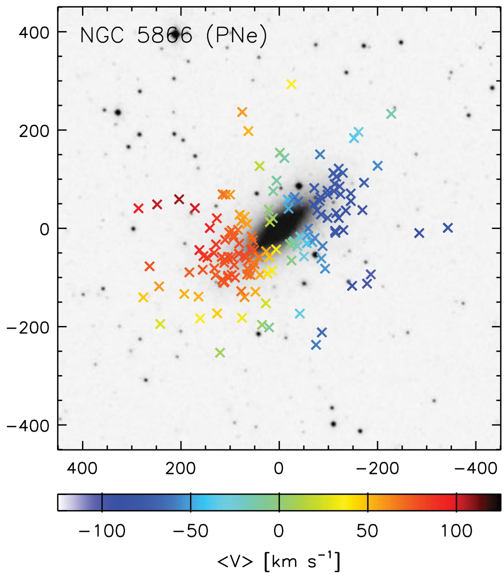

Figure 1. Digitised Sky Survey (DSS) image of NGC 5866, as an example of the galaxies in the sample, with the PN positions marked with crosses. The colours of the crosses represent the measured radial velocity of the PNe, after applying a kernel smoothing, according to the velocity scale below the panel.

tracers, such as planetary nebulae (PNe) and globular clusters (GCs), allow us to recover the kinematics of early type galaxies at large radii (Coccato *et al.* 2009, among others).

2. Analysis & Conclusions

We use PNe as tracers of the stellar kinematics of 10 lenticular and 2 spiral galaxies (see Fig. 1). To separate the kinematics of the disk and spheroid components, we use a maximum-likelihood method that combines the discrete kinematic data with a photometric component decomposition. The results of this analysis reveal that: the discs of S0 galaxies are rotationally supported; however, the amount of random motion in these discs is systematically higher than in comparable spiral galaxies. We compare the recovered TF relation with simulations that explain lenticular galaxies as major merger remnants (Tapia *et al.* 2017), or the results of merger of clumps at z $\sim$ 2 (Saha & Cortesi 2018). All of these findings are consistent with a scenario in which spirals are converted into S0s through a process that heats up the disk, ruling out ram pressure stripping and AGN feedback. Yet, the high value of rotation over dispersion velocity can hardly be reproduced by a recent major merger event. We conclude that mild harassment or minor mergers can lead to the formation of S0 galaxies. Today' s low-mass ($log(M/M) < 9.5$) isolated S0s could be primordial galaxies formed at z = 2 by clumpy disk formation (Saha & Cortesi 2018), where clump migration builds a prominent bulge with no spiral structure formation as an intermediate step. We here confirm Morgan's suggestion that the SO classification type is a repository of physically quite distinct sorts of objects (Van den Bergh 1990).

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