
The Formation and Evolution of S0 Galaxies

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Abstract

This thesis studies the origin of local S0 galaxies and their possible links to other morphological types, particularly during their evolution. To address these issues, two different – and complementary – approaches have been adopted: a detailed study of the stellar populations of S0s in the Fornax Cluster and a study of the Tully–Fisher Relation of local S0s in different environments.

The data utilised for the study of Fornax S0s includes new long-slit spectroscopy for a sample of 9 S0 galaxies obtained using the FORS2 spectrograph at the 8.2m ESO VLT. From these data, several kinematic parameters have been extracted as a function of position along the major axes of these galaxies. These parameters are the mean velocity, velocity dispersion and higher-moment h_3 and h_4 coefficients. Comparison with published kinematics indicates that earlier data are often limited by their lower signal-to-noise ratio and relatively poor spectral resolution. The greater depth and higher resolution of the new data mean that we reach well beyond the bulges of these systems, probing their disk kinematics in some detail for the first time. Qualitative inspection of the results for individual galaxies shows that some of them are not entirely simple systems, perhaps indicating a turbulent past. Nonetheless, circular velocities are reliably derived for seven rotationally-supported systems of this sample.

The analysis of the central absorption line indices of these 9 galaxies indicates that they correlate with central velocity dispersions (σ_0) in a way similar to what previous studies found for ellipticals. However, the stellar population properties of Fornax S0s indicates that the observed trends seem to be produced by relative differences in age and α -element abundances, contrary to what is found in ellipticals where the overall metallicities are the main drivers of the correlations. It was found that the observed scatter in the line indices versus σ_0 relations can be partially explained by the rotationally-supported nature of many of these systems. The tighter correlations found between line indices and maximum rotational velocity support this statement. It was also confirmed that the dynamical mass is the driving physical property of all these correlations and in our Fornax S0s it has to be estimated assuming rotational support.

In this thesis, a study of the local B - and K_s -band Tully–Fisher Relation (TFR) in S0 galaxies is also presented. Our new high-quality spectral data set from the Fornax Cluster and kinematical data from the literature was combined with homogeneous photometry from the RC3 and 2MASS catalogues to construct the largest sample of S0 galaxies ever used in a study of the TFR. Independent of environment, S0 galaxies are

found to lie systematically below the TFR for nearby spirals in both the optical and infrared bands. This offset can be crudely interpreted as arising from the luminosity evolution of spiral galaxies that have faded since ceasing star formation.

However, a large scatter is also found in the S0 TFR. Most of this scatter seems to be intrinsic, not due to the observational uncertainties. The presence of such a large scatter means that the population of S0 galaxies cannot have formed exclusively by the above simple fading mechanism after all transforming at a single epoch.

To better understand the complexity of the transformation mechanism, a search for correlations was carried out between the offset from the TFR and other properties of the galaxies such as their structural properties, central velocity dispersions and ages (as estimated from absorption line indices). For the Fornax Cluster data, the offset from the TFR correlates with the estimated age of the stars in the centre of individual galaxies, in the sense and of the magnitude expected if S0 galaxies had passively faded since being converted from spirals. This correlation could imply that part of the scatter in the S0 TFR arises from the different times at which galaxies began their transformation.

Published work

Much of the work in this thesis has been previously presented in two papers:

1. Bedregal et al. (2006a), “S0 galaxies in Fornax: data and kinematics”.
2. Bedregal et al. (2006b), “The Tully-Fisher relation for S0 galaxies”.

The rest will be presented in:

3. Bedregal et al. (2007), “S0 galaxies in Fornax: Central Stellar populations” (submitted to MNRAS).

Bedregal et al. (2006a) contains much of the work detailed in Chapter 2. Bedregal et al. (2006b) describes the work presented in Chapter 4. The contents of Chapter 3 will be presented in Bedregal et al. (2007). The work presented in this thesis was performed by the author, with advice from the paper coauthors listed above. Where the material presented is taken from literature, this is mentioned explicitly in the relevant chapter.

Finally, other work performed during the PhD which *is not* included in this thesis has being publish in two other papers:

4. Aragón-Salamanca et al. (2006), “Measuring the fading of S0 galaxies using globular clusters”.
5. Barr et al. (2007), “The Formation of S0 galaxies: evidence from globular clusters” (submitted to A&A).

Bibliography

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- [3] Bedregal A.G., Aragón-Salamanca A. & Merrifield M.R., 2006b, *MNRAS*, 373, 1125