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THE DYNAMICS OF S0 GALAXIES

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We investigate the detailed dynamical properties of a sample of disc-dominated S0 galaxies, with a view to understanding their formation, evolution and structure. By using long-slit spectra of edge-on systems along their major axis, we have derived an estimation of the phase density of their stars and the approximate form of their gravitational potentials. Using their asymptotic rotation speeds and their absolute magnitudes, we find that these S0 galaxies are systematically offset from the Tully-Fisher relation for later-type galaxies.

S0 galaxies are usually classified between spiral and elliptical galaxies. They share some properties with both elliptical and spiral galaxies: like ellipticals they have very little gas and dust and relatively old stellar populations while their exponential discs resemble those of spirals. S0 galaxies may be a heterogeneous morphological class with diverse formation histories. It has been suggested that gas might be swept out of normal spirals as they move through the ambient gas in a cluster of galaxies, thus converting spirals into S0s. Another way of forming S0s could be by galaxy merging between spirals, similar to the processes forming elliptical galaxies. To test these different formation scenarios, one important dynamical probe would be provided by the study of the Tully-Fisher relation. If S0s formed in a relatively benign way from spirals, we would expect to find the kind of correlation between circular rotation speed and optical luminosity characteristic of spirals.

To test this hypothesis we investigate the dynamical properties of a relatively homogeneous sample of disc-dominated S0 galaxies by building dynamical models for these objects. From the models we can determine accurate circular rotation speeds for the Tully-Fisher relation. We have selected six edge-on S0s with small bulges from the sample of S0 galaxies of Kuijken, Fisher & Merrifield (1996). From long-slit absorption line spectra along the major axes of the S0s, we have derived their full line-of-sight velocity distributions (LOSVDs) as a function of projected radius and line-of-sight velocity.

To reproduce the kinematics we adopt a pure thin disc model which is a reasonable approximation as our S0s have small bulges. For the potential we adopt a two-parameter softened isothermal sphere that yields a flat rotation curve. We have developed a new modeling method for thin discs based on an iterative algorithm that allows to invert the two-dimensional LOSVD to find the two-integral distribution function of the system and estimate its gravitational potential (Mathieu & Merrifield 2000). With this method, from long-slit spectra of our 6 edge-on S0 galaxies, we have reconstructed the LOSVD along the galaxies' major axes (see Mathieu, Merrifield & Kuijken 2002). The detailed dynamical models reproduce the observed LOSVDs and we have derived both model distribution functions and the approximate form of their potential, from which we obtain the circular velocity needed for the Tully-Fisher relation.

With the estimates of their asymptotic rotation speeds, we analyze the Tully-Fisher relation for our S0 galaxies in the I-band and compare the results with a study using data from another sample of S0 galaxies (Neistein et al. 1999). We show that our galaxies obey a reasonably tight Tully-Fisher relation offset from the relation for normal spirals. The interpretation of these data points to a simple picture in which these systems were formed by the stripping of gas from normal spiral galaxies. The scatter and offset in the relation are what one would expect if star formation had been shut off a few Gyrs ago, so that all that remains in these systems are the rather fainter old stellar populations. This results appear to conflict with Neistein et al. (1999), showing a much greater scatter and less systematic offset. More data are needed to see whether S0s are a "mixed bag" that formed in a variety of ways as suggested by Neistein et al. (1999), or whether they reflect the limitations of their simpler dynamical modeling.

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