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CLUES ON THE EVOLUTION OF CLUSTER GALAXIES FROM THE ANALYSIS OF THEIR ORBITAL ANISOTROPIES

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We study the evolution of galaxies in clusters by the analysis of a sample of $\sim$ 3000 galaxies, members of 59 clusters from the ESO Nearby Abell Cluster Survey (ENACS, Katgert et al. 1998), for which redshifts, *R*-band magnitudes, as well as morphologies are available (Thomas 2002; Biviano et al. 2002, B02 hereafter, and references therein).

In order to make the most efficient use of our data, we combine the 59 clusters into a single ensemble cluster as described in B02. In the ensemble cluster, after excluding galaxies in substructures, we find that there are 4 cluster galaxy populations that must be distinguished because they have different phase-space distributions: (i) the brightest ellipticals, with $M_R \leq -22$ (using $H_0 = 100\,\mathrm{km\,sec^{-1}Mpc^{-1}}$), (ii) the other ellipticals together with the S0 galaxies (we refer to this class as $E+S0$ hereafter), (iii) the early spirals (Sa–Sb), and (iv) the late spirals and irregulars (Sc–Ir) together with the emission-line galaxies (ELG's).

About 2/3 of all cluster galaxies (outside substructures) belong to the $E+S0$ class. The shape of the $E+S0$ velocity distribution indicates that these galaxies move on nearly isotropic orbits, $\beta \approx 0$ (see also van der Marel et al. 2000). We can therefore use $E+S0$ as isotropic tracers of the cluster gravitational potential. We solve the Abel and Jeans equations (see, e.g., Binney & Tremaine 1987) using both a direct non-parametric approach, and the inverse method described by van der Marel (1994). We find that a NFW (Navarro, Frenk, & White 1997) mass profile with $r_s/r_{200} = 0.25^{+0.15}_{-0.10}$ (68% confidence limits) provides a very good fit to our data. We use this mass profile to estimate the anisotropy profiles for the other three cluster galaxy populations, using the method of Solanes & Salvador-Solé (1990).

We do not find any acceptable solution for the brightest ellipticals, most likely because these galaxies do not fulfil the conditions for the applicability of the *collisionless* Jeans equations. As a matter of fact, the brightest ellipticals mostly sit at the bottom of the cluster potential well, and move very slowly, if at all (B02). They have probably been slowed down by dynamical friction, and could have grown by mergers of other massive galaxies (Brough et al. 2002).

We do find acceptable solutions for the early spirals. We cannot exclude fully isotropic orbits for these galaxies, but the data taken at face value indicate that *near the cluster center* they move on radially-anisotropic orbits ($\beta \approx 0.6$). Since there is evidence that these galaxies evolve into S0's (Katgert, Thomas, & Biviano 2002), it is possible that the early spirals that are still visible near the cluster center are those that have managed to avoid transformation, by the amplitude and direction of their velocities.

We also find acceptable solutions for the class of late spirals + ELG's. The anisotropy is close to zero in the center, but there are not many galaxies (if any) of this class there. For radii $\geq 0.5\,r_{200}$ the anisotropy grows almost linearly, reaching $\beta \approx 0.6$ at a radius $\sim 1.5\,r_{200}$, which is the limit of our observational data. Such an anisotropy profile indicates that the late spirals + ELG's are field galaxies infalling into the cluster. The lack of these galaxies in the central cluster region suggests that they get transformed (into dwarf galaxies) or destroyed, once they reach the high density central regions of the clusters (see also Katgert, Thomas & Biviano 2002).

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