Systematic Differences Between the Field and Cluster Ellipticals

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We applied multivariate statistical techniques to study the possible systematic differences between the field and cluster ellipticals, in the framework of the fundamental plane (FP) of elliptical galaxies on the samples of elliptical galaxies from the general field and loose groups, and from rich clusters. The data set used here are the ellipticals from the "7 Samurai" (Burstein et al. 1987; Davies et al. 1987), limited to $cz < 6000$ km/s. There are 55 galaxies in the cluster sample (mostly from the Coma and Virgo clusters), and 57 galaxies in the field sample, which may include galaxies in loose and poor groups. We have also used the data set from Djorgovski & Davis (1987), with very similar results.

We find that the properties of ellipticals in rich clusters and in the field show systematic differences. The field ellipticals show a marginally higher statistical dimensionality than the cluster ellipticals; this difference is more prominent when the stellar population variables are included; i.e., the field ellipticals show more intrinsic scatter in their properties. This is also seen directly in the bivariate fits. In general, the field ellipticals seem to be a more heterogeneous family of objects. Pairwise (monovariate) correlations for the two samples are different; the correlations are systematically better for the cluster sample. This means that ellipticals in the two samples populate their fundamental planes in different ways. Bivariate correlations (equations of the FP) are also different for the two samples, implying that the two samples have different fundamental planes. This is especially true for the correlations which include the population variables Mg_2 and $(B - V)$, which are sensitive both to the enrichment history, and the star formation history. The field ellipticals are too blue, have too low Mg_2 and too high surface brightness at a fixed effective radius or luminosity, suggestive of the younger average ages.

These differences in scaling laws and correlations may be indicative of different formative histories. Specifically, they can be understood in the framework where cluster ellipticals form early, perhaps through numerous dissipative mergers of smaller fragments and the infall of gas, whereas at least some field ellipticals form through late, major mergers.

These systematic differences show again that one must be very careful in applying distance-indicator relations for galaxies defined in one sample to all galaxies of the given type: the field ellipticals do not follow the same distance-indicator relations as the ellipticals in rich clusters. We recall that the $D_n - \sigma$ relation of the "7 Samurai" (Dressler et al. 1987) was defined mainly using the rich clusters sample, and then applied indiscriminately to all ellipticals in their sample (a subset of which we have used here to demonstrate the systematic differences). It is important to understand the limits of accuracy of distance-indicator relations such as the various aspects of the FP (including the $D_n - \sigma$ relation) before credible claims of measurements of large-scale peculiar velocities can be made (cf. Djorgovski de Carvalho & Han 1988).

Related discussion and a complete list of references cited here can be found in Djorgovski & de Carvalho 1990, in Windows on Galaxies, ed. G. Fabbiano et al., (Dordrecht: Kluwer) p. 9. S.D. acknowledges support from the Alfred P. Sloan Foundation, the NSF PYI award AST-9157412, and a travel grant from the AAS.