Evolution and Environment of Early-Type Galaxies

Mariangela Bernardi

Department of Physics, Carnegie Mellon University, Pittsburgh, PA 15213

Abstract. The properties of early-type galaxies drawn from the SDSS database depend weakly, but significantly, on environment. Objects in regions of lower density tend to have slightly lower luminosities, velocity dispersions, bluer colors, and to be less homogeneous than objects in denser cluster-like regions. The chemical abundances of early-type galaxies drawn from the SDSS database also depend weakly on environment. Since chemical abundances also evolve with redshift, the observed trends constrain how strongly the luminosity weighted age depends on environment, provided the low redshift population is simply a passively aged version of the more distant population. The constraint does not depend on the detailed properties of stellar population synthesis models.

1 Introduction

There are two competing scenarios for the formation of giant early-type galaxies. Either they formed from a monolithic collapse, or they formed from the stochastic mergers of smaller systems. The differences between these scenarios are small if the stellar populations in these galaxies formed at high redshift. In the merger model, stars are likely to have formed earlier in the densest regions, so early-type galaxy observables are expected to correlate with environment, as is the evolution of the population with redshift. In what follows, I describe the results of a search for trends with environment and redshift. I select a sample of early-type galaxies from the SDSS database, and assign them to one of three types of environment: high density, low density, and in between. Very briefly, all objects with concentration index in the i^* band $\geq 2.75 - 2.5$ (depending on redshift), and `eclass < 0`, for which the spectroscopic pipeline had measured velocity dispersions, are selected (59405 objects). The subset with $14.5 \leq r_{\rm Pet} \leq 17.6$ and inside the SDSS "masked" region contains 39320 objects. Of these, 39251 have $z \leq 0.30$, and 25423 have $z \leq 0.14$. These are assigned to one of three different environments as shown in Figure 1 (see Bernardi et al. 2004 for details). Only objects in the densest (bottom left) and least dense (top right) environments are used in the analysis which follows: in all there were 3685 and 6258 early-types in the two environments at $z \leq 0.14$.

The typical S/N of the galaxy spectra in my catalog (∼18) is considerably smaller than the value (∼50) required to make reliable estimates of line-strengths. Therefore, for each environment, I construct high S/N composite spectra, suitable for line-index measurements, by co-adding the spectra of similar

ESO Symposia: Multiwavelength Mapping of Galaxy Evolution and Formation, pp. 308–313, 2005.

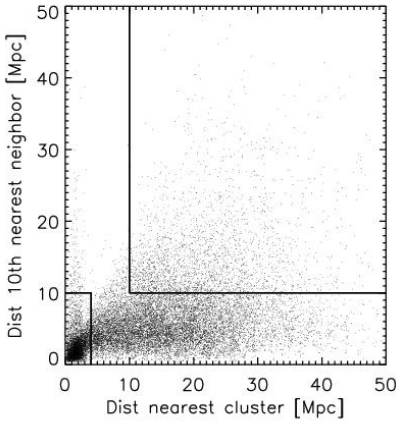

Fig. 1. Classification into high density (lower left) and low density environments (upper right) is based on the comoving distance to the tenth nearest luminous ($L > 3L_*$) neighbour, and on the comoving distance to the nearest massive cluster in the C4 catalog (Miller et al. 2004; each cluster is more luminous than $1.75 \times 10^{11}h^{-2}L_\odot \sim 10L_*$).

objects (I use narrow bins in luminosity, size, velocity dispersion, and redshift; see Bernardi et al. 2003 for details).

2 Structural Parameters, Chemical Abundances and Environment

At any given redshift, the objects in less dense regions tend to be slightly less luminous, to have smaller velocity dispersions, masses and sizes, and to be bluer, although these differences tend to be smaller than ten percent of the rms variation across the entire sample. The left panel of Figure 2 illustrates these trends using objects at $z \sim 0.1$; results at other redshifts are similar. (Of course, because of the magnitude limit, the higher redshift samples contain objects which are more luminous, have higher velocity dispersions, larger masses and sizes, and are redder.) In all cases, the population in dense regions is slightly more homogeneous.

The colors and chemical abundance indicators (Bernardi et al. 2003) of early-type galaxies correlate primarily with velocity dispersion. To see if the environment plays an additional role in determining chemical abundances we have selected objects in narrow magnitude and redshift bins in which the median velocity dispersion is the same in both environments. The panel on the right of Figure 2 shows that objects in less dense regions tend to be bluer, even though the luminosities and velocity dispersions are the same in both environments. This