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WINGS: The First Results

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Abstract

A two-band (B and V) wide-field imaging survey of a sample of nearby galaxy clusters is presented. The sample comprises 78 clusters in the redshift range z=0.04-0.07. This survey will provide the astronomical community with a complete set of homogeneous, CCD-based surface photometry and morphological data of nearby cluster galaxies located within 1.5 Mpc from the cluster center. As a natural follow up of the photometric survey, we are carrying out a long term spectroscopic program with the WHT-WYFFOS and AAT-2dF multifiber spectrographs.

1.1 Introduction

Clusters of galaxies are the largest, yet well defined, known entities in the Universe. An adequate photometric and spectroscopic information on nearby clusters is crucial for studying the morphology and the stellar populations of galaxies in a systematic way, as well as for setting the zero-point for evolutionary studies.

Here we present the first results of a two-band (B and V) wide-field imaging survey (WINGS) of a complete, all-sky X-ray selected sample of 78 clusters in the redshift range z=0.04-0.07. The photometric WINGS survey has been conceived to fill in the lack of a systematic investigation of nearby clusters and their galaxy content. WINGS is the deepest ($M_V \sim -14$), best resolution ($1'' = 1.3\ kpc$ at z=0.07, H_0=70) survey of a complete sample of galaxies in nearby clusters to date.

The data collection has been completed in seven observing runs at the INT and ESO-2.2m telescopes.

For each cluster, photometric data of about 3500 galaxies (down to $V \sim 23$) and detailed morphological information of about 400 galaxies (down to $V \sim 21$) are obtained by using specially designed automatic tools.

As a natural follow up of the photometric survey, we are carrying out a long term spectroscopic program with the WHT-WYFFOS and AAT-2dF multifiber spectrographs. Star formation rates and histories, as well as metallicity estimates will be derived for about 350 galaxies per cluster from the line indices and equivalent widths measurements. This will allow us to explore the link between the spectral properties and the morphological evolution in high to low-density environments, and across a wide range in cluster X-ray luminosities and optical properties.

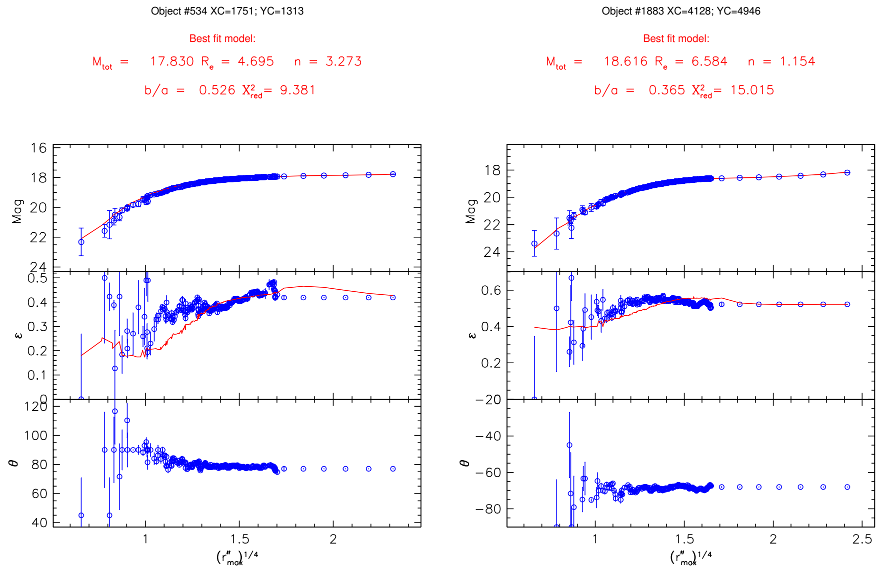

Fig. 1.1. Two examples of our morphological analysis obtained by fitting the surface brightness profile with the Sersic model. On the left: an elliptical galaxy is well described by a Sersic index greater than 3. On the right: a spiral galaxy has a Sersic index near to 1.

1.2 The Morphological Analysis

To analyse the distribution of galaxies of the different morfological types in the clusters, we need some efficient and automatic tool for surface photometry and morphological classification of galaxies. The package GASPHOT (Pignatelli, Fasano 2003, in preparation) is able to produce automatically the luminosity and geometrical profiles for a large number of galaxies as well as to perform the fit of the profiles with the Sersic and/or de Vaucouleurs+exponential models. In particular, it provides us with total magnitude, effective radius (r_e) and Sersic index (n) of each galaxy (see, for example, Fig. 1.1).

About 400 galaxies for each cluster have been processed and classified by GASPHOT. Now we are comparing the results with the morphological classifications derived from visual inspection of the images. The aim of this comparison is to combine the most significant profile parameters to obtain an automatic, coherent morphological classification.

1.3 The Kormendy Relation

The analysis of the scaling relations among the global photometric parameters of galaxies is a very important tool to understand galaxy structure and evolution. The photometric survey allows us to study, in particular, the Kormendy relation ($<\mu_e>$-r_e) for the elliptical galaxies. In Figure 1.2 the Kormendy relation for 17 north-sample clusters is presented. The GASPHOT analysis with a preliminary visual classification allows us to detect the elliptical galaxies in clusters: we chose $n = 2$ to rough discriminating between late and early-type.

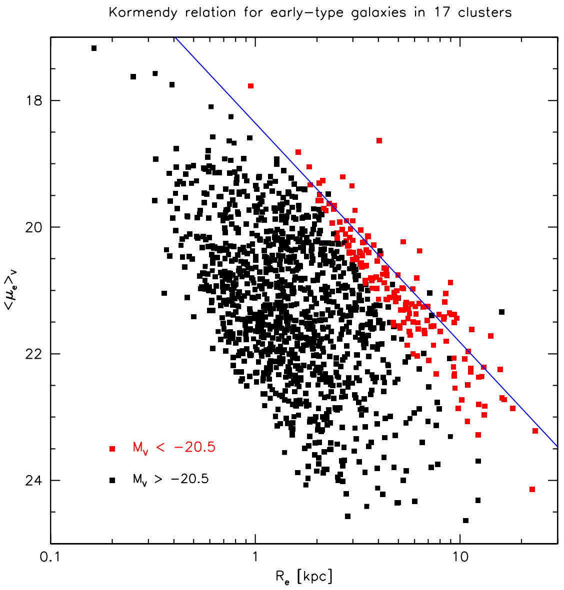

Fig. 1.2. The Kormendy relation for the elliptical ($n > 2$) galaxies in 17 north-sample clusters. The blue solid line represents the Kormendy relation as obtained by Jørgensen et al. (1999) in the Coma cluster, scaled to the V band. The red points are elliptical galaxies more luminous than $M_V \sim -20.5$; the fainter the galaxies the farther they are from the blue line.

The Fundamental Plane will be investigated to add the third dimension to the description of elliptical galaxies.

1.4 Galaxies in Clusters

Galaxy clusters display a large variation in their own structure and in morphological galaxy content. Therefore, a wide and well-defined sample is needed to investigate in a systematic way what cluster property/ies are driving the variations in galactic properties.

For each cluster we detect about 3500 galaxies, contained in our “deep galaxy catalogs”. The completeness of these galaxy catalogs is typically achieved down to $V \sim 22$.

All the galaxies observed in each cluster have been plotted in the color-magnitude diagram (m_V vs. $(B-V)$) of the cluster (see Figure 1.3). The homogeneity in color and the closeness in space define a precise color-magnitude sequence for each cluster. We can take advantage of this very useful property in separating the cluster members from the field galaxies.

Additional catalogs for surface photometry and morphology of galaxies have been extracted from the “deep catalogs”, including only galaxies with threshold area ~ 200 pixels. The completeness of these “bright catalogs” is typically achieved down to $V \sim 20$.

1.4.1 Cluster Profiles

A preliminary analysis led us to use the Sersic index $n = 2$ in roughly distinguishing early-type and late-type galaxies (red and blue points in Figure 1.3, respectively).

However, the visual inspection remains, at the moment, the best way to determine the galaxy morphology. Preliminary results based on a visual morphological classification are

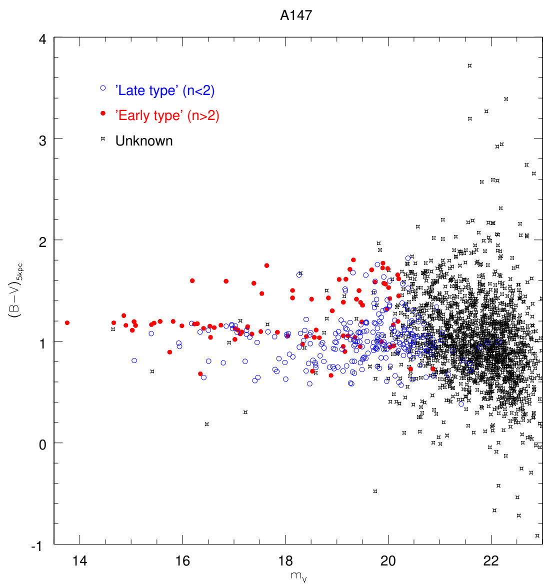

Fig. 1.3. The color-magnitude diagram of the Abell cluster A147. It is possible to identify another cluster in the same field. The red sequence of this farther cluster has a $(B-V) \sim 0.6$ *mag* redder than that of the galaxies in A147. Red and blue points represent "early-type" and "late-type" galaxies, respectively.

presented in Figure 1.4a). The cumulative profiles of early and late-type galaxies are presented for the cluster A2593, using two different criteria in separating the morphological types: we obtain the best match with the morphological profiles using $n = 1.4$ to discern between early and late-type. Unfortunately, this result is not only ascribed to a real and univocal correspondence between Sersic index and morphological type.

Referring only to a visual classification, in Figure 1.4b) we compare the profiles for two different cluster (A2593 and A2457).

The galaxy magnitudes have been corrected for galactic extinction, according to Burstein & Heiles (1982). The statistical correction for back and foreground galaxies has also been applied, according to the galaxy counts by Cabanac et al. (2000). Also, we refer to Whitmore, Gilmore & Jones (1993) to account for the relative contribution of early-type (E+S0) and late-type galaxies to the field (18%, 23%, 59% of ellipticals, S0s and spirals, respectively).

In the central region, the number of early-type galaxies is greater than that of spirals. At intermediate radii ($log(r/deg) \sim -0.9$) the number of spirals grows steeper than that of early-type galaxies.

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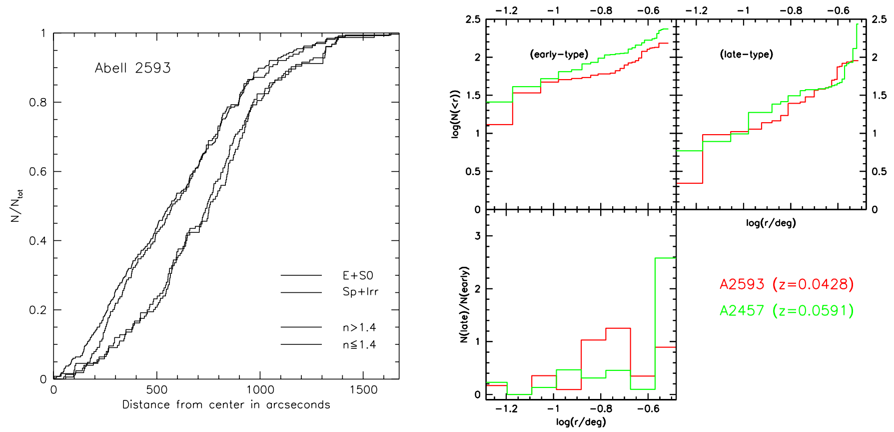

Fig. 1.4. (a). On the left. The cumulative profiles of early and late-type galaxies for the cluster A2593: we obtain the best match with the morphological profiles using $n = 1.4$ to discern between early and late-type. (b). On the right. Top: the cumulative profiles for the two clusters A2593 and A2457 are plotted, separating early and late-type by visual inspection. Bottom: the differential profile of the ratio late-type/early-type galaxies.

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