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WINGS: the first results

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Abstract. WINGS is a two-band (B and V), wide-field imaging survey of a complete, all-sky X-ray selected sample of nearby clusters. This sample comprises 78 clusters in the redshift range z=0.04-0.07. The aim of this survey is to 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. For each cluster, photometric data of about 2500 galaxies (down to V∼23) and detailed morphological information of about 500 galaxies (down to V∼21) are obtained by using specially designed automatic tools.

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.

WINGS is a two-band (B and V), wide-field imaging survey of a complete, all-sky X-ray selected sample of nearby clusters. This sample comprises 78 clusters in the redshift range z=0.04-0.07. The data collection has been completed in seven observing runs at the INT and ESO-2.2m telescopes. The aim of this survey is to 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. For each cluster, photometric data of about 2500 galaxies (down to V∼23) and detailed morphological information of about 500 galaxies (down to V∼21) are obtained by using specially designed automatic tools.

The photometric WINGS survey has been conceived to fill in the lack of a systematic investigation of nearby clusters and

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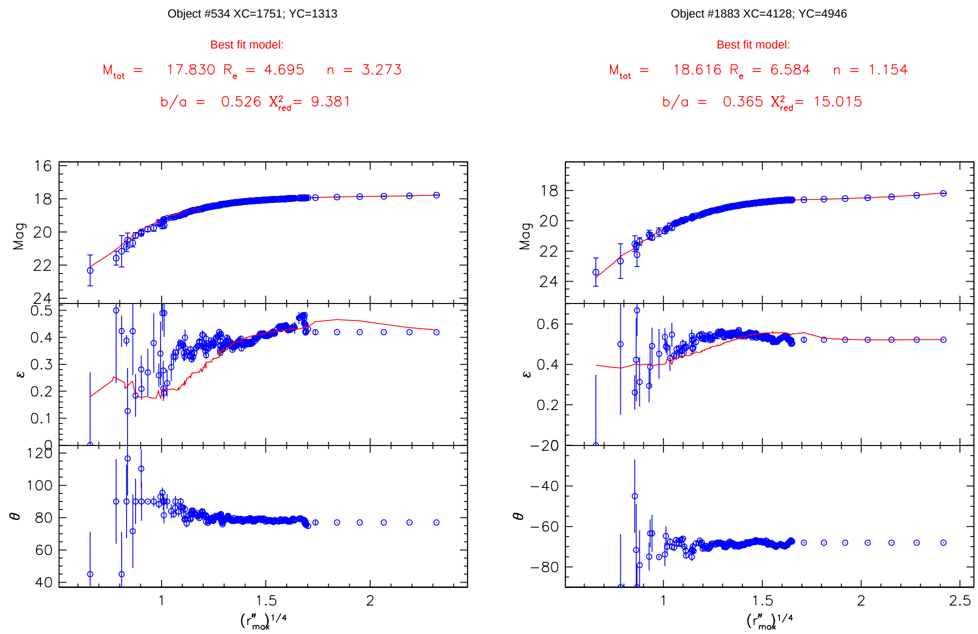

Fig. 1. Two examples of our morphological analysis obtained by fitting the surface brightness profile with the Sersic model. On the left: an elliptical galaxy is well described by a Sersic index greater than 3. On the right: a spiral galaxy has a Sersic index near to 1.

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. For instance, even if the nominal resolution (FWHM in kpc) of WINGS is only slightly better than that of the survey of Dressler (1980), its data quality (CCD) is definitively better and its deepness is incomparably better ($\sim$ 6 mag) with respect to the Dressler's survey.

We hope to be able to perform a IR photometric follow-up in the J, H and K band using the new infrared wide field camera at the UKIRT telescope. This would add useful pieces of information to our huge database of galaxy clusters, especially with regard to the stellar mass function of galaxies and their photometric and spectroscopic properties as a function of the mass. The NIR surface photometry would also likely provide more robust estimates of the structural parameters of the galaxies. Moreover, color-magnitude and color-color relations, as well as optical/NIR SEDs, would help on guessing both the membership of the galaxies and their stellar content.

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 multi-fiber 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.

2. Galaxy properties

For each cluster of the sample, by using specially designed automatic tools, we produce the following outputs:

- A deep photometric catalog of galaxies (about 2500 objects per cluster, complete down to V∼22) containing coordinates, approximate V and B magnitudes, concentration index, rough ellipticity and position angle estimated with SeXtractor (Bertin & Arnout 1996).
- A surface photometry catalog (about 500 objects per cluster, complete down to V∼20) extracted from the "deep catalog", including only galaxies with an isophotal area greater than 200 pixels. In this catalog we include the photometric profiles of each object together with the global parameters extracted from the profiles (better estimate of magnitudes, effective radius and average surface brightness, Sersic index, morphological type, etc.)

The morphological catalogs were produced using GASPHOT (Pignatelli & Fasano 2003, in preparation).

For each galaxy, the luminosity and ellipticity profiles were fitted by a Sersic law convolved with the proper PSF (see Fig. 1)

The best fit model will provide us the profile parameters: total magnitude, effective radius (r_e), Sersic index, ellipticity and position angle.

About 500 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. A preliminary analysis led us to use the Sersic index $n = 2$ in roughly distinguishing early-type and late-type galaxies (full and open dots in Figure 2, respectively).

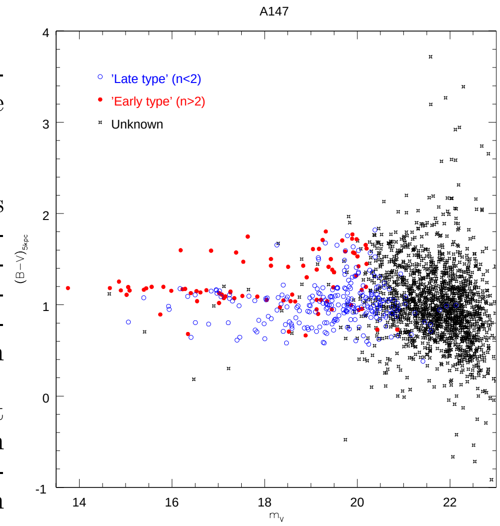

Fig. 2. The color-magnitude diagram of the Abell cluster A147. It is possible to identify another cluster in the same field. The red sequence of this farther cluster has a $(B-V) \sim 0.6$ mag redder than that of the galaxies in A147. Full and open points represent "early-type" and "late-type" galaxies, respectively as classified by Gasphot.

3. Cluster properties

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 properties are driving the variations in galactic properties.

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 2). 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.

The analysis of the scaling relations among the global photometric parameters of galaxies is a very important tool to understand galaxy structure and evolu-

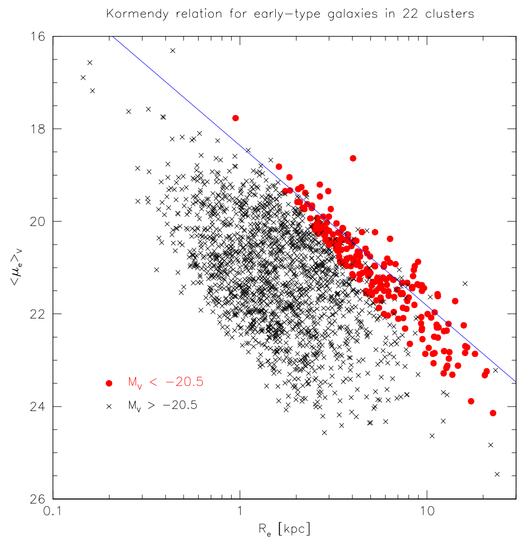

Fig. 3. The Kormendy relation for the elliptical ($n > 2$) galaxies in 17 north-sample clusters. The solid line represents the Kormendy relation as obtained by Jörgensen et al. (1999) in the Coma cluster, scaled to the V band. The full points are elliptical galaxies more luminous than $M_V \sim -20.5$; the fainter the galaxies the farther they are from the line.

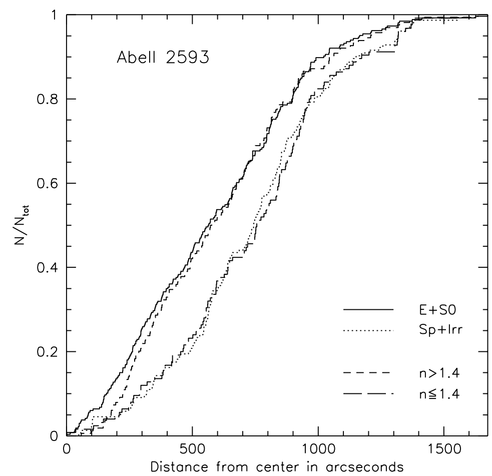

Fig. 4. The cumulative profiles of early and late-type galaxies for the cluster A2593: we obtain the best match with the morphological profiles using $n = 1.4$ to discern between early and late-type.

tion. The photometric survey allows us to study, in particular, the Kormendy relation ($< \mu_e >$-r_e) for the elliptical galaxies. In figure 3 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.

Now we plan to investigate the Fundamental Plane to add a third dimension to the description of the elliptical galaxies.

We also obtain cumulative distribution of early and late-type galaxies as a function of the distance from the center of the cluster: for the cluster A2593 we show the results using both visual inspection and the Sersic index n for morphological classification: we obtain the best match with the morphological profiles using $n = 1.4$ to discern between early and late-type.

The comparison between the Sersic index and the visual morphological classification will be essential to learn how to combine the most significant profile parameters to obtain a coherent morphological classification.

As expected, in the central region the number of early-type galaxies is greater than that of spirals. On the other hand, at intermediate radii ($\log(r/deg) \sim -0.9$) the number of spirals grows steeper than that of early-type galaxies.

References

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