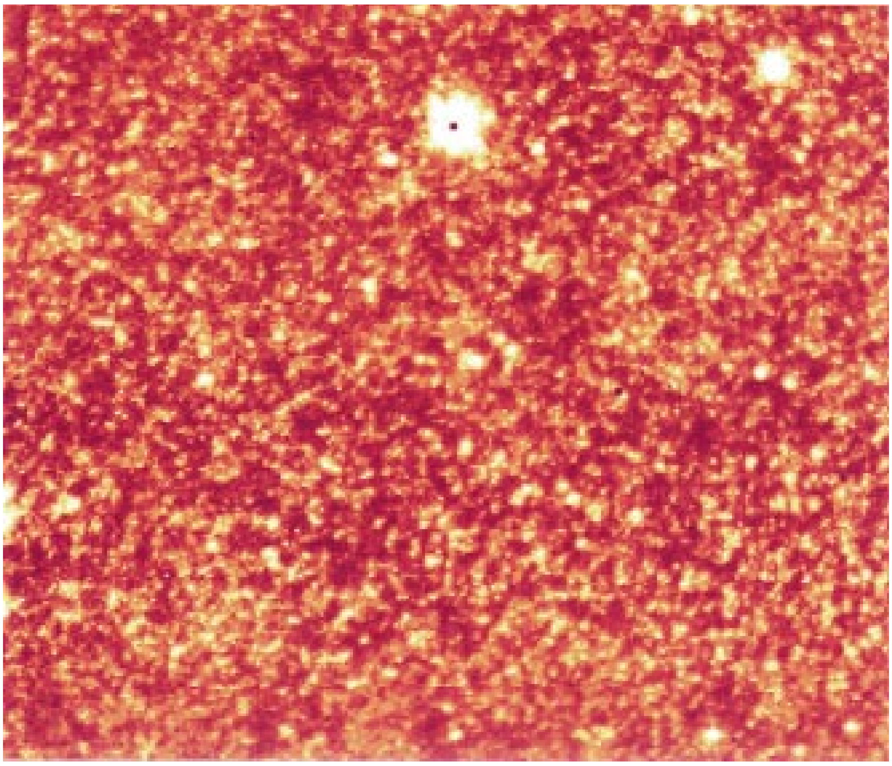

Figure 8: HST image of a halo field in NGC 5128 taken with NICMOS (Camera 3). The image is about 50″ by 45″ (the lower portion was discarded because of vignetting), centred at $\alpha_{2000} = 13^h\ 24^m\ 57^s$, $\delta_{2000} = -43°\ 02'\ 57''$. It is the mean of several 512-s integrations taken with filter F160W (H band). The two brightest objects (top) are probably foreground stars. Image courtesy of Pat McCarthy (OCIW).

Group galaxies (neglecting reddening). For comparison, the Centaurus group has $m - M = 27.8$ (Soria et al., 1996).

The results presented here should be surpassed by HST/NICMOS. Figure 8 shows an HST image of a halo field in NGC 5128 taken with NICMOS. It is one of the first images taken in the public access parallel programme. The halo of NGC 5128 is clearly resolved into thousands of red giants down to about $H = 22$.

Observations using adaptive optics on the VLT, while restricted to small fields of view, should be competitive with the HST/NICMOS image shown here because of the larger aperture and higher spatial resolution. New deconvolution and co-addition codes (e.g., Magain et al., 1997) should further improve the performance of adaptive optics. Thus, the VLT has the potential to transform extragalactic astronomy into stellar astronomy. There will be no need to rely on models and observations of the integrated light to find the physical properties of distant galaxies and their star-formation histories. Instead, we will be able to directly determine ages, metallicities and distances for the stellar populations of very distant galaxies. We might also be able to put important constraints on galaxy formation and decide on the history of mergers for a particular galaxy, just by looking at its shells and shreds.

Acknowledgements

This project was initiated when the first three authors were at ESO Garching (as Fellow, Fellow and student, respectively). We are very grateful to ESO for providing this opportunity of working in such a stimulating environment. We are happy to thank the ADONIS team and the Adaptive Optics Group at ESO for their efficiency and support, especially J.-L. Beuzit, P. Bouchet, N. Hubin, D. Le Mignant, P. Prado and E. Prieto. We also thank A. Quirrenbach, A. Zijlstra and R. Fosbury for their help and useful discussions.

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The Luminosity Function of Clusters of Galaxies: A 496

NEW CLUES TO CLUSTER FORMATION AND EVOLUTION

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1. Observations and Data

In 1993 we started, using the 1.5-m Danish telescope at La Silla, a large project aimed at a detailed investigation of the population and Luminosity Function, down to the faintest dwarf population, of the brightest clusters of the southern sample of clusters detected by ROSAT. Such sample is described in detail by Molinari et al. (1998).

All observations were carried out using Gunn *g, r* and *i* filters. In Figure 1, we display the observed mosaic for the cluster A 496. For each cluster we observed 4 fields of about 500 × 500 arcsec moving from the central region toward the outskirts up to a distance of about 20 arcmin. We were able in this way to correct for background contamination.

Assuming a King's approximation for the density distribution and a core radius of 0.25 Mpc (this corresponds, for A 496, to 531.2 arcsec for $H_0 = 0.75$) we expect in this field about 76/1000 of the galaxies which are present in the centre alone. We can therefore quite safely use this farthest frame for background correction.

The completeness of this frame was then computed in two ways. We estimated, firstly, differential counts *dN/dM* in our control field and we checked our data against the values published by Tyson (1987). The comparison gave our completeness function, but that was possible only for the *r* and *i* passbands. For the *g* band, the counts of the control field were very well fitted in the range $16 \leq g \leq 21$ by a straight line and we extrapolated it to $g = 24$ in order to correct for completeness.

Secondly, to have more control on the faint end of the luminosity distribution, we also estimated the sample completeness via a bootstrap technique, Moretti (1997). We generated a set of images for each filter in the whole range of isophotal magnitudes and added to the observed frames. Using the distance *r* from the central cD galaxy as a free parameter, we were able to quite accurately determine the function P(*r, m*) which gives the probability of detection for a galaxy of magnitude *m* and at a distance *r* from the centre of the cluster.

Once that function is estimated for each sample of galaxies, the corrected number of counts in a given bin of magnitudes is determined by the relation:

$$N_j \; corr = \sum_i p_{j,i} = \sum_i P_{j,i}(r_i, m_i)^{-1}$$

The Luminosity Function which we discuss next was estimated using this second method, but, when applicable, the two methods agreed well within 1 sigma as to make the results rather robust.

2. The Luminosity Function

The estimate of the Luminosity Function parameters has been based on three different ways of selecting the subsample of the catalogue of galaxies which we extracted from the observations after star-galaxy separation (Moretti et al., 1998, Molinari et al., 1998). Briefly, *(i)* we considered the sample as it is without considering either the morphology of galaxies or the colour; *(ii)* we then used only a sample of red galaxies and, finally, *(iii)* we estimated the distribution of the bright E galaxies to the magnitude ~ 19.0 which is the limit within which we are able to estimate the morphology.

The results are in excellent agreement among them and in this note we illustrate only the first more general procedure.

We chose as control field the area with co-ordinates x and y referred to the centre of the cluster such that (in arcsec): $-1100 \leq x < -450$ and $440 \leq y < 1030$ (80.15 arcmin^2, upper left in Fig. 1). For the following analysis we referred to the area $-650 \leq x < 200$ and $-255 \leq y < 245$ as the cluster region (95.89 arcmin^2, bottom right in Fig. 1).

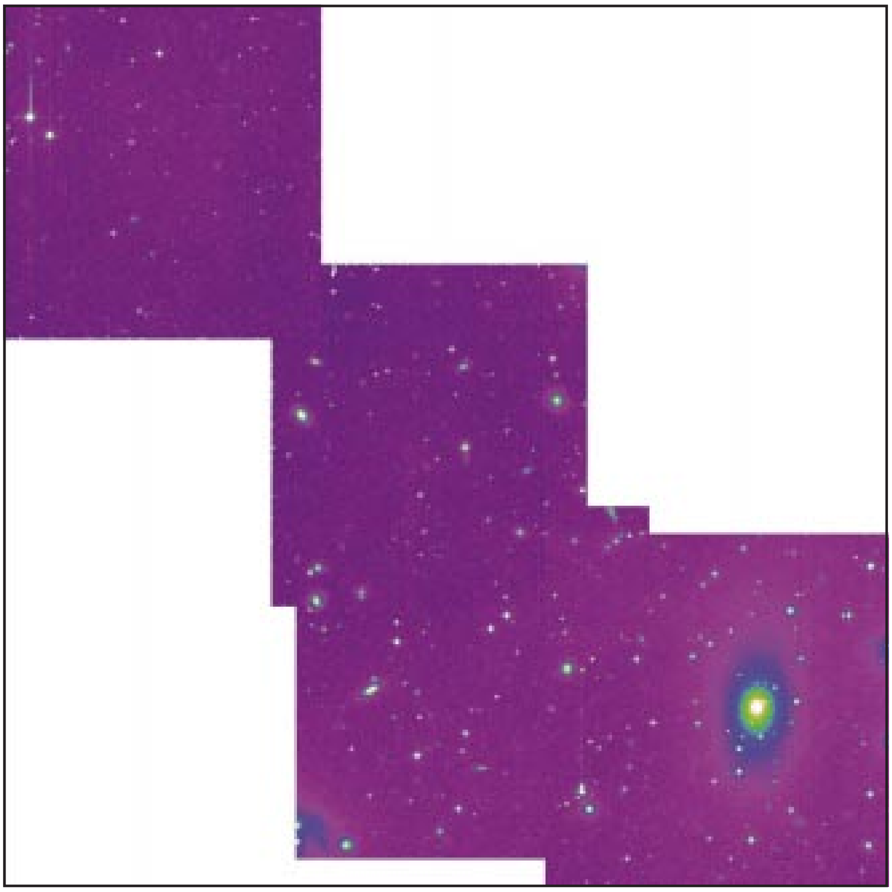

Figure 1. A composite image of Abell 496.

The cluster counts have then been derived by simply subtracting, after normalisation to the same area, the counts of the two fields for each magnitude bin. The error bars have been estimated by Poisson statistics.

In Figure 2 we reproduce the counts for the three filters and the best fitting which has been obtained by a Gaussian plus a Schechter function.

Some of the parameters are affected by a considerable error, especially the normalisation coefficients for the Gaussian and Schechter functions, with best fit given by the data taken with the Gunn *i* filter, where we have the best statistics. Anyway, there is very strong consistency and agreement among the different passbands.

3. Conclusions

We have established that in the cluster A 496 we can clearly distinguish between two populations of galaxies: the first which dominates the core of the cluster and is characterised by Elliptical and Lenticular galaxies and the second composed by fainter galaxies. This, after Virgo (Sandage et al., 1985), is the first robust result of a composite Luminosity Function.

In Coma, Bernstein et al. (1995) show, with deep exposures and excellent analysis, a sharp steepening of the Luminosity Function at very faint magnitudes in the region of Globular Clusters, in the magnitude range $-12 < M < -10$. They do not see, however, the gaussian distribution first detected by Biviano et al. (1995).

The search for such distinct populations, together with the faint tail analysis, was the motivation driving our rather large programme. Whether we can also detect differences among clusters of different morphology and with various X-ray properties will be one of the goals of the complete cluster sample.

Empirically the emerging picture is rather simple: the cluster itself is defined by the bright population of Elliptical galaxies, an old concept stressed especially by George Abell. The mass, or luminosity, distribution of such objects in a cluster clearly depends on the processes during formation and evolution. What we are able to see now is a bright population which is well mixed with the faint one in irregular, dynamically young clusters (Virgo), which is more clearly visible in more evolved clusters (Coma, Bautz-Morgan type II), and which shows as a striking feature in cD dominated clusters (Abell 496, Bautz-Morgan type I). Comparison with field luminosity functions (such as the reliable study of Zucca et al., 1996) should give hints for the understanding of the processes involved.

To some extent we rediscover, on a quantitative basis however, the old known fact that the cluster core, when compared to the field, is dominated by early-type galaxies.

The core birth scenario could have started in the epoch z ~ 10–20 involving huge masses and helping the formation of large E/S0 galaxies. Later infall sets in and continues to the present day with galaxy-ICM interaction and subsequent ICM enrichment. Here we begin to form the dwarf spheroids, trigger starbursts in the infalling galaxies via the shocks induced by the interaction galaxy – ICM, and to shape the faint end of the cluster LF. The final shape of the faint end could also be modified by active fragmentation and become steeper than in the field, but such hypothesis needs to be investigated.

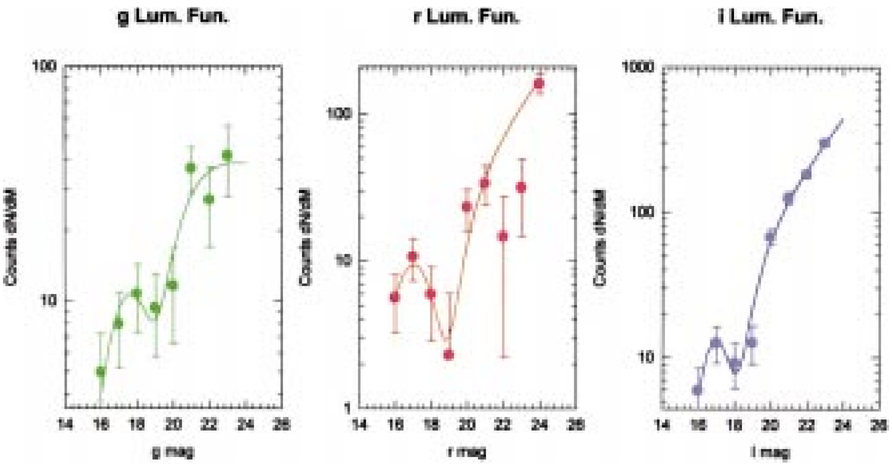

Figure 2. *The Luminosity Function of the cluster A496 (m–M = 35.53, H_0 = 75 km/s/Mpc) as observed in the g, r and i Gunn filters. The Gauss + Schechter functions have been plotted using the parameters estimated from the fit, continued line. The analysis is based on the photometry of 2355 objects of which 2076 have been classified as galaxies.*

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From EROS to DUO, ALADIN, GATT and Others: Wide-Field Astronomy

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The purpose of this report is to illustrate the major role of large-field imaging in all the domains of astrophysics, and to present some recent results. Most of these are based on digitisation and analysis of Schmidt images taken in the course of either sky surveys or specific programmes; however, the experience gained as well as the tools developed for the exploitation of photographic plates, have started benefiting ground-based and space CCD projects. Special emphasis will be put on the crucial importance of computer storage and processing capabilities, as well as efficient analysis and calibration software, for images up to 2 gigabytes. The resources of the Image Analysis Centre of the Observatoire de Paris, including the MAMA facility, used by a wide national and international community of astronomers, will be briefly presented.

1. General Context

The activities of the Image Analysis centre (hereafter: the CAI), started in 1987 with the first operational scans performed by the MAMA microdensitometer. MAMA (Machine Automatique à Mesurer pour l'Astronomie), was designed and built by the Technical Division of INSU (Institut National des Sciences de l'Univers, CNRS). Equipped with a linear RETICON array of 1,024 photodiodes, MAMA digitises a 14 × 14-inch plate in a few hours, providing a positional accuracy of 1 micron and a repeatability of 0.2 micron. In ten years, several thousands plates or films of various origins have been scanned, leading to several terabytes of pixels, and to catalogues with as many as 10 million detected objects per Schmidt field.

The MAMA facility also includes, in addition to the computer system close to the microdensitometer, a set of workstations in charge of image processing and data reduction. More than 100 gigabytes of on-line magnetic disk storage, tape recorders of different types (DAT, Exabytes, DLT), complement the CPU resources. These can be used for the exploitation of images either digitised from plates or produced by CCD devices.

Applications for scanning time, image processing, and assistance to data reduction, are examined by a Committee which meets twice a year. Collaborations with French teams are encouraged when groups from other countries are interested in extensive use of this national facility.

2. Some Scientific Results

2.1 Microlensing

• The some 300 plates taken at the ESO Schmidt in the course of the EROS (Expérience de Recherche d'Objets