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First results from the ALHAMBRA-Survey

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Summary. — We present the first results from the ALHAMBRA survey. ALHAMBRA will cover a relatively wide area (4 square degrees) using a purposely-designed set of 20 medium-band filters, down to an homogeneous magnitude limit AB $\approx$ 25 in most of them, adding also deep near-infrared imaging in JHK_s. To this aim we are using the Calar Alto 3.5m telescope. A small area of the ALHAMBRA survey has already been observed through our complete filter set, and this allows for the first time to check all the steps of the survey, including the pipelines that have been designed for the project, the fulfilment of the data quality expectations, the calibration procedures, and the photometric redshift machinery for which ALHAMBRA has been optimised. We present here the basic results regarding the properties of the galaxy sample selected in a 15×15 arcmin^2 area of the ALHAMBRA-8 field, which includes approximately 10000 galaxies with precise photometric redshift measurements. In a first estimate, approximately 500 of them must be galaxies with $z > 2$.

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1. – Introduction

The ALHAMBRA-Survey will produce accurate photometric redshifts for a large number of objects, enough to track cosmic evolution, i.e., the change with z of the content and properties of the Universe, a kind of *Cosmic Tomography*. ALHAMBRA is imaging 4 square degrees (Table 1) with 20 contiguous equal-width medium-band filters covering from 3500 Å to 9700 Å (see Figure 1), plus the standard JHK$_s$ near-infrared bands. The optical photometric system has been designed to maximise the number of objects with accurate classification by Spectral Energy Distribution type and redshift and to be sensitive to relatively faint emission features in the spectrum [2].

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TABLE I. – *The ALHAMBRA-Survey Fields*

Field name	RA(J2000)	DEC(J2000)	100 μm	E(B−V)	l	b
ALHAMBRA-1	00 29 46.0	+05 25 28	0.83	0.017	113	-57
ALHAMBRA-2/DEEP2	02 28 32.0	+00 47 00	1.48	0.031	166	-53
ALHAMBRA-3/SDSS	09 16 20	+46 02 20	0.67	0.015	174	+44
ALHAMBRA-4/COSMOS	10 00 28.6	+02 12 21	0.91	0.018	236	+42
ALHAMBRA-5/HDF-N	12 35 00.0	+61 57 00	0.63	0.011	125	+55
ALHAMBRA-6/GROTH	14 16 38.0	+52 25 05	0.49	0.007	95	+60
ALHAMBRA-7/ELAIS-N1	16 12 10.0	+54 30 00	0.45	0.005	84	+45
ALHAMBRA-8/SDSS	23 45 50.0	+15 34 50	1.18	0.027	99	-44

The observations are being carried out with the Calar Alto 3.5m telescope using two wide field cameras: LAICA in the optical, and OMEGA-2000 in the NIR. The magnitude limit, for a total of 100 ksec integration time per pointing, is AB $\geq$ 25 mag (for an unresolved object, S/N = 5) in the optical filters from the blue to 8300 Å, and ranges from AB = 24.7 to 23.4 for the redder ones. The limit in the NIR, for a total of 15 ks exposure time per pointing, is K_s = 20 mag, H = 21 mag, J = 22 mag. We expect to obtain accurate redshift values $\Delta z/(1+z) \leq 0.03$ for about 6.6 $\times 10^5$ galaxies with I$\leq$ 25 (60% completeness level) and z_{med} = 0.74. In Table 2 we compare the properties of the ALHAMBRA-Survey with other similar endeavours in cosmic cartography.

This accuracy, together with the homogeneity of the selection function, will allow for
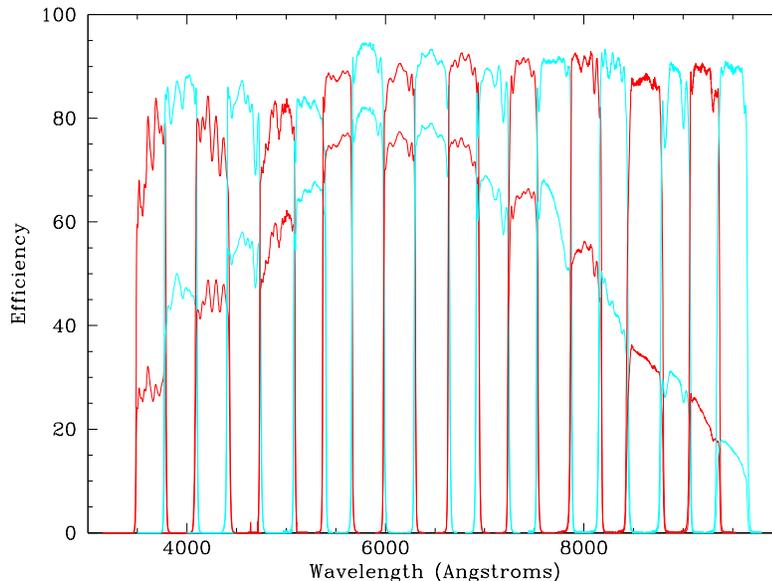

Fig. 1. – Transmission curves measured for one of the optical filter sets alone (higher curves), and combined with the joint effect of the CCD detector, the atmosphere and the telescope (lower curves).

TABLE II. – *Main characteristics of wide field ($\geq$ 0.5 square degrees) spectroscopic surveys*

Survey	Area (sqdeg)	Spectral range (Å)	z (median)	$N_{objects}$
CfA/SRSS	18000	4300-6900	0.02	1.8×10^4
SDSS/DR6	6860	3800-9200	0.1	7.9×10^5
LCRS	700	3350-6750	0.1	2.6×10^4
2dFGRS	2000	3700-8000	0.11	2.2×10^5
VVDS	16	5500-9500	0.7	1.0×10^5
DEEP2	3.5	6500-9100	1.0	5.5×10^3
ALHAMBRA-60	4	3500-9700 $(+JHK)$	0.74	$6.6 \ (3.0) \times 10^5$
ALHAMBRA-90	4	3500-9700 $(+JHK)$	0.63	$3.5 \ (1.0) \times 10^5$

the study of the large scale structure evolution with z, the galaxy luminosity function and its evolution, the identification of clusters of galaxies, and many other studies, without the need for any further follow-up. It will also provide exciting targets for detailed studies with 10m class telescopes. Given its area, spectral coverage and its depth, apart from those main goals, ALHAMBRA will also produce valuable data for galactic studies.

2. – Redshift expectations

We have calculated the number of objects that the survey will detect to a fixed accuracy in the measured z-value, for the adopted configuration and strategy. A more extense description of the survey and initial results, is given in [3].

Amongst the different ways to present the figure of merit of a planned survey, we show in Figure 2 the total number of objects detected to a given redshift accuracy. It can be seen that the total number of objects with $\Delta z/(1 + z) \leq 0.03$ is over 7×10^5, and it is over 5×10^5 for the higher accuracy of 0.015. Our simulations show that the survey will be complete at the 90% level with $\Delta z/(1 + z) \leq 0.03$ (0.015) down to I$\approx$ 23.5 (21.8), and to the 60% level till I$\approx$ 25.2 (24.3). In the redshift-complete samples the number of objects expected are 3.5×10^5 (1.0×10^5) and 6.6×10^5 (3.5×10^5) respectively. All the calculations were done using the package BPZ [1]. Complete details about the simulations and the results are given in [2].

3. – Present status

At the time of this conference, some of the project milestones have already been reached and met with success. In particular, in August 2006 the first pointing (within the field ALHAMBRA-8) has been completed, having been observed to the expected depth through all 20+3 filters. The percentage of the total area to be surveyed that has been covered to date is approximately 55% in the near infrared and 40% in the visible range—it must be remarked that OMEGA2000, the Calar Alto NIR imager, was available for our observations from the very beginning, whereas the optical imager Laica was still under commissioning. We expect to complete our observations in 2009.

Our strategy has been from the beginning that of refraining from starting the data analysis until the data treatment pipelines and analysis tools are definitive. However, some basic analysis can be performed with the first complete pointing, and this work is in fact important for the definition and testing of the different tasks involved in the survey.

We show in Figure 3 a color image of the first complete pointing in the ALHAMBRA-8 field. The region covers an area of 15 arcminutes side and contains approximately 10000 objects to AB≈ 25.

Just to illustrate the depth that can be reached with the ALHAMBRA images, we show in Figure 4 a small (1.3 × 1.8 arcminutes) section of the ALHAMBRA-8 field. Here two bright red objects are found. Each of the ten panels corresponds to one of the ALHAMBRA filters running from F520 to F799, with central wavelengths that span the range between 5200 and 7990 Å. The reddest object (center left) has a strong break between 6130 and 6440 Å(AB(6130)−AB(6440) > 1.5 mag), and a second one between 7060 and 7370 Å(AB(7060)−AB(7370) ∼ 1 mag), which identify it as either a moderate ($z \approx 1$) redshift galaxy with an old/reddened population, or a high-redshift object at $z \approx 4$. A full, calibrated ALHAMBRA "spectrum" can be seen in Figure 5, together with the corresponding SDSS spectrum and photometry.
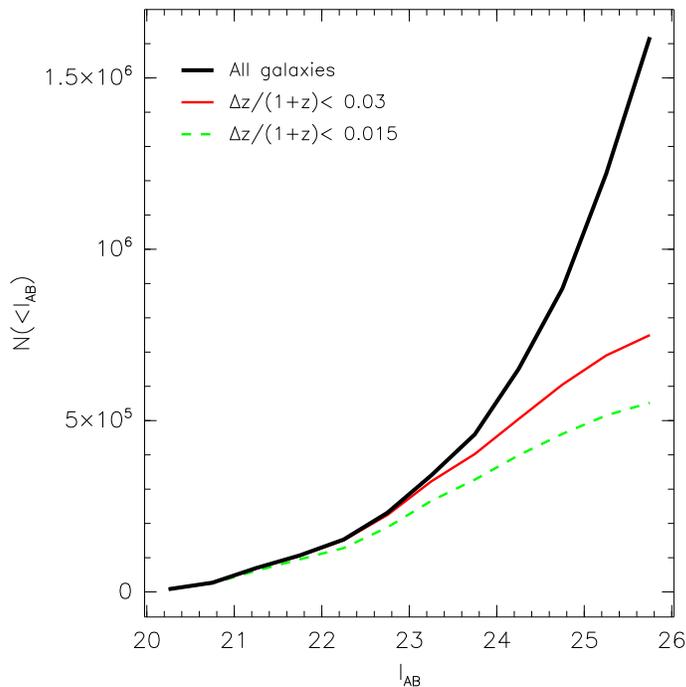
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Fig. 2. – The total number of galaxies detected in the ALHAMBRA-Survey expected from our simulations (thick line). The thin continuous (dashed) line gives the total number of galaxies with $\Delta z/(1 + z) \leq 0.03$ (0.015)

Fig. 3. – The first complete pointing of the ALHAMBRA-8 field in a square region of 15 arcminutes side. This color image has been created making use of data from 14 out of the 23 filters.

REFERENCES

[1] Benítez, N., 2000, ApJ, 536, 571
[2] Benítez, N. et al, 2008, A&A, submitted
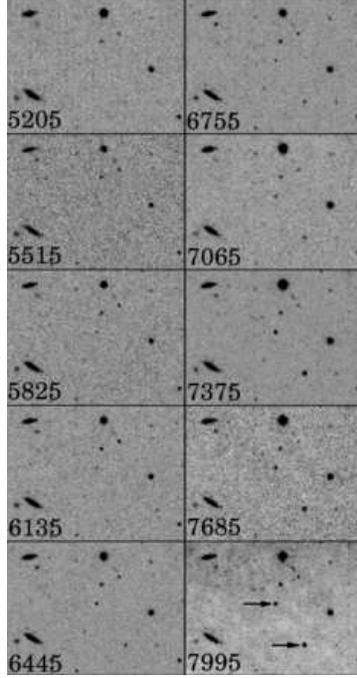[3] Moles, M. et al, 2008, AJ, submitted

Fig. 4. – A region of 1.3×1.8 arcminutes is shown in this strip containing 10 images corresponding to 10 optical filters spanning from 5200 to 7990 Å. Two easily identified bright red objects having $AB(7990) - AB(5200) > 3$ are marked in the bottom right image, corresponding to $\lambda = 7990$ Å.
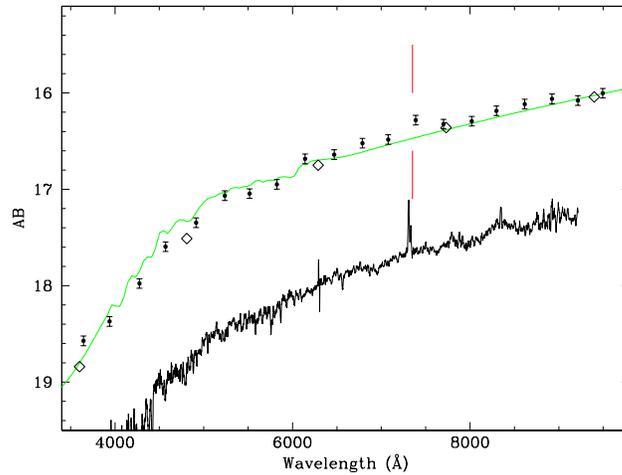

Fig. 5. – SDSS spectrum (line) and photometry (diamonds), and ALHAMBRA photometry for one of the galaxies in our field with SDSS spectroscopy. The vertical ticks mark the expected position of the Hα emission line at the redshift measured from the ALHAMBRA data alone. The SDSS spectrum is ≈ 1 magnitude fainter because it includes only the flux within the SDSS spectrograph fiber.