The ALHAMBRA Survey: Evolution of Galaxy Clustering with Segregation

ALHAMBRA SURVEY

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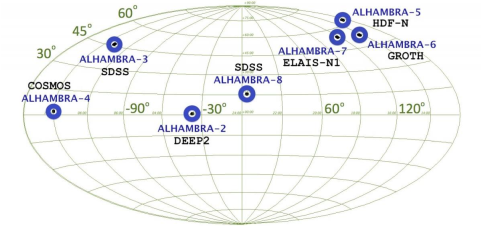
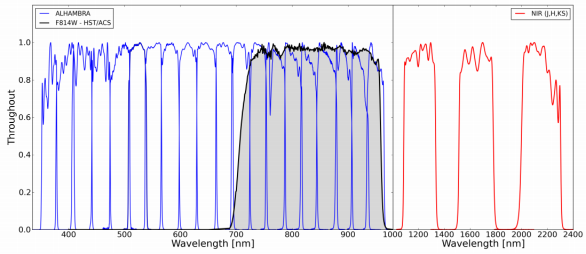
The Advanced Large, Homogeneous Area Medium Band Redshift Astronomical (ALHAMBRA) Survey is devoted to probe Cosmic Evolution. In order to achieve this goal it is necessary to cover cosmological meaningful volumes at all redshifts for which a large area coverage and good depth are needed. Besides, good spectral resolution is fundamental to identify the different populations of objects and large spectral coverage is important to sample enough redshift range and allow easier identifications.

ALHAMBRA is composed by 8 independent pencil-beam regions covering up to $4deg^2$ with redshifts between 0.1 and 7.

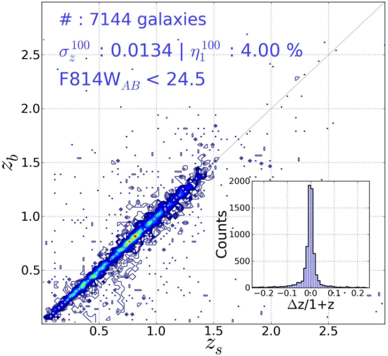


The project was designed having in mind all the subtleties of the techniques to get photometric redshifts, to be able to use them in the most advantageous way. The ALHAMBRA optical photometric system was eventually designed to include 20 contiguous, medium-band, FWHM = 310 Å, square-like shaped filters with minimal overlapping in lambda, covering the complete optical range from 3500 to 9700 Å. In addition we use the three standard board-band filters (J, H, and H_S) in the NIR. With this configuration it is possible not only to accurately determine the SED and z even for faint objects, but also to detect rather faint emission lines.



The comparison performed for the $\sim$ 7000 galaxies with spectroscopic redshift shows that the global accuracy in the photo-z is $\sigma_z \lesssim 0.014(1+z)$ for $I < 24.5$ (equivalent to Hubble Space telescope $F814W$ filter).

For every galaxy we count as well with information regarding its spectral type. This spectral type is the best fitting template in the BPZ code.



You can learn more and download the ALHAMBRA survey at:

cosmo.iaa.es/content/ALHAMBRA-Gold-catalog

or email me

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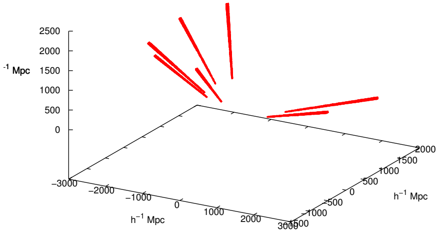
We select the galaxies satisfying:

-$I < 24$.

-$0.35 < z < 1.25$

-Star-galaxy separation

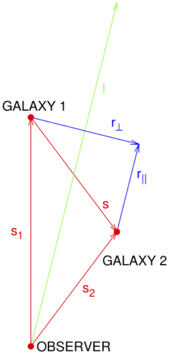
The final catalogue used contains a total of 174.633 galaxies. Which represents a global density of $\bar{n} = 15.63 h^3 Mpc^{-3}$.



The projected correlation function $W_p(r_p)$

The projected correlation function is a variation of the two points correlation function $\xi(r)$ devised by Davis & Peebles (1983) to deal with the redshift-space effects present in spectroscopic samples and it can be used as well to optimize the study of photometric populations. It can be computed as

$$\xi(r_p, \pi) = 1 + \left(\frac{N_R}{N_D}\right)^2 \frac{DD(r_p, \pi)}{RR(r_p, \pi)} - 2\frac{N_R}{N_D}\frac{DR(r_p, \pi)}{RR(r_p, \pi)}$$



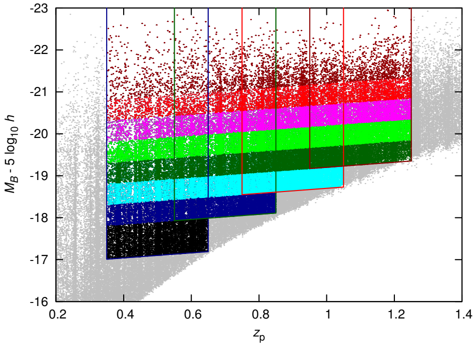
where N_D is the number of galaxies and N_R is the number of random points ($N_R = 20N_D$) used in the calculations. The functions DD, RR and DR are the number of pair between galaxies, random points or crossed pairs at a distance given by vectors r_p and π as indicated by the figure. Now we can integrate to obtain

$$w_p(r_p) = 2\int_0^{+\infty} \xi(r_p, \pi) d\pi$$

In order to study the evolution of galaxy clustering through redshift and luminosity we create samples following:

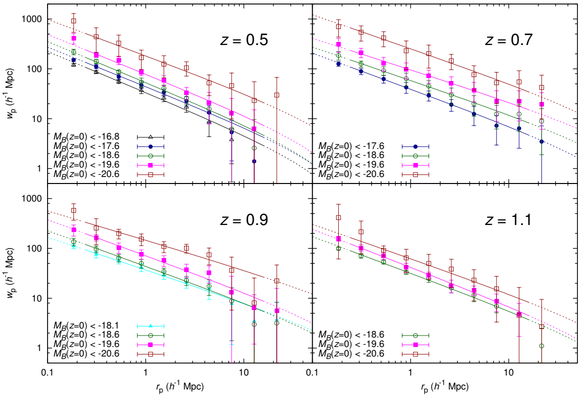
-Overlapping redshift bins: [0.35,0.65], [0.55,0.85], [0.75,1.05], [0.95,1.25]

-Luminosity thresholds: $M_B(z) - 5\log h < M_B^{th}(0) - 0.6z$



The projected correlation function $W_p(r_p)$

Evolution of galaxy clustering: luminosity segregation (Arnalte-Mur et al. 2014).

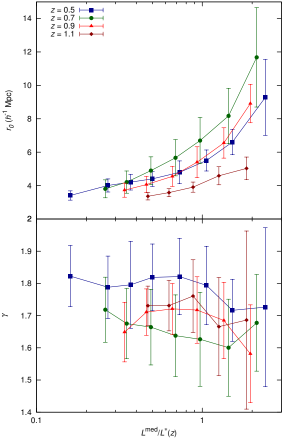


$w_p(r_p) = Ar_p^b = (\frac{r_p}{r_0})^\gamma$. As we can see, bright galaxies are systematically more clustered than faint ones in all four redshift bins, following a power law behavior for scale $r_p \gtrsim 0.2h^{-1}$ Mpc (Zehavi, 2002).

The projected correlation function $W_p(r_p)$

Evolution of galaxy clustering: luminosity segregation (Arnalte-Mur et al. 2014).

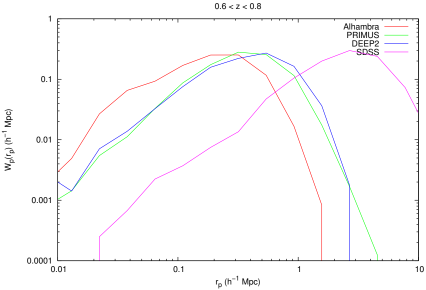
The evolution of the slope γ is approximately constant and around $\gamma \sim 1.75$. r_0 shows a clear dependence with luminosity though not monotonic, showing a stronger clustering at $z = 0.7$ bin. This could be due to the cosmic variance introduced by the pencil-beam overlapping with COSMOS survey. For further plots and calculations, we avoid this beam as justified in Arnalte-Mur et al. (2013).



The projected correlation function $W_p(r_p)$

Evolution of galaxy clustering: small scales (Hurtado-Gil et al. *in prep*).

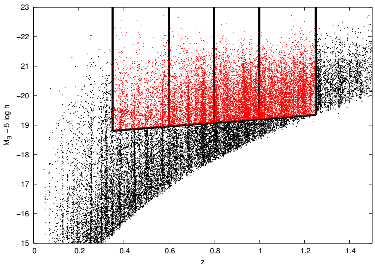
But ALHAMBRA allows us to extend our work over distance ranges never studied before. Due to its high intracluster density, the number of galaxy pairs at distances below $0.1h^{-1}$ Mpc is high enough to show us the shape of the projected correlation function in the intracluster medium.
The near-neighbor distribution shows a higher density of objects at shorter distances for the ALHAMBRA survey compared with other surveys.

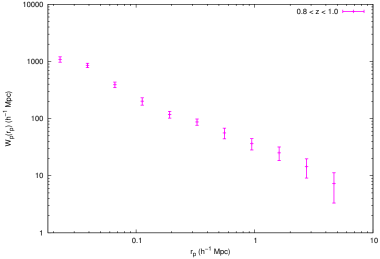


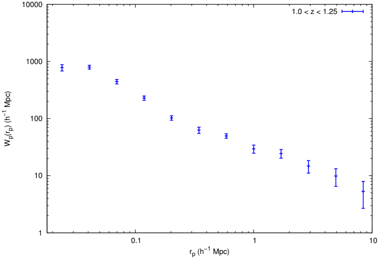
The projected correlation function $W_p(r_p)$

Evolution of galaxy clustering: small scales (Hurtado-Gil et al. *in prep*).

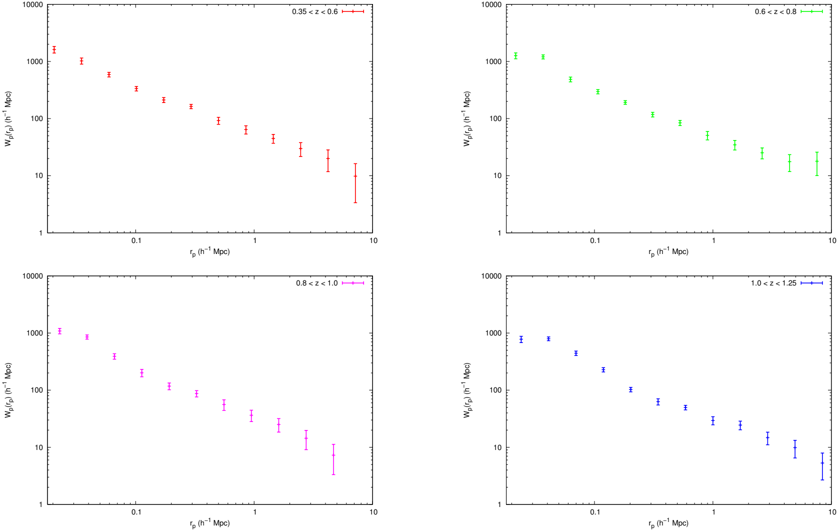
Now we use only galaxies with $M_B(z) - 5\log h < -18.6 - 0.6z$, which is the fainter magnitude threshold that keeps redshift completeness, and disjoint redshift bins: $[0.35, 0.6], [0.6, 0.8], [0.8, 1.0], [1.0, 1.25]$.







Evolution of galaxy clustering $0.02 < r_p < 10h^{-1}$ Mpc.



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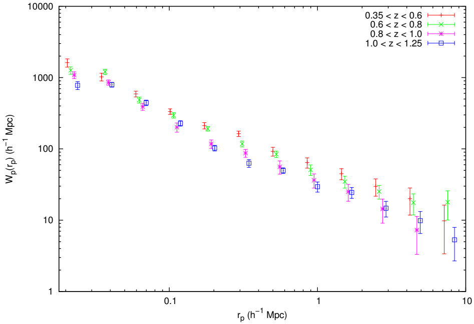
Evolution of galaxy clustering: small scales (Hurtado-Gil et al. *in prep*).



We can see how at high redshift the W_p function shows a break point around $r_p \sim 0.2h^{-1}$ Mpc. For shorter distances the curve present a higher slope, creating two different branches. Then, the slope γ decreases monotonically until redshift $z = 0.5$ when both branches match into the usual power law (A cosmic coincidence: the Power-Law galaxy correlation function, Watson, Berlind & Zentner (2011)).

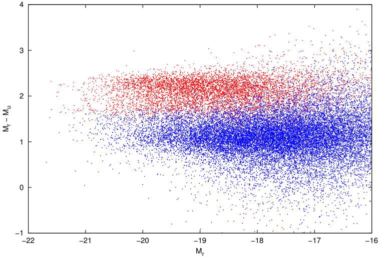
The projected correlation function $W_p(r_p)$

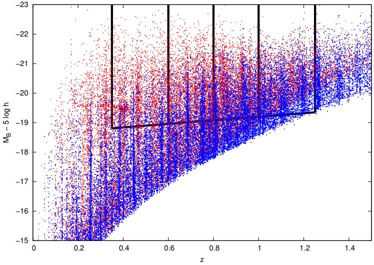
Evolution of galaxy clustering: spectral segregation (Hurtado-Gil et al. *in prep*).

In order to understand the break point found around $r_p \sim 0.2h^{-1}$ Mpc we study the evolution of galaxy clustering focusing on spectral segregation. Using the same magnitude threshold, we segregate our population in Early and Late-type galaxies as follows:

-Red: Elliptical galaxies

-Blue: Spirals and Irregular galaxies





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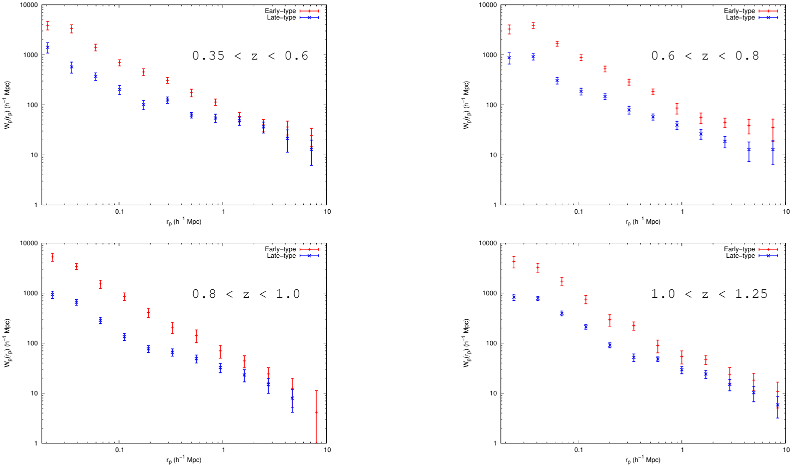

Evolution of galaxy clustering for segregated populations.

Conclusions

-Luminosity and Spectral segregation at $z < 1.25$.

-The projected correlation function deviates from a power law at $r_p < 0.2h^{-1}$ Mpc.

-This deviation corresponds to Late-type galaxy clustering, probably done to their tendency to cluster in lower mass halos with smaller virial radii (Seljak 2000).

Future work

-Physically motivated fitting: Halo Occupation Distribution (HOD). Description of clustering through the one-halo term and the two-halo term.

Future surveys

-Upcoming photometric surveys (JPAS) will provide very interesting data for those interested in galaxy behavior at short distances (galaxy evolution and morphology, galaxy clustering,...).