UNVEILING COLD BARYONS IN HIGH REDSHIFT CLUSTER GALAXIES

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Abstract. This work is aimed at finding galaxies responsible for MgII λλ 2796, 2803 Å absorptions that may be associated with RCS galaxy clusters and were detected in the spectrum of background quasars (Lopez et al. 2008). For this purpose Gemini Multi Object Spectroscopic observations of galaxies in the field surrounding the lines of sight to background quasars were planned and reduced. Here we present the preliminary results of the Quasars behind Clusters Survey QbC.

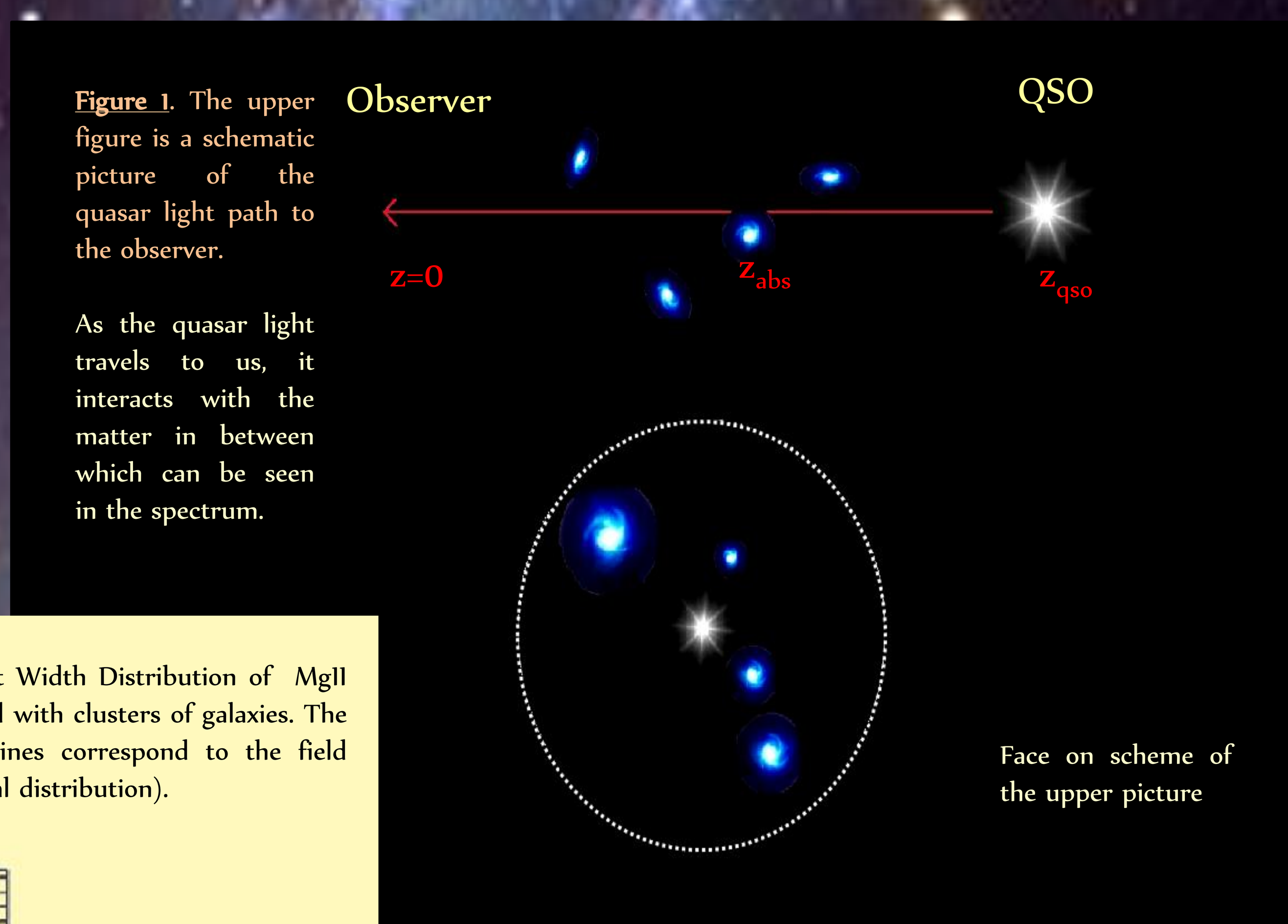


Figure 1. The upper figure is a schematic picture of the quasar light path to the observer.

As the quasar light travels to us, it interacts with the matter in between which can be seen in the spectrum.

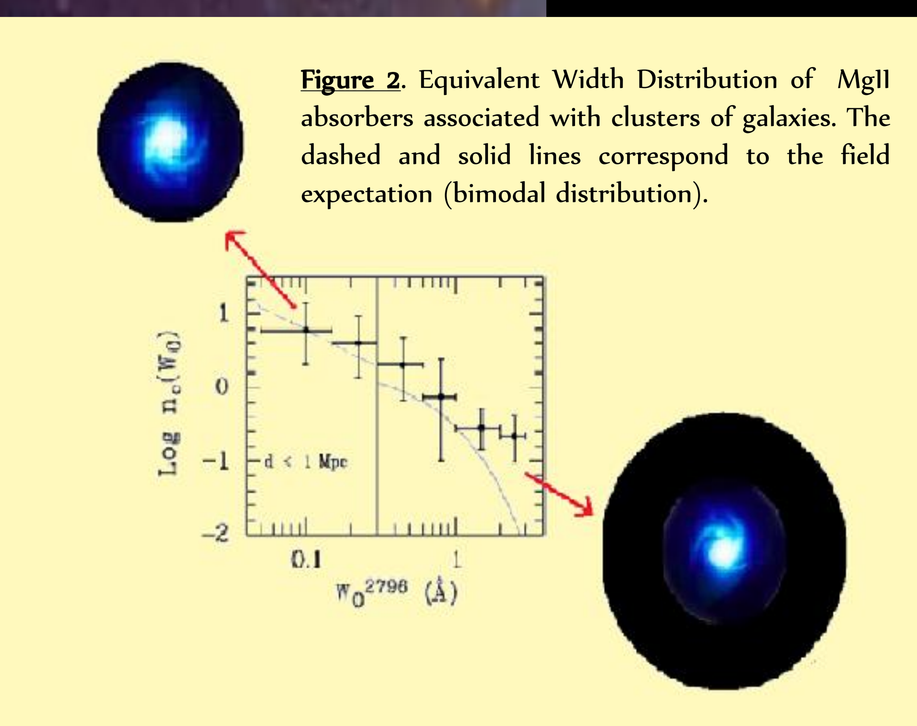


Figure 2. Equivalent Width Distribution of MgII absorbers associated with clusters of galaxies. The dashed and solid lines correspond to the field expectation (bimodal distribution).

The Quasars behind Clusters Project. The QbC project is focused on the study of absorption systems associated with galaxy clusters, which will tell us a great deal about the cold baryon reservoirs at high redshift. The first paper released (Lopez et al. 2008) is the first optical survey of MgII absorption systems observed in the spectra of background quasars having foreground galaxy clusters in the LOS at z_{clus}=0.3–0.9. Differences between absorbers related to clusters and those related to the field were notorious. While strong MgII systems (W_0^{2796} > 1Å) associated with galaxy clusters were more abundant than those found in the field -being this overabundance more evident at lower impact parameters d < 1 h_{71}^{-1} Mpc-, weak MgII systems (W_0^{2796} < 0.3Å) did not present such overabundance. An explanation for this signal may be that weak systems are associated with galaxy haloes truncated due to environmental effects, such as galaxy harassment or ram pressure stripping (figure 2).

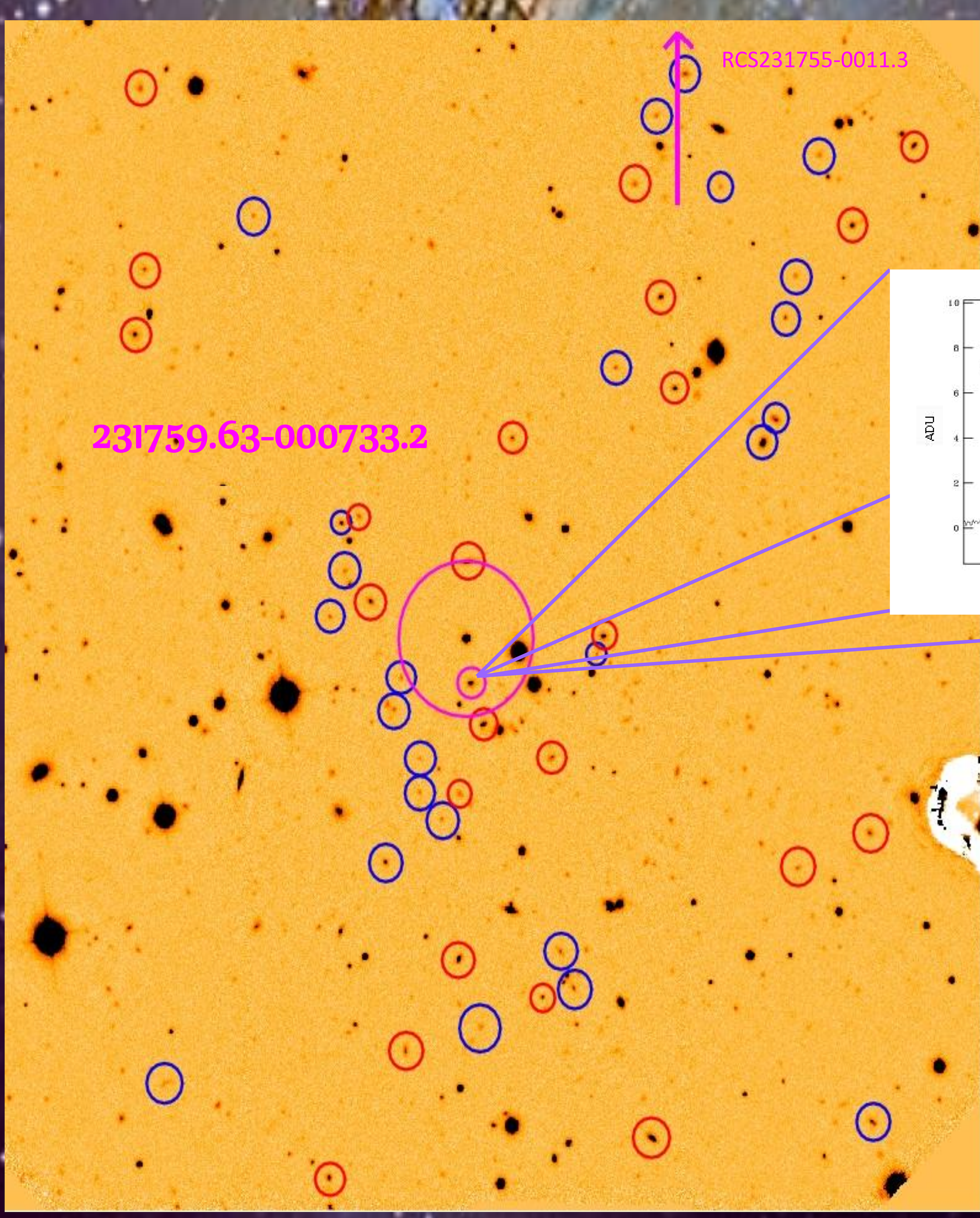
In order to confirm the previous statement, GMOS observations were planned for a sample of 9 fields of SDSS quasars, associated with a total of 31 galaxy clusters. More specifically, the analysis of these observations has three main objectives: find the absorbing galaxies (and their impact parameters to the LOS), verify the overabundance of galaxies in the vicinity of each LOS (confirming spectroscopically the redshifts of the RCS galaxy clusters) and –the most important goal of all- determine whether the absorbing galaxies belong to galaxy clusters or not. The preliminary results are shown in table 1.

As a result, we have obtained redshifts for an average of 42 galaxies per field. We were able to identify the absorbing galaxy in 9 out of the 23 absorption systems in our sample (see table 1), and to detect galaxies at a redshift consistent with the cluster redshifts (indicating a high probability of having confirmed spectroscopically the RCS galaxy clusters hosting the absorbing galaxies). Considering only the "hits", we were able to identify the absorbing galaxy in ~50% of the 13 cases, and for most of them we have detected the overabundance of galaxies at a near redshift. We have confirmed 13 out of 31 RCS galaxy clusters; we did not detect 5, and the 13 left needs further testing in order to characterize them better.

Table 1: Preliminary results of the QbC Survey. For each field (near the LOS to a background quasar), the MgII absorptions found in the spectra of background quasars are given, together with their rest frame equivalent width W_0^{2796} and its uncertainty $\sigma_{W_0^{2796}}$; also shown are the redshift at which the absorbing galaxy was found z_{obs} and its error $\sigma_{z_{obs}}$; its transverse distance to the LOS in kpc, whether it was defined as a "hit" or not (a "hit" is considered when the MgII absorption is at a redshift near a cluster redshift; see Lopez et al. 2008 for further details), the redshift z_{clus} at which a group of N_{gal} galaxies was found (being consistent with the overdensity of galaxies expected due to the presence of RCS galaxy cluster candidates), the velocity dispersion of that group and the difference –in velocity space– between the absorbing galaxy and the cluster candidate redshift.

Field	z_{abs}	W_0^{2796}	$\sigma_{W_0^{2796}}$	z_{obs}	$\sigma_{z_{obs}}$	d(kpc)	Hit	z_{clus}	σ_v	N_{gal}	δv(km/s)
022553.59+005130.9	0.6816	0.3330	0.019	–	–	–	yes	0.6824	0	1	142.772
"	0.7494	0.1590	0.015	–	–	–	yes	0.7484	536.756	3	171.575
"	1.0945	1.6850	0.065	1.0945	0.0008	16.253	no	–	–	–	–
022441.09+001547.9	0.2503	0.7320	0.037	0.2508	0.0001	23.370	yes	–	–	–	–
"	0.3785	1.1810	0.043	0.3787	0.0001	32.157	yes	0.3824	709.747	4	804.345
"	0.6146	0.1810	0.016	0.6145	0.0008	99.750	no*	0.6124	398.079	3	384.996
"	0.9395	0.0800	0.020	–	–	–	no	–	–	–	–
"	1.0554	0.8810	0.036	–	–	–	no	–	–	–	–
022300.41+005250.0	0.9493	0.0430	0.010	–	–	–	yes	–	–	–	–
022839.32+004623.0	0.6542	0.5970	0.016	–	–	–	yes	0.6558	274.115	8	297.388
HE2149–2745A	0.6008	0.1750	0.006	0.6010	0.0002	64.720	yes	0.6003	688.669	6	97.469
"	0.6028	0.0150	0.004	–	–	–	yes	0.6003	688.669	6	97.469
"	0.4086	0.2280	0.008	0.4086	0.0001	142.368	no	–	–	–	–
"	0.4460	0.0160	0.005	–	–	–	no	–	–	–	–
"	0.5139	0.0280	0.003	–	–	–	no	–	–	–	–
"	1.0184	0.2190	0.013	–	–	–	no	–	–	–	–
231500.81–001831.2	0.5040	0.1480	0.009	–	–	–	yes	0.5038	470.604	14	37.901
"	0.5068	0.0630	0.009	0.5065	0.0008	72.983	yes	0.5038	470.604	14	37.901
231509.34+001026.2	0.4470	1.7580	0.009	0.4467	0.0008	59.649	yes	–	–	–	–
231759.63–000733.2	0.6010	0.1090	0.016	0.6010	0.0002	84.816	yes	0.6026	425.010	4	295.879
231958.70–002449.3	0.8460	2.0280	0.024	–	–	–	yes	0.8468	276.622	2	121.858
"	0.4067	0.1510	0.017	–	–	–	no	–	–	–	–
"	0.4154	0.1920	0.021	–	–	–	no	–	–	–	–

* This is a special case where at first the system was defined as a "non hit system", but now we have found 3 galaxies near z_{abs} and they all show CaIIH-CaIIK absorptions in their spectra, typical of elliptical galaxies.This case requires further treatment.



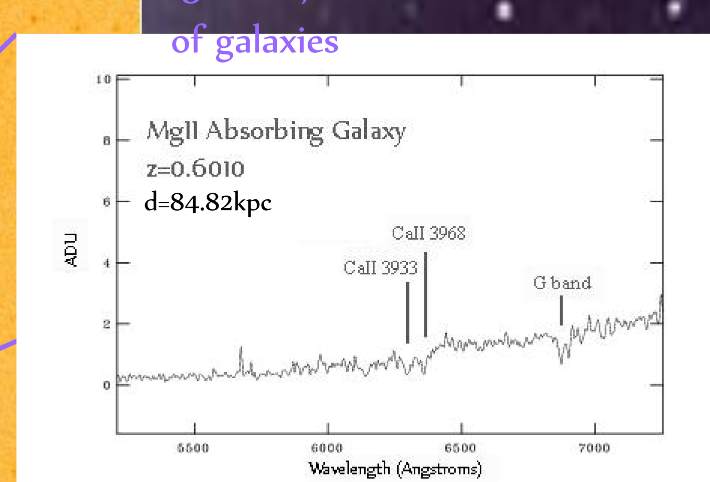


Figure 3. This is an image of the field centered on the SDSS quasar 231759.63-000733.2. This LOS presents one weak MgII absorption (W_0^{2796}=0.109Å) at z_{abs}=0.6010. Objects in blue and red circles are the galaxies observed with GMOS in two spectroscopic masks with different exposure times: in blue there are the faint objects (t_{exp}=3000s) and in red the brighter ones (t_{exp}=1800s). The magenta circle is centered on the quasar and it has a transverse radius of 150kpc. The smaller magenta circle is centered on the absorbing galaxy (see the spectrum). And the magenta arrow is pointing in the direction where the galaxy cluster RCS231755-0011.3 (z_{RCS}=0.573) is situated. (outside the FOV at a transverse distance of d=1536.7kpc from the LOS).

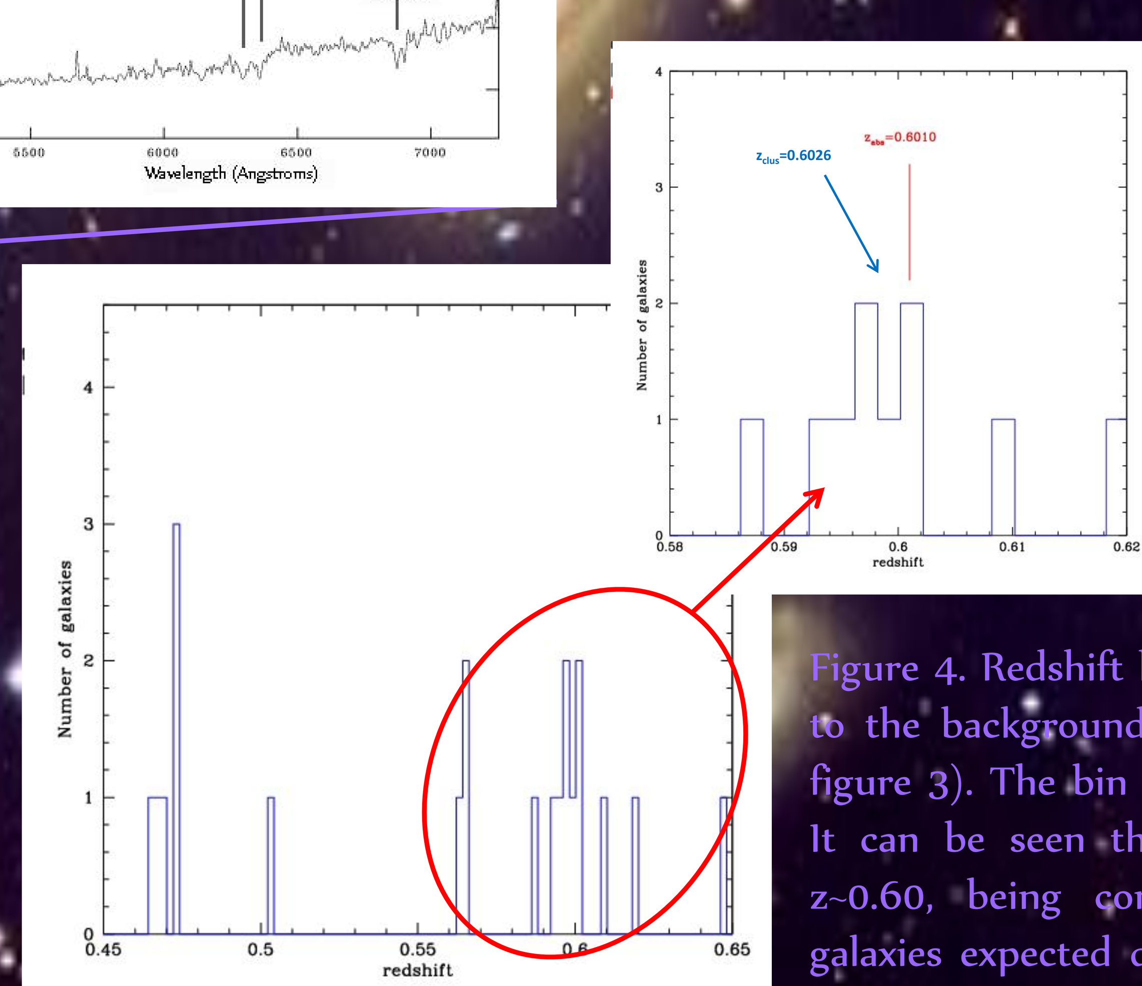


Figure 4. Redshift histogram of the galaxies near the LOS to the background quasar 231759.63-000733.2 (see also figure 3). The bin size used is of 0.002 in redshift space. It can be seen that a group of galaxies is present at z~0.60, being consistent with the overabundance of galaxies expected due to the presence of the RCS galaxy cluster RCS231755-0011.3, which has a photometric redshift z_{RCS}=0.573 with an uncertainty Δz=0.1. There are also a few galaxies at z~0.47. However this last one is not found in the RCS cluster catalog.

Andrews et al. (2009) in preparation

According to these results, our hypothesis of truncated haloes to explain the weak MgII absorption statistics in clusters is being confirmed with the observations. However, in many cases the absorber was not identified, mainly because of the target selection which relied on the expected S/N of the spectra.

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