Outskirts of Galaxy Clusters: Intense Life in the Suburbs
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Spectroscopy of high-redshift EIS clusters

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Abstract. We present multi-object spectroscopic observations from FORS1 mounted at the VLT for 5 clusters detected in the ESO Imaging Survey. Together with the results for three other clusters presented previously, we confirm a total of 6 out of 8 clusters with estimated redshift $z_{MF} \geqslant 0.6$. The spectroscopic redshifts are in good agreement with the estimated ones.

1. Introduction

Based on the EIS I band survey Olsen (2000) presented a catalogue of 310 cluster candidates using a matched filter technique. The estimated redshifts z_{MF} range from 0.2 up to 1.3. Hansen et al. (2002) and Olsen et al. (2003) have presented spectroscopic confirmation of 14 cluster candidates at $z_{MF} = 0.2$-0.3 and Ramella et al. (2000) have confirmed 4 clusters at $z_{MF} \leqslant 0.7$. Some preliminary results for three EIS cluster candidates in the range $0.8 \leqslant z \leqslant 1.3$ were given by Benoist et al. (2002). Here we present results for further five EIS cluster candidates at $0.6 \leqslant z_{MF} \leqslant 1.0$.

2. Observations

We selected the target clusters $z_{MF} \geqslant 0.6$ on the basis of optical/infrared imaging data, that were used to detect simultaneous overdensities in color and space. For all the targeted clusters we detected a promising overdensity of galaxies with similar $I - K_s$ and $J - K_s$-colors (Olsen 2000). The target galaxies were selected from their optical-infrared colour properties.

The observations were carried out using FORS1 mounted at VLT-ANTU telescope. In the multi-object spectroscopy (MOS) mode FORS1 provides 21 slits. We used grism 150I+17 with the order separation filter OG590 covering the wavelength range 6000-11000Å. This grism combined with a slitwidth of 1.4 arcsecs gave a resolution of 29Å.

3. Results

To identify groups in redshift space we use the "gap"-method by Katgert et al. (1996). We use a gap-size of $0.005(1 + z)$ to separate individual groups. This separation corresponds to a rest-frame velocity of 1500 km/s. Additionally we require that there are at least 3 galaxies in a group to consider it for further analysis. To assess the significance of

Table 1. The identified groups with significance $\sigma \geqslant 99\%$.

Field	# galaxies	z	σ_v km/s	σ
EISJ0046-2951	17	0.616	1340	99.9
EISJ0046-2951	**10**	**0.671**	**890**	**99.7**
EISJ0048-2942	7	0.402	1040	99.4
EISJ0048-2942	**33**	**0.638**	**1110**	**>99.9**
EISJ0050-2941	12	0.559	1390	99.9
EISJ0050-2941	8	0.617	1060	99.1
EISJ2236-4017	12	0.509	940	99.9
EISJ2249-3958	**8**	**0.710**	**400**	**99.4**

the systems we determine the probability of detecting a group with the same number of members at the same redshift in a pure field galaxy sample. The details of the methods are given in Benoist et al. (2002).

EISJ0046-2951. We find 2 significant groups in this field as listed in Table 1. The two groups have redshifts $z = 0.616$ and $z = 0.671$. In order to decide which of the groups is the one most likely to have caused the matched filter detection we inspect the positions of the galaxies in each group. The group at $z = 0.616$ forms an elongated structure to the north from the EIS position, and thus cannot have caused the matched filter detection. The other group with $z = 0.671$ has five galaxies at the matched filter position and five members further away. Therefore, we consider this the confirmation of the EIS cluster. The group has a velocity dispersion of $\sigma_v = 890$ km/s, which makes it a fairly massive system.

EISJ0048-2942. We find two significant groups in this field with redshifts $z = 0.402$ and $z = 0.638$. Given the large number of members in the latter group there is no doubt that the cluster at $z = 0.638$ is responsible for the matched filter detection. The cluster is rich and completely dominating the field. The velocity dispersion of this system is $\sigma_v = 1110$ km/s making it a massive system.

EISJ0050-2941. We find two significant groups in this field with redshifts $z = 0.559$ and $z = 0.617$. Both groups are spread over the field and it is unclear which one corresponds to the matched filter detection. Considering the originally estimated redshift of EISJ0050-2941 of $z_{MF} = 1.0$ compared with the much lower redshifts of the groups detected here it is interesting to note that there is a group of faint galaxies at the matched filter position that has not been observed spectroscopically. From inspecting the luminosity function of excess galaxies at the matched filter position we find that the excess galaxies have magnitudes fainter than $I \geqslant 21$, which corresponds well to the magnitudes expected for the bright cluster galaxies at $z \sim 1$. Therefore, we consider this case inconclusive.

EISJ2236-4017. In this field only one group is found to be significant. This group has a redshift of $z = 0.509$ and a velocity dispersion of $\sigma_v = 940$ km/s. This group is spread over a large fraction of the field, and is thus surprising to have caused the matched filter detection. Inspecting the image of the field we find a concentration of fainter more concentrated galaxies that could be responsible for the matched filter detection. These galaxies were unfortunately not covered by our spectroscopic observations. It should be noted that we had to abandon one of our masks for this field, which could potentially have included a number of interesting galaxies.

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EISJ2249-3958. Also in this field we find only one significant group. It has a redshift of $z = 0.710$ and a velocity dispersion of $\sigma_v = 400$ km/s corresponding to a rather poor system. The structure is rather elongated and one may therefore speculate that it could be a non-virialized system.

4. Conclusions

An important question for the potential of the EIS cluster candidate catalog for populating the high-redshift domain of known clusters is related to the reliability of the matched filter estimated redshifts, z_{MF}. For the high-z cluster sample of 8 systems (5 reported in this work and 3 reported by Jørgensen et al. 2004) we compare the spectroscopic redshifts with the original z_{MF}. Altogether we have 6 confirmed systems which we use to investigate the redshift reliability of the EIS cluster candidates. We use the difference, $\Delta z = z_{spec} - z_{MF}$, between the spectroscopic and matched filter estimated redshift as a measure of the redshift reliability. For the five systems we find that the spectroscopic redshifts ranges from $\Delta z = -0.23$ to $\Delta z = 0.21$. The average deviation is $\Delta z = -0.02$ with a standard deviation of 0.16. Altogether the matched filter estimated redshifts are on average consistent with the spectroscopic ones, even though deviations can be up to $\Delta z \sim 0.23$. This result is valid all the way to the highest redshifts found in the catalog and thus makes the EIS cluster candidate catalog a good source for populating the high-z universe.

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