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The galaxy environment of a QSO at $z \sim 5.7$

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Abstract. High-redshift quasars are thought to reside in the most massive halos in the early universe and should therefore be located in fields with overdensities of galaxies, which are expected to evolve into galaxy clusters seen in the local Universe. In Bañados *et al.* (2013), we used deep narrow-band imaging to study the environment of the $z = 5.72$ quasar ULAS J0203 + 0012. The redshift range probed by our narrow band selection is $\Delta z \sim 0.1$. This was the first time that Lyman alpha emitters (LAEs) were searched for near a $z \sim 6$ quasar, to provide clues on the surroundings of quasars at the end of the epoch of reionization. The main result of this work is that no enhancement of LAEs has been found in the surroundings of ULAS J0203 + 0012. We discuss different explanations and interpretations for this non-detection of a galaxy overdensity.

Keywords. galaxies: formation — galaxies: high redshift — quasars: individual (ULAS J0203 + 0012)

1. Introduction

Numerical models predict that the most massive dark matter halos at $z \sim 6$ will evolve into massive $> 10^{14-15}$ $M_\odot$ clusters in the local Universe and that the most massive halos host the most massive black holes (e.g., Costa *et al.* 2014).

Based on the premise that high-redshift quasars trace the most massive dark matter halos, several groups have tried to identify galaxy overdensities associated with $z \sim 6$ quasars. However, different studies have come to different results. Some of them finding no evidence for overdensities of *dropout* galaxies in quasar fields (e.g., Willott *et al.* 2005), others finding overdense regions (e.g., Zheng *et al.* 2006) and there are studies finding that regions near high-redshift quasars are sometimes overdense and sometimes underdense (e.g., Kim *et al.* 2009). In summary, current dropout studies at $z \sim 6$ give partly contradictory results. No unambiguous relation between galaxy overdensities and high-redshift quasars has been found, mainly due to the difficulty of finding galaxies with accurate redshifts at $z \sim 6$. This may be due to the observational strategy that has been employed thus far: i.e., the selection of galaxies through continuum dropouts. This technique probes a redshift range of approximately $\Delta z \approx 1$. This range is large and possibly identifies galaxies which are not physically related to the quasar. An efficient alternative

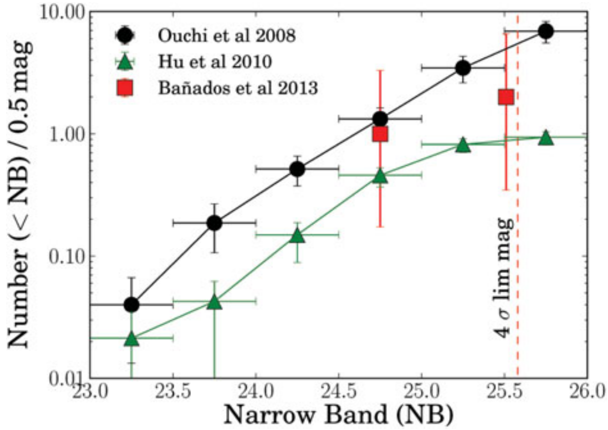

Figure 1. Cumulative number of LAEs scaled to a common area vs. narrow-band magnitude (NB). Circles and triangles correspond respectively to the blank field samples from Ouchi *et al.* (2008) and Hu *et al.* (2010). The squares correspond to the quasar field from Bañados *et al.* (2013). The measurements are consistent with no overdensity in our quasar field.

is to search for LAEs in a narrow redshift range near the quasar using narrow-band filters. However, until recently no high-redshift quasars were known to have a redshift that shifts the Lyα line into a region of the optical spectrum that is devoid of bright sky emission lines.

2. Data

We observed a field of 44.4 arcmin^2 around the $z = 5.72$ quasar ULAS J0203+0012 in the optical R and Z bands and in a narrow band (NB) centered in $\lambda = 8150$ Å with FORS2 at the Very Large Telescope. The redshift range of the Lyα line probed by the narrow band filter is $5.66 < z < 5.75$, significantly narrower than continuum dropout searches. With this setup we were able to search for LAEs near a $z \sim 6$ quasar for the first time. The selection of the LAEs is described in detail in Bañados *et al.* (2013).

3. Discussion

The main result of this work is that no enhancement of LAEs has been found in the surroundings of the quasar ULAS J0203+0012 (see see Figure 1). Possible explanations for this non-detection of an overdensity include a) The strong ionizing radiation from the quasar may prevent galaxy formation in its surroundings, which is not seen around radio galaxies and would be in contradiction with unified models of AGN. b) High-redshift quasars may not reside in the most massive dark matter halos, which is in strong contrast with prediction based on current galaxy and black hole formation models. For details on this work and a more complete discussion, please refer to Bañados *et al.* (2013).

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