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LAE'S AT $Z \sim 4.5$: THE ENVIRONMENT OF THE RADIO QUIET QSO SDSS J080849.42+521515.3

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RESUMEN

Hemos comenzado un estudio sistemático del medio ambiente en cuásares radio fuertes (RLQSO) y radio callados (RQQSO) de alto-z usando OSIRIS-GTC. La idea del proyecto es buscar LAE's en una región de $\sim$4 Mpc alrededor de un objeto seleccionado de nuestra muestra de QSO. Se ha encontrado que el medio ambiente de algunos cuásares de alto-z conforma una región de formación de proto-cúmulos de galaxias. En particular, este estudio tiene como objetivo proveer una comparación directa entre el medio ambiente de RLQSO y RQQSO y también para estudiar la evolución de proto-cúmulos de galaxias con z. Nuestros resultados incrementarán la cantidad de campos con Emisores Lyman Alfa (LAE's) alrededor de QSO's conocidos hasta ahora. En este trabajo presentamos algunos resultados preliminares obtenidos con datos obtenidos con OSIRIS+TFRED del medio ambiente del RQQSO SDSS J080849.42+521515.3 a $z = 4.46$. Mostraremos la presencia de unos cuantos objetos candidatos a LAE's que parecen estar asociados al medio ambiente de este RQQSO.

ABSTRACT

A systematic study of the environment of Radio Loud and Radio Quiet Quasars (RLQSO and RQQSO) at high-z has started using OSIRIS-GTC. The idea of the project is to search for LAE's in a region of $\sim$4 Mpc around an object that has been drawn from our selected QSO sample. The environment of some high-z QSO's has been found to conform a region of proto-cluster formation. In particular, this study aims to provide a direct comparison between the environment of RLQSO and RQQSO and also to study the evolution of proto-clusters of galaxies with z. Our results will increase the amount of Lyman Alpha Emitters (LAE s') fields studied around QSOs known up to date. In this work we show some preliminary results obtained with OSIRIS+TFRED on the environment of the RQQSO SDSS J080849.42+521515.3 at $z = 4.46$. We will show the presence of a few LAE's candidates that seems to be associated with the environment of this RQQSO.

Key Words: galaxies:high-redshift

1. INTRODUCTION

The discovery of Lyman α emitters (henceforth, LAE's) has been crucial since it made possible the study of faint galaxies at high-z. LAE's are usually defined as distant starburst galaxies having rest-frame Lyα emission equivalent widths >20 Å. Initially, LAE's were proposed to be proto-galaxies experiencing their first burst of star formation (see Hu & McMahon 1996). However, recent works (e.g. Finkelstein et al. 2009) have looked at the distribution of stellar population ages in LAE's of $z\sim$4.5 for the first time, and find a very interesting age bimodality, i.e. LAE's are either very young (<15 Myr) or old (>450 Myr). Most LAE's show Lyα FWHM widths $\leq$500 km s^{-1} (Dawson et al. 2004; Tapken et al. 2007) and usually this line is the only spectroscopy signature used to confirm the redshift of the galaxy. LAE's have been found associated with high-z QSOs and some have found to be tracers of large-scale structures (e.g. Hayashino et al. 2004). Nevertheless, there are some studies that found evidences for low level clustering of LAE's at $z = 3.1$ (e.g. Gawiser et al. 2007).

It is well known that overdense regions of galaxies around QSOs at high-z are proto-clusters of galaxies. Thus, proto-clusters of galaxies are important to study since they can be the first sites for the co-evolution of QSOs and galaxies. At $z > 3$, there are some examples of proto-clusters of galaxies around QSOs (e.g. Venemans et al. 2005). In particular, in a study done in a field of a $5 \times 5'$around a RLQSO at $z = 5.8$, Zheng et al. (2006) find an overdensity of faint companions. These studies have led to the idea that QSO fields are special regions of galaxy early formation and gave support to some theoretical predictions made about high-z QSOs. In particular, for

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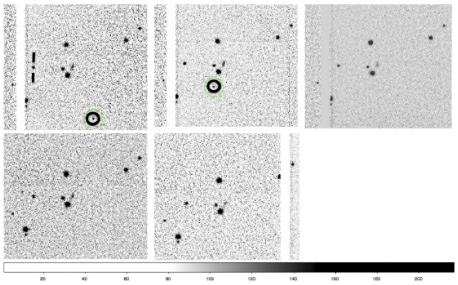

Fig. 1. GTC+OSIRIS+TFRED images of the RQQSO J080849.42+521515.3 obtained in five different telescope positions. The vertical white gap in some images is due to the separation of the two CCD's. Each image shows a region of size $\sim(3 \times 3)'$around the target. The target is marked only in the upper left panel. We can clearly appreciate the presence of two LAE's candidates (shown inside the black circles) that were detected in our study. The images were obtained with a PA of 80 degrees and are shown with this orientation.

our project it is crucial to detect companion galaxies of QSOs at high-z in order to see if RLQSOs are associated (or not) with richer environments in comparison with RQQSOs. The detected LAEs will enable us to test if such QSO environment differences are related (or not) with the onset of QSO activity.

Therefore, the main goals of this project are (see Benítez et al. 2005): (1) detect LAE's within 4 Mpc ($\sim 9'$) around the target QSOs, possible sites of proto-cluster formation, above a line flux threshold corresponding to faint emitters of 1.14×10^{-17} erg cm^{-2} s^{-1} at $z = 4.5$ (see Dawson et al. 2004). (2) Characterize the environmental properties of RLQSOs and RQQSOs and establishing its possible dependence with z.

2. OBSERVATIONS AND DATA REDUCTION

The radio quiet QSO SDSS J080849.42+521515.3 was observed for a total of 1.5 h using the Optical System for Imaging and low Resolution Integrated Spectroscopy (OSIRIS) instrument at the Gran Telescopio Canarias (GTC), La Palma. OSIRIS consists of two 2048 × 4096 pixel Marconi CCDs with a 72 pixel gap between the two CCDs. The observations were done on November 20th 2009 with a seeing varying between 1.2–1.5″. The 2×2 binning mode was used resulting in a pixel scale of $\sim 0.25''$ pixel^{-1} and a total field of view of $\sim(8 \times 8)'$. Target was positioned near the optical center, near the left edge of CCD 2. The individual exposures have been dithered with offsets of 2 arcmin in right ascension and in declination. The narrow-band images were obtained at three different central wavelengths λ_c, allowing us to find LAE's with z around these wavelengths due to the variation of the central wavelength of the TFs across the field of view (see González et al. 2012, in preparation). The maximum full width at half-maximum (FWHM) of the TF used is 19 Å; therefore, accordingly with our simulations described in Benítez et al. (2007) we need to do at least 4 passes with different λ_c in order to cover the entire redshift range of a possible proto-cluster. Due to observing time limitations, we performed 3 passes only with different λ_c in order to search for possible LAE's associated with the target.

At $z \sim 4.5$, the Lyα line is shifted to 6580 Å, so the central wavelengths for the TF were chosen to be at 6667, 6645 and 6623 Å. The reduction of all the data is done using IRAF. The reduction of the broad-band images includes the standard steps of bias and dark-current subtraction and flat-fielding. It is interesting here to point out that our data were obtained in a time when the GTC has problems due to the presence of a high-level dark-current. Each set of images obtained with the telescope in the same position with the three TF's were co-added together. We present as an example a small region of our co-added images in Figure 1, where we show some of our detected LAE's candidates.

3. PRELIMINARY RESULTS

The methodology proposed for this project proved to be adequate since we have successfully detected a few LAE's candidates associated with the RQQSO J080849.43+521515.3. Our results show that LAE's could be also present in the environment of RQQSOs at high-z, and therefore support previous results that found no differences between the environment of radio loud and radio quiet QSOs at lower-z. We will continue with our observational program and ask time for more observations around high-z QSOs. This will enable us to complete our initial study of 10 RQQSOs and 10 RLQSOs fields in two different redshift windows and therefore study the evolution of the environment with z.

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