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GALAXIES AT $Z = 3$ AROUND DAMPED LY-α CLOUDS

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RESUMEN

Exloramos la conexión entre sistemas de absorpción de Ly$-\alpha$ amortiguados (DLA) y galaxias con quiebre de Lyman (LBG) usando imágenes de banda ancha profundas – $m_{lim,I}(5\sigma)$=26 m_{AB}– en cuatro campos (0.25 grados^2 cada uno) obtenidas en el telescopio de 4-m de Kitt Peak con MOSAIC. Cada campo contiene una DLA a $z \sim 3$. Deseamos estudiar la naturaleza de los DLAs a altos z: (1) ¿Están los DLAs embebidos en sistemos galácticos más grandes? (2) ¿Cómo se relaciona la distribución espacial de los emisores en 3D (espacio y z) con los absorbedores? Al contrario de estudios previos sobre DLAs, no estamos buscando el absorbedor y no contamos con campos de control, pues cada uno de nuestros campos es $40 \times 40 h^{-1}$ Mpc (comóvil). Presentamos resultados preliminares en dos de nuestros campos. Uno de ellos indica una sobredensidad de galaxias en una escala de 5 Mpc. Analizamos posibles implicaciones y fuentes de contaminación.

ABSTRACT

We are exploring the connection between Damped Ly$-\alpha$ Absorption systems and Lyman Break Galaxies using deep – $m_{lim,I}(5\sigma)$=26 m_{AB}– broad band imaging (UBVI) of four wide fields (0.25deg^2 each) obtained at the Kitt Peak 4-m telescope with MOSAIC. Each field contains a DLA at $z \sim 3$. We want to address the nature of DLA at high-redshifts: (1) Are the DLAs embedded in much larger systems of galaxies? (2) How does the spatial distribution of emitters in 3D (space and redshift) correlate with the absorber? Contrary to most previous DLA studies, we are not looking for the absorber, and we do not rely on control fields because each of our fields is $40 \times 40h^{-1}$ Mpc (co-moving). We present preliminary results in two of our fields. In one case, it indicates an overdensity of galaxies on a scale of 5 Mpc. We discuss the possible implications and sources of contamination of our results.

Key Words: **GALAXIES: EVOLUTION, HIGH-REDSHIFT — QUASARS: ABSORPTION LINES, INDIVIDUAL (APM08279+5255, PC1233+4752)**

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1. INTRODUCTION

By definition, damped Ly-α absorbers (DLAs) found in the spectra of quasars have neutral hydrogen (HI) column densities greater than 2×10^{20} cm^{-2}. Their nature is unknown and has been an ongoing debate for more than a decade. Two classes of hypothesis can explain DLA properties, (1) DLAs are large disks or proto-disks, or (2) DLAs arise from the superposition of small gas clouds in a large halo. The former was first proposed by Wolfe et al. (1986), the latter is more recent. Maller et al. (2000) showed that DLAs can arise from the combined effects of massive central galaxies and a number of smaller satellite galaxies in a virialized halo. In this scenario, a DLA would lie in an over dense region.

Lyman Break Galaxies (LBGs) are active star forming objects, hence are bright $L_{UV} = 10 \times L^*(today)$ (e.g. Steidel 2000) and they trace the underlying matter distribution as indicated by their strong clustering.

Based on this, the motivation of this work is to try to answer the following question: *Are DLAs in over- or under-dense regions?* In order to test this, we selected four QSO fields that have (i) a low galactic extinction, and (ii) $z_{DLA} \sim 3 < z_{QSO}$. In order to constrain the environment and the nature of the damped systems at $z \sim 3$, we imaged four fields with the MOSAIC camera at the Kitt Peak 4-m telescope in UBVI. The area covered (0.25deg^2/field to $I_{AB}(5\sigma) < 26$) allow us to identify several hundred LBG candidates both close to the QSO/DLA line of sight (50 kpc) and up to 20 h^{-1} Mpc (co-moving) away. Thus, unlike previous studies, we do not rely on a randomly selected control field.

In this proceeding, we present preliminary results in the fields APM 08279+5255 and PC1233+4752 that contain a DLA at $z_{DLA} = 2.97$ and $z_{DLA} = 3.5$ respectively.

At $z \sim 3$, $1'$ corresponds to $\sim 1.3h^{-1}_{100}$ Mpc (co-moving) for $\Omega_M = 0.3$, $\Omega_\Lambda = 0.7$.

2. PHOTOMETRIC REDSHIFTS

We used the photometric redshift code from Bolzonella et al.(2000) to estimate the redshifts of our candidates. In order (1) to assess the accuracy and reliability of the technique, and (2) to refine our set

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of templates, we ran various tests on the HDF-N published data (see e.g. Fernández-Soto 2001). We find that (1) near-IR data are not necessary in our redshift range ($2.8 < z < 3.8$), (2) our best set of templates consists of 4 Coleman Wu & Weedman (1980) templates (E, Sbc, Scd & Irr) extended in the UV using Bruzual & Charlot (1993) models, and 4 Starburst99 (50Myr, 100Myr with 2 metallicities) from Leitherer et al. (1999), (3) the rms of the normalized difference between photometric and spectroscopic redshifts $|z_{spec} - z_{sphot}|/(1 + z_{spec}$ is 0.05 in our redshift range ($2.8 < z < 3.7$) and (4) the number of low redshift objects contaminating our high redshift sample is on the order of 10%. We plan to implement Bayesian's prior probabilities as shown in Benitez (2000) to significantly reduce the level of contamination in the future.

3. RESULTS AND DISCUSSION

We selected high-redshift candidates to be U-band drop-outs with $21 < I < 24.5$. We then estimated the redshift according to Section 2. Our results, the spatial and radial distributions of LBGs candidates around the DLA, are shown in Figure 1 for APM08279+5255 separated in two redshift bins around the DLA, $|z_{DLA} - z| < 0.2$, and $0.2 < |z_{DLA} - z| < 0.5$. The surface density indicates an overdensity. The upper limit is 0.5 to account for incompleteness in our redshift distribution, for our selection function drops sharply at $z \sim 2.8$. In each case, the radial surface density is plotted. Note that we find the same signature even when we split the first bin in half. Around PC1233+4752, we do not find such a signature.

Our results indicate that at least some DLAs may lie in overdense regions. We note that Adelberger et al. (2002) found an under-density (marginally), and Gawiser et al. (2001) were inconclusive. Our results are potentially limited by our lack of accurate redshifts — $\Delta z = 0.1$ corresponds to 75 h^{-1} Mpc at $z = 3$— and contamination by low redshift objects and red stars (estimated to be 10% or less). This would tend to reduce the overdensity signature. If our results were due to a clustering of stars, the signature would disappear when we increase our lower magnitude limit. We find the over-dense signature remains.

This Fall, we will obtain multi-object spectroscopy (with GMOS) of some of our candidates in order to test our photometric redshifts and to confirm our results. We are in the process of applying the same techniques to our two other fields (Bouché et al 2003).

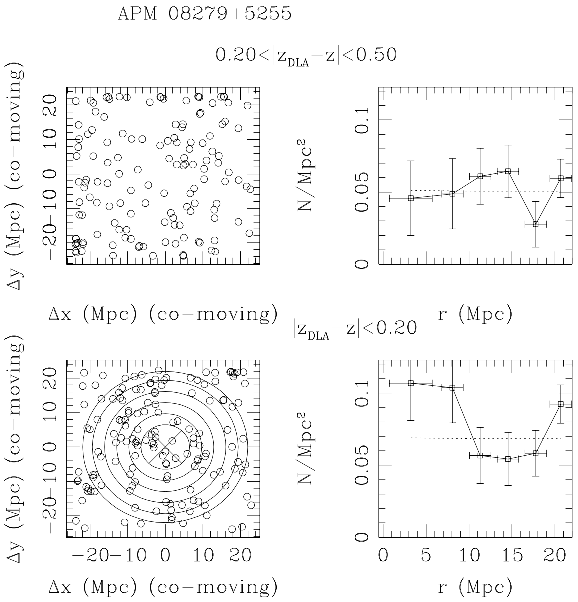

Fig. 1. Left: Spatial distribution of LBG candidates. Right: Radial surface density as a function of radial distance from the QSO line-of-sight (shown with the cross). The lower panels are for the candidates with $|z_{DLA} - z| < 0.2$, and the upper panels are for $0.2 < |z_{DLA} - z| < 0.5$. The dashed line is the average of density of the last three radial bins, representing the underlying density. A 1σ signature of an overdensity is seen.

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