

# A Deep Narrow Band Imaging Search for CIV $\lambda$ 1548Å and HeII $\lambda$ 1640Å Emission from Lyman Alpha Blobs

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**Abstract.** To study the nature of Ly $\alpha$  blobs (*aka* LABs), we conduct a deep C IV and He II narrowband imaging survey of 13 Ly $\alpha$  blobs located in SSA22 proto-cluster at  $z \sim 3.1$ . We reach the unprecedented sensitivity,  $5\sigma$  surface brightness limit of  $2.1 - 3.4 \times 10^{-18} \text{ erg s}^{-1} \text{ cm}^{-2} \text{ arcsec}^{-2}$  per  $1 \text{ arcsec}^2$  aperture for two emission lines. We do not detect any extended C IV and He II emission, placing strong upper limits on the He II/Ly $\alpha$  and C IV/Ly $\alpha$  line ratios. We compare our limits with data in the literature related to the nebulae associated with high-redshift radio galaxies (HzRGs) and quasars, and we recover the data by modeling the LABs as nebulosities powered by a central QSO. For further information see Arrigoni Battaia *et al.* (2014).

**Keywords.** LAB, QSO, CGM, photoionization

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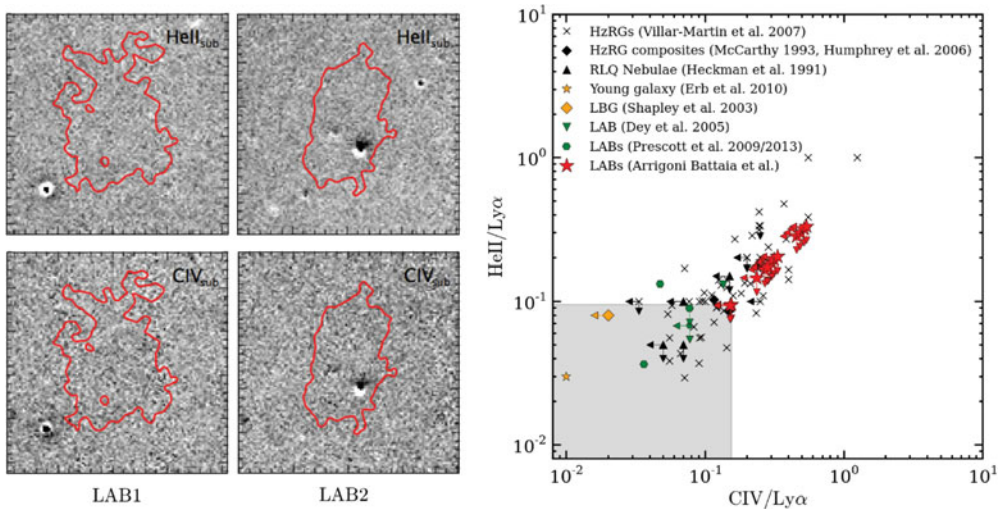
## 1. Introduction

The recently discovered giant Ly $\alpha$  nebulae, the so-called Ly $\alpha$  blobs (LABs), are large (50–100 kpc) spatially extended regions emitting copious amounts of Ly $\alpha$  emission [ $L(\text{Ly}\alpha) \sim 10^{43-44} \text{ erg s}^{-1}$ ] (e.g., Yang *et al.* 2009). Despite the intense interest, what powers these gigantic gas halos are still not understood. The proposed scenarios include photoionization by AGNs, shock-heated gas by galactic superwinds, cooling radiation from cold-mode accretion, and resonant scattering of Ly $\alpha$  from star-forming galaxies.

The dominant mechanism powering these extreme objects remains unclear mainly because of the lack of other emission line diagnostics besides strong Ly $\alpha$  lines. In this work, to distinguish among various mechanisms for powering Ly $\alpha$  blobs, we present very deep narrowband imaging observations tuned to the C IV  $\lambda$ 1549 and He II  $\lambda$ 1640 emission lines of 13 Ly $\alpha$  blobs at  $z \sim 3.1$ . Our observations exploit the fortuitous match between two narrowband filters on VLT/FORS2 and these two emission lines from a large sample of Ly $\alpha$  blobs that were discovered in the SSA22 proto-cluster region at  $z = 3.1$  (Steidel *et al.* 2000, Matsuda *et al.* 2004). Because this region shows a remarkable overdensity of Ly $\alpha$  emitters (LAEs) and LABs, we are able to carry out a statistical study of C IV/Ly $\alpha$  and He II/Ly $\alpha$  line ratios for a large sample of LABs.

## 2. Data

We obtain deep C IV and He II narrowband images of 13 LABs including the two largest LABs that were originally discovered by Steidel *et al.* (2000). Data were taken in service-mode using the FORS2 instrument on the VLT 8.2m. We use two narrowband filters, OI/2500+57 and SII+62, matching the redshifted C IV  $\lambda$ 1549 and He II  $\lambda$ 1640 at  $z = 3.1$ , respectively. The OI/2500+57 filter has a central wavelength of  $\lambda_c \approx 6354 \text{ \AA}$



**Figure 1.** **Left:** Continuum-subtracted images of LAB1 and LAB2 in the He II line (top panels) and C IV line (bottom panels). The  $2\sigma$  Ly $\alpha$  isophotes are shown in red (Matsuda *et al.* 2004). Note the lack of extended emission. **Right:** HeII/Ly $\alpha$  versus CIV/Ly $\alpha$  log-log plot. Our upper limits on the HeII/Ly $\alpha$  and CIV/Ly $\alpha$  ratios are compared with the values quoted in the literature for HzRG, QSOs, and LABs. Due to their larger size, LAB1 and LAB2 define the strongest limits on these ratios: the gray shaded area highlights the regime constrained by these limits. Note however that these data are quite difficult to compare because of their heterogeneity.

and has a bandwidth of  $\Delta\lambda_{\text{FWHM}} \approx 59 \text{\AA}$ , while the SII+62 filter has  $\lambda_c \approx 6714 \text{\AA}$  and  $\Delta\lambda_{\text{FWHM}} \approx 69 \text{\AA}$ . To subtract continuum from our narrowband images and compare the C IV and He II line fluxes with those of Ly $\alpha$ , we rely on previous Subaru observations by Hayashino *et al.* (2004), who observed the SSA22 field in  $B$ ,  $V$ ,  $R$ ,  $i'$ , and NB497 bands.

### 3. Overview of the Results

For all LABs in our sample, we do not detect any extended C IV and He II emission comparable to the Ly $\alpha$  line down to our sensitivity limits (see above). Figure 1 is a He II/Ly $\alpha$  versus C IV/Ly $\alpha$  log-log plot where we highlight with red stars the 5 sigma upper limits for LABs in our sample, in comparison with all previous measurements for LABs (Prescott *et al.* 2013), and with all the Ly $\alpha$  nebulosities in the literature associated with HzRGs and quasars which have C IV and He II measurements. As there are points below our tighter limits, this Figure clearly states that other data are needed in order to really constrain the He II and C IV emission from the LABs in the SSA22 field. In order to understand how much deeper we need to go, we model LABs as nebulae powered by a central hard ionizing source (i.e. QSO), following the prescription in Hennawi & Prochaska (2013). See Arrigoni Battaia *et al.* (2014) for the complete analysis and results.

### References

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