Galaxies at High Redshift and Their Evolution Over Cosmic Time
Proceedings IAU Symposium No. 319, 2015
S. Kaviraj, ed.

doi:10.1017/S1743921315010388

Galaxies at $z \sim 6$: physical properties at the edge of the cosmic reionization

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Abstract. An important effort has been recently made to detect spectroscopically galaxies at $z \sim 6$ and higher where the cosmic reionization is thought to occur. The drop of the fraction of Lyman Alpha Emitters (LAEs) at $z > 6$ is currently interpreted as an effect of the increasing neutral hydrogen density.

We present preliminary results from the latest VLT/FORS2 programs, combined with ESO archival data, to perform a large census of $z \sim 6$ galaxies. We derive their physical properties as stellar mass and dust attenuation with an SED fitting tool including nebular emission which is of primeval importance because IRAC channels are strongly contaminated by emission lines at those redshifts. We take a special care to derive with precision the redshift of non LAEs to perform a comparison of their properties with the LAE population and derive as accurately as possible the fraction of LAEs. In particular, we compare the UV beta slope with the Lyα equivalent width which are known to correlate at lower redshift.

We also report the detection of few peculiar $z \sim 6$ galaxies with extremely blue UV β slope (~ -3), which can be a signature of unusual stellar populations (e.g., very hot and massive stars).

Keywords. galaxies: distances and redshifts – galaxies: formation – galaxies: high-redshift

1. Introduction

One of the most pressing, unanswered questions in cosmology and galaxy evolution is determining which sources are responsible for the reionization of the intergalactic medium (IGM; Robertson *et al.* 2015) and are capable of keeping it ionized afterwards (Fontanot *et al.* 2014; Giallongo *et al.* 2015). Until recently, it was difficult to draw a consistent picture based on the different observational constraints (e.g., reconciling the ionizing background and the galaxy UV luminosity density; Bouwens *et al.* 2015). A drop of LAEs fraction between $z \sim 6$ and $z \sim 7$ is considered as evidence for increase in the neutral hydrogen content (e.g., Hayes *et al.* 2011; Pentericci *et al.* 2014), while other physical processes can be involved (Dijkstra *et al.* 2014).

Large efforts have been performed to search for Lyman alpha emission from galaxies at $z \sim 6$ and $z \sim 7$ to better constrain the drop of LAE fraction between $z \sim 6$ and $z \sim 7$ at different luminosity regime, and also to derive the physical properties of galaxies at this epoch to highlight physical processes leading to cosmic reionization. We present the result of a large VLT/FORS2 program aiming to increase significantly the sample size at $z \sim 6$.

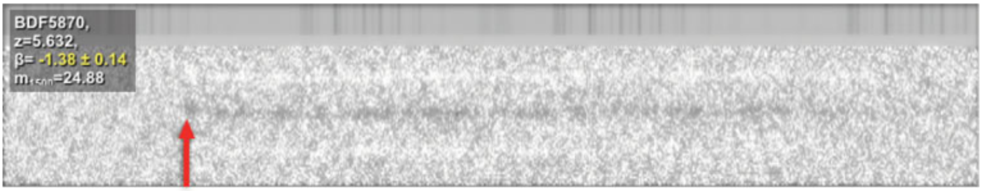

Figure 1. Two-dimensional VLT/FORS2 spectrum of a $z = 5.632$ non Lyman-α emitter. While there is no line detected, the observation is deep enough to detect the continuum. The red arrow shows the Lyman break.

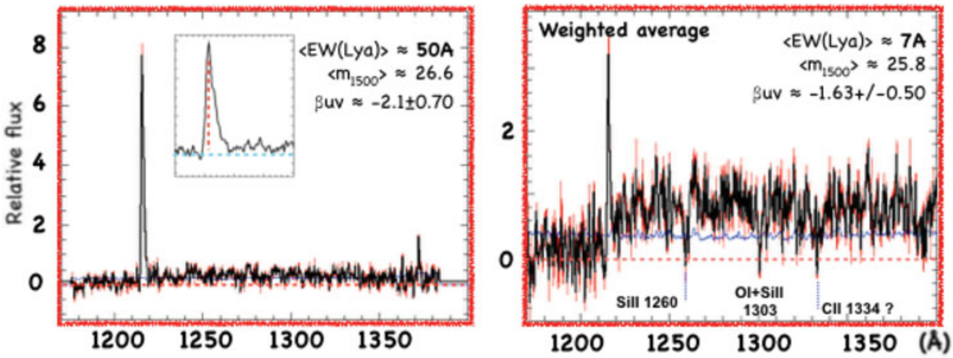

Figure 2. Stacking of VLT/FORS2 spectra for $z \sim 6$ LAEs (left) and non LAEs (right). Some interstellar medium lines are visible in the stacked spectrum of non LAEs.

2. Overview

To have a sample as large as possible, we use the result of a VLT/FORS2 Large Program (PI: Pentericci) with 45 hours observation of the UDS field, 50 hours observation of the GOODS field, and 45 hours observation of the COSMOS field (total: 140 hours). We combine these data with a VLT/FORS2 program (PI: Fontana) with observation of the NTT, GOODS, BDF, and UDS fields (total: 63 hours). We also use ESO archival data, with 27 hours observation of HUDF (PI: Bunker).

Adding data from Vanzella *et al.* (2009), we obtain a sample of > 200 $z \sim 6$ galaxies and ~ 110 $z \sim 7$ galaxies. We also use multi-wavelength photometric catalogs (CANDELS) to derive physical parameters such as for example stellar mass or age of the stellar population.

3. Physical properties

For the first time, we are able to stack UV spectra of LAEs *and* non LAEs, thanks to the depth of the data which allows to detect the continuum and observe the Lyman break, allowing to constrain the redshift (Fig. 1). We show the resulting stacks in Figure 2: low-ionization interstellar medium absorption lines are clearly visible in the non LAE stack allowing for the first time to better characterize this population. For example, we study the relation between the UV β slope ($F_\lambda \propto \lambda^\beta$) with the Ly$\alpha$ equivalent width: as reported previously (e.g., Schenker *et al.* 2014), we find that galaxies with large EW(Lyα) have bluer slopes than galaxies with weak Lyα emission (Fig. 3, Left). This is thought to be related to the correlation between UV β slope and the dust content of galaxies (e.g.,): galaxies exhibiting redder slopes have more dust and so, Lyα photons are more easily absorbed.

https://doi.org/10.1017/S1743921315010388 Published online by Cambridge University Press

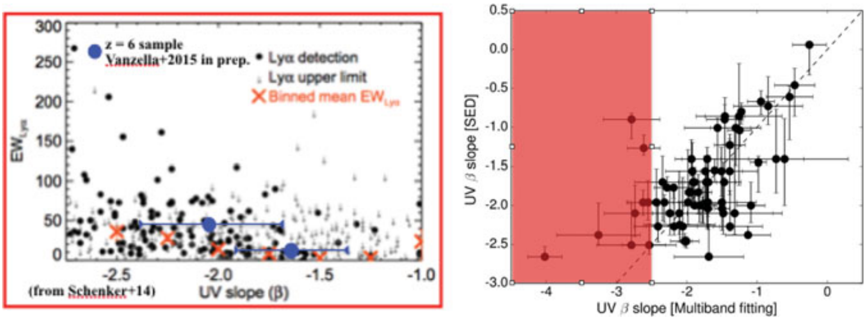

Figure 3. *Left:* Relation between UV β slope and the Lyα equivalent width from Schenker *et al.* (2014). We report the β slope and EW(Lyα) derived from the stacked spectra for LAEs and non LAEs (blue dots). *Right:* Comparison between UV β slopes derived from multiband fitting of the photometry (Castellano *et al.* 2012) and UV β slopes derived from SED fitting. The red region indicates observed UV slopes bluer than theoretically expected (see Text).

Regarding UV β slopes, we report a small galaxy fraction exhibiting extremely blue UV slopes with values below expected intrinsic β values (Meurer *et al.* 1999, Reddy *et al.* 2015), which can be due to unusual stellar population (Fig. 3, Right).

4. Future

We are preparing several publications with one presenting the data and another which will present a detailed analysis of the physical properties of these galaxies.

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https://doi.org/10.1017/S1743921315010388 Published online by Cambridge University Press