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DETAILED REST-FRAME UV SPECTROSCOPY OF LYMAN BREAK GALAXIES

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RESUMEN

Presentamos resultados de un estudio de las condiciones astrofísicas de galaxias Lyman Break (LBGs) a $z \sim 3$, haciendo énfasis en lo que pueden enseñarnos los espectros UV en el marco en reposo de las LBGs. Utilizando ~ 1000 espectros y construyendo espectros compuestos de alta S/R de galaxias agrupadas según propiedades tales como el perfil de Lyα, la cinemática, la luminosidad y la extinción, mostramos que las propiedades espectroscópicas UV en el marco en reposo dependen sistemáticamente de otras propiedades galácticas. Esta información es crucial para entender la naturaleza de las LBGs y su impacto sobre el medio intergaláctico circundante.

ABSTRACT

We present the results of detailed studies of the astrophysical conditions in $z \sim 3$ Lyman Break Galaxies (LBGs), with particular emphasis on what can be learned from LBG rest frame UV spectra. By drawing from our database of ~ 1000 spectra, and constructing high S/N composite spectra from galaxies grouped according to properties such as Lyα profile, kinematics, luminosity, and extinction, we show how the rest frame UV spectroscopic properties systematically depend on other galaxy properties. Such information is crucial to understanding the detailed nature of LBGs and their impact on the surrounding inter-galactic medium (IGM).

Key Words: **COSMOLOGY: OBSERVATIONS — GALAXIES: HIGH-REDSHIFT — GALAXIES: EVOLUTION — GALAXIES: FORMATION**

1. INTRODUCTION

Until now, the rest-frame UV spectra of Lyman Break Galaxies (LBGs) have been used primarily to measure redshifts (Steidel et al. 1996) Given the faint nature of LBGs (most have $\mathcal{R}_{AB} = 24 - 24.5$), the desire to observe a large sample results in individual spectra with low signal-to-noise ratios and spectral resolution. In most cases, the low signal-to-noise of LBG spectra precludes any analysis more detailed than the determination of redshifts.

Even from typical low signal-to-noise $z \sim 3$ spectra, we discern a large variation in the types of spectra associated with LBGs. Most obviously, there are a large range of Lyα profile shapes and UV continuum slopes. There are also variations among the equivalent widths of the few strong interstellar absorption lines which we detect most of the time in individual spectra, and the kinematic offsets measured between Lyα emission and interstellar absorption. The kinematic offsets are indicative of large-scale outflows of interstellar material which may have a profound impact on the inter-galactic medium (Adelberger et al. 2002).

Our group has assembled a sample of almost 1000 spectroscopically confirmed $z \geq 2$ galaxies over the past six years. By dividing our spectroscopic database into subsamples according to specific criteria, and creating high S/N composite spectra of each subsample, we will understand how the LBG spectroscopic properties depend in a systematic way on other galaxy properties. From this analysis, we hope to derive the physical conditions in LBG star-forming regions and large-scale outflows.

2. RESULTS

Rest-frame UV spectra of LBGs are dominated by the emission from O and B stars. The overall shape of the UV spectrum above the Lyman cutoff is modified by dust extinction internal to the galaxy, and, at rest wavelengths shorter than 1216 Å by inter-galactic HI absorption along the line of sight. In addition to photospheric and P-Cygni wind features from massive stars, the most prominent spectral features in composite LBG rest-frame UV spectra are those interstellar features associated with large-scale star-formation-induced outflows. These include Lyα, which is seen in emission, absorption, or a combination of both emission and absorption; and blueshifted low- and high-ionization metal absorption lines associated with outflowing neutral and ionized hydrogen gas, respectively, (Pettini et al. 2002). We also see weak collisionally and photo-excited emission lines which originate from the HII regions where stars are forming, the same regions where familiar rest-frame optical nebular emission lines are produced (Pettini et al. 2001).

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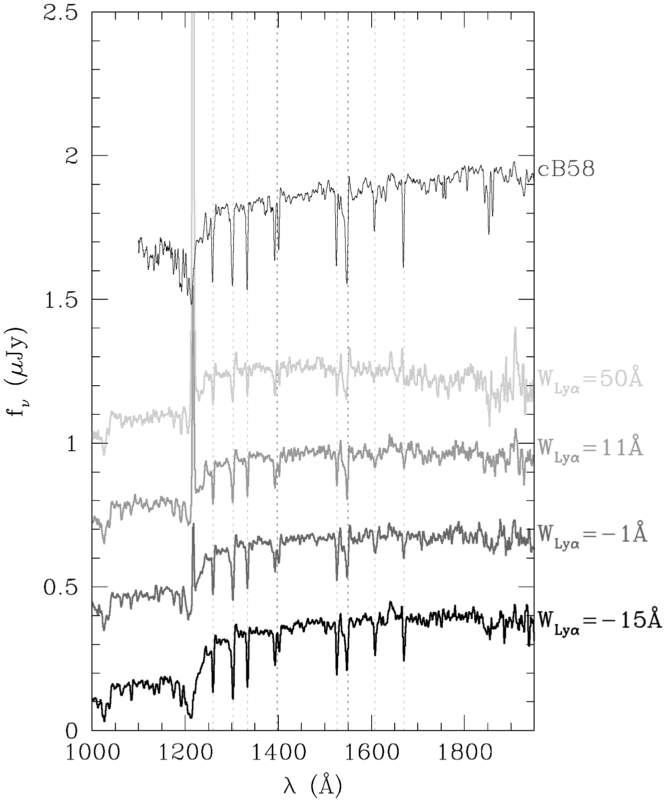

Fig. 1. Composite LBG spectra, each formed from bins of 200 galaxy spectra sorted by by rest-frame Lyα EW (1216 Å). The rest-frame Lyα EW of each of the four composite spectra is indicated on the right-hand side of the figure. From bottom to top, the composite spectra range in Lyα from the strong absorption to strong emission. Strong low- and high-ionization interstellar absorption features are marked with dotted lines. The spectrum of the lensed LBG MS1512-cB58 (plotted at the top of the figure) is most similar to the absorption-dominated spectrum, though cB58 has even stronger interstellar absorption features and redder UV continuum slope.

Figure 1 shows the results of binning the LBG spectroscopic sample according to Lyα equivalent width. Quite strikingly, LBGs with stronger Lyα emission have bluer UV continua, weaker low-ionization interstellar absorption lines, smaller kinematic offsets between Lyα emission and interstellar absorption lines, and smaller star-formation rates. The dependence of low- and high-ionization equivalent widths on other spectral properties is decoupled. Additionally, galaxies with rest-frame $W_{Ly\alpha} \geq 20$ Å in emission have nebular emission lines which are significantly stronger than in the rest of the sample. These trends provide insight into the covering fraction, velocity dispersion, and dust-content of the gas outflows detected in LBGs, as well as the temperature and metallicities in LBG star-forming regions. Understanding the properties of the outflowing gas will help to constrain the impact of LBGs on the distribution and ionization state of the IGM at $z \sim 3$.

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