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Active and dust obscured star-forming galaxies at $z \sim 4$ probed with UV spectral slope beta

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Abstract. We investigate the stellar population of star-forming galaxies at $z \sim 4$ by focusing on their slope of rest-frame ultraviolet continuum called UV spectral slope β. We analyze the sample of bright Lyman Break Galaxies (LBGs) with Subaru/$i' \leq 26.0$ in the Subaru/XMM-Newton Deep Survey field. Our detailed SED fitting analysis indicates that the LBGs with observed UV slope > -1.7, Av > 1.0, and intrinsic UV slope < -2.5 are the intrinsically active star-forming galaxies with star formation rates larger than a few $\times 10^2\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$. A significant fraction of the UV-selected LBGs at $z \sim 4$ is on-going active and dust obscured star-forming galaxies.

Keywords. galaxies: evolution, galaxies: formation, galaxies: high-redshift, galaxies: starburst

1. Introduction

The UV continuum spectrum of star-forming galaxies is characterized by the spectral index β in the form of $f_\lambda \propto \lambda^\beta$ (Calzetti *et al.* 1994). The UV spectral slope β is a useful probe for the physical quantities of star-forming galaxies such as the dust attenuation, the age of galaxy, the Star Formation History (SFH), and the metallicity. The UV spectral slope β is one of the most important information for star-forming galaxies.

Typical β values for given redshift and UV luminosity are individually studied in the previous literature, and it is considered that the star-forming galaxies, which are at higher redshift and/or have fainter UV Luminosity, tend to have bluer β values. In particular, because the β value varies mainly with the dust attenuation value, the "β–redshift trend" is interpreted as the dust attenuation history. Moreover recent Atacama Large Millimeter/submillimeter Array observations have revealed the dust properties of high redshift star-forming galaxies through the relation between the ratio of IR to UV (IRX) and the UV spectral slope β. In order to interpret these results, it is very important to investigate the detailed relation between the UV spectral slope β and the stellar population which is hidden by dust attenuation.

2. Data and Analysis

In this work, we select Lyman Break Galaxies (LBGs) at $z \sim 4$ in the Subaru/XMM-Newton Deep Survey (SXDS) field which is partially covered by other surveys. We make the multi-band photometry catalog which includes Subaru/*B, V, R, i', z', updated-z'*

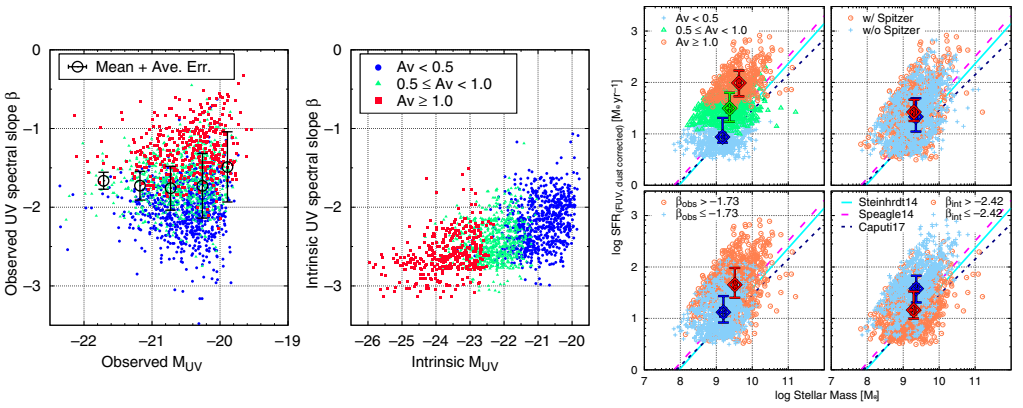

Figure 1. Left: Observed β vs. UV magnitude. Middle: Intrinsic (dust-corrected) β vs. UV magnitude. Right: Dust-corrected SFR vs. stellar mass for each sub-sample.

(Furusawa *et al.* 2008, 2016), UKIRT/*J, H, K* (Lawrence *et al.* 2007), HST/*F125W, F160W* (Grogin *et al.* 2011, Koekemoer *et al.* 2011), Spitzer/3.6μm, and 4.5μm (Ashby *et al.* 2013). By using our catalog, we calculate the observed β value, and conduct the SED fitting analysis for estimating the physical quantities. From the best-fit quantities, we estimate the *intrinsic* (dust-corrected) UV spectral slope β, the intrinsic UV magnitude, and the intrinsic Star Formation Rate (SFR).

3. Results and Discussion

The left panel of Fig. 1 shows the observed β–M_{UV} distribution, and the mean observed β value shows the weak correlation with the observed UV magnitude in the range of $-22.0 < M_{UV} < -20.0$. The middle panel of Fig. 1 shows the *intrinsic* (dust-corrected) β–M_{UV} distribution, and the intrinsic β value seems to slightly increase with the intrinsic UV magnitude. The right panel of Fig. 1 shows the distribution of the dust-corrected SFR and stellar mass for some sub-samples. The figure shows that the most intense star-forming galaxies in our sample have SFR $\gtrsim$ a few $\times 10^2$ $M_\odot$ yr^{-1}, and they are the objects with Av $\gtrsim 1.0$, $\beta_{obs} > -1.7$, and $\beta_{int} < -2.5$. Due to the dusty star-forming population, we see the flat β_{obs}–$M_{UV,obs}$ distribution. Our analysis indicates that a significant fraction of $z \sim 4$ LBGs are highly dust attenuated. This population has not been recognized very well in the previous analysis but is important in understanding the early phase of galaxy formation possibly linking the typical blue LBGs and the further very red sub-mm selected galaxies.

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