On the dependence between UV luminosity and Lyα equivalent width in high-redshift galaxies

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ABSTRACT

We show that with the simple assumption of no correlation between the Lyα equivalent width and the ultraviolet (UV) luminosity of a galaxy the observed distribution of high-redshift galaxies in an equivalent width–absolute UV magnitude plane can be reproduced. We further show that there is no dependence between Lyα equivalent width and Lyα luminosity in a sample of Lyα emitters. The test was expanded to Lyman-break galaxies and again no dependence was found. Simultaneously, we show that a recently proposed lack of large equivalent width, UV-bright galaxies can be explained by a simple observational effect, based on too small survey volumes.

Key words: galaxies: high-redshift – cosmology: observations.

1 INTRODUCTION

Two of the most common methods to find high-redshift galaxies are based on detecting the Lyman-break or the Lyman α emission line of the galaxy. The Lyman-break technique, finding so-called Lyman-break galaxies (LBGs), has been extremely successful in gathering samples of galaxies in the redshift range \( z \approx 3–6 \) (e.g. Steidel et al. 1996, 1999; Pettini et al. 2001; Shapley et al. 2003; Bunker et al. 2004; Ouchi et al. 2004). In parallel, the search for high-redshift galaxies by targeting the Lyα emission of star-forming galaxies with narrow-band imaging, finding so-called Lyman emitters (LAEs), has also been successful in the redshift range \( z \approx 2.5–7 \) (e.g. Møller & Warren 1993; Cowie & Hu 1998; Fynbo et al. 2002, 2003; Matsuda et al. 2005; Malhotra et al. 2005; Shimashuku et al. 2006; Tapken et al. 2006; Kashikawa et al. 2006; Venemans et al. 2007; Finkelstein et al. 2007; Nilsson et al. 2007, 2009; Ouchi et al. 2008). In both types of surveys, two of the most robustly measured properties are those of flux in the rest-frame ultraviolet (\( M_{UV} \)) and the equivalent width (EW) of the Lyα line. For LAEs, these numbers are a direct product of the selection method. For LBGs, the Lyα EW is only constrained in samples with spectroscopic follow-up.

Lately, it has been suggested that there is a lack of high-redshift galaxies with large Lyα EWs and large ultraviolet (UV) fluxes. In Ando et al. (2006), a sample of LBGs at \( z \approx 5 \) and 6 were studied for their Lyα EWs and rest-frame UV fluxes. Their results were also compared to LAEs at similar redshifts, and they reported a lack of UV-bright objects with high EWs. The proposed explanations by the authors were those of different dust extinctions, smaller/larger amount of neutral hydrogen gas, age differences or gas kinematic effects. However, Ando et al. (2006) also suggested that larger samples are necessary to confirm this apparent deficiency of UV-bright, high-Lyα-EW objects. Following this publication, several other authors have claimed to see the same effect. In the observational publications of Ando et al. (2007), Iwata et al. (2007), Ouchi et al. (2008), Vanzella et al. (2009) and Shioya et al. (2009), a lack of these objects is reported. Ando et al. (2007) and Vanzella et al. (2009) both suggest that this may be a result of larger amounts of dust and a higher metallicity in UV-bright galaxies. Ouchi et al. (2008) propose that it infers a young, low-mass population of galaxies at high redshift. The lack of high-EW, UV-bright galaxies has also been seen in theoretical work. Mao et al. (2007) present a simple physical model for high-redshift galaxies, including a dust screen model. In parallel, Kobayashi, Totani & Nagashima (2009) developed a semi-analytical model of high-redshift galaxy evolution, including gas not homogeneously distributed, but rather in clumps. They both find their models to predict the lack of high-EW, UV-bright galaxies. On the other hand, there are also publications claiming not to see this effect. Verma et al. (2007) and Stanway et al. (2007) both study samples of \( z \approx 5–6 \) LBGs and see no UV dependence on the EW. Neither did Deharveng et al. (2008), observing nearly 100 LAEs at \( z \sim 0.3 \). Deharveng et al. (2008) also argue that the claim to see such an effect may be due to small number statistics. This is the same argument as Dijkstra & Wyithe (2007)
propose. Their simple star formation rate (SFR) based galaxy evolution model does not reproduce any correlation between UV flux and Ly\(\alpha\) EW.

In two recent publications, Pflamm-Altenburg, Weidner & Kroupa (2009) and Meurer et al. (2009) discuss how a varying initial mass function (IMF) can cause a decline in H\(\alpha\) luminosity, and thus the EWs, at bright UV fluxes. Even though it is unclear what the relation between Ly\(\alpha\) and H\(\alpha\) is in the high-redshift Universe, there should exist a correlation between the two fluxes, and hence this effect could potentially also cause the Ly\(\alpha\) EW to decrease. Pflamm-Altenburg et al. (2009) predict that this effect will take place at SFRs below 0.01 M\(\odot\) yr\(^{-1}\). As surveys for high-redshift galaxies are unable to reach these low SFRs, this particular effect is not expected to be observable.

Given the large number of recent publications concerned with this issue, the number of proposed interpretations, and given that there still seems to be disagreement as to whether an effect is actually observed, we find it appropriate to subject the issue to a rigorous statistical test. In this paper, we address if there is a dependency between the Ly\(\alpha\) EW and UV luminosity (or Ly\(\alpha\) flux) in observed, high-redshift galaxy samples. We focus on results from \(z \sim 3\) LAE, and LBG, surveys as the amount of available, observational data is the largest at that redshift. Section 2 describes the method used. The results are given in Section 3 and a discussion of the results is found in Section 4.

Throughout this paper, we assume a cosmology with \(H_0 = 72\) km s\(^{-1}\) Mpc\(^{-1}\) (Freedman et al. 2001), \(\Omega_m = 0.3\) and \(\Omega_\Lambda = 0.7\).

2 METHOD

The two observed parameters used here are the Ly\(\alpha\) and UV fluxes of a galaxy. For simplicity, we choose to perform our tests on plots involving the EW of the galaxy (see also Fig. 1 or Fig. 3). This is a simple coordinate transformation, according to

\[
EW_{Ly\alpha} = \frac{F_{Ly\alpha}}{f_{UV}}
\]

(1)

where \(F_{Ly\alpha}\) is the Ly\(\alpha\) flux and \(f_{UV}\) is the flux density in the UV at the Ly\(\alpha\) wavelength. The one-dimensional EW distributions for high-redshift galaxies, averaged over large samples, have shown to closely resemble an exponentially declining function (Gronwall et al. 2007; Nilsson et al. 2009):

\[
P(\text{EW}) \, d\text{EW} = \text{constant} \times \exp(-\text{EW}/w_u) \, d\text{EW},
\]

(2)

where \(w_u\) is a scaling constant that can be fitted for each data set. The suggestion there may be a lack of high-luminosity objects with high EWs would then imply that \(w_u\), at any given redshift, must be a function of the luminosity in the sense that the EW distribution becomes narrower for high-luminosity objects as the high-EW tail of the distribution is truncated. In principle, this is easy to test simply by dividing a sample of galaxies into luminosity bins and then ask if there is any evidence for a significant change of \(w_u\) between the high- and low-luminosity subsamples. In practice, the expected number of objects in the high-luminosity, high-EW bin is too small to give a robust answer.

Instead, we introduce a potential dependence on the EW from the Ly\(\alpha\)/UV flux, allowing a Monte Carlo approach. To quantify the dependence, the parameter \(w_{EW}\) is introduced into the scaling constant according to:

\[
w_{u,\text{LAE}} = w_{0,\text{LAE}} - w_{EW,\text{LAE}} \times \frac{L_{Ly\alpha}}{10^{48.3}}
\]

(3)

for LAEs, where \(w_{0,\text{LAE}}\) is the best-fitting scaling constant if \(w_{EW,\text{LAE}} = 0\) and \(L_{Ly\alpha}\) is the Ly\(\alpha\) luminosity in erg s\(^{-1}\). For LBGs, instead, we have

\[
w_{u,\text{LBG}} = w_{0,\text{LBG}} - w_{EW,\text{LBG}} \times f_{UV} \times 10^{-18.5},
\]

(4)

where

\[
f_{UV} = 10^{-0.4(M_{UV}+48.6)}.
\]

(5)

The constants in equations (3) and (4) are carefully chosen to allow a change in \(w_u\) at the brightest end of the order of \(\pm 1\) when \(-30 < \text{EW} < 30\) and a change in the faintest end of the order of a few \(\text{Å}\). These equations resolve into no dependence between Ly\(\alpha\)/UV flux and EW if \(w_{EW} = 0\) and a large dependence when \(w_{EW} \sim \pm w_{0}\). A large positive \(w_{EW}\) will result in fewer objects with large EWs at bright fluxes, and a large negative \(w_{EW}\) in an excess of large-EW objects at bright fluxes. Fig. 1 illustrates the effect of \(w_{EW}\) on the EW–flux distribution. It is important to note that it is necessary to fit the two types of galaxies with different equations, because they are flux limited in different parameters: LAEs in Ly\(\alpha\) flux and LBGs in the UV flux. Ideally, both galaxy samples would be fit with the same equation, with, for example, a dependency on only \(f_{UV}\). This would, however, infer a flux-dependent lower limit to the EW of the LAEs, an effect which is clearly illustrated in the left-hand panel of Fig. 3. Because of this, we choose to fit LAEs and LBGs with separate equations and dependencies.

To test the value of \(w_{EW}\), we make a simulated distribution of galaxies by drawing from one-dimensional distributions for the flux and the EW, with different values on \(w_{EW}\), and test if the simulated galaxy distribution resembles the observed distribution. We do this in three steps. First, we model the observed EW distribution, to find \(w_{0}\). The procedure to find the best-fitting \(w_{EW}\) then includes creating simulated EW–flux distributions of galaxies by drawing randomly from the Ly\(\alpha\)/UV luminosity functions and the exponentially declining EW distribution function according to equations (2) and (3) or (4) for different values of \(w_{EW}\). The one-dimensional flux distributions we draw from are the observed respective Ly\(\alpha\) and UV luminosity functions, summarized in Table 1. As this paper is focused on results at redshift 3, the luminosity function is drawn from Gronwall et al. (2007) in the case of LAEs. Several other luminosity functions have been published but they all agree very well (see also Van Breukelen, Jarvis & Venemans 2005; Ouchi et al. 2008; Grove et al. 2009). In the case of LBGs, we use the luminosity function of Reddy et al. (2008).

Finally, we compare the simulated galaxies with the observed sample of 232 LAEs and 128 LBGs (see Section 3 for a definition on the samples). For each simulated distribution, two statistical tests are performed to find the simulated distribution that best fits the observed data. Both methods are based on dividing the plane of data into four quadrants, with the intersection placed in an arbitrary point on the plane (see also Peacock 1983). In each quadrant, the ratio between the number of galaxies in that quadrant to that of the number of galaxies in the total sample is computed. This is done for both the data subset sample and the simulated galaxy sample. This process is reiterated for every point in the plane until the largest difference between the observed and test sample ratios is found in one quadrant. In our case, the sampling of the plane has effectively one million resolution elements \((1000 \times 1000)\), ensuring that the maximum difference varies by less than 0.1 per cent in the points nearest to the maximum. Based on the largest difference found, the following two tests are performed:

(i) Monte Carlo test;
Figure 1. Plot of EW versus Ly\textalpha luminosity for LAEs. Red stars mark the observed sample (see the text for details). Each panel includes black contours with 68, 95 and 99.7 per cent significance of the simulated sample for different values of $u_{\text{EW,LAE}}$ for LAEs. It is clearly seen that very large or very small $u_{\text{EW,LAE}}$ are ruled out by the observations.

Table 1. Luminosity functions and EW distributions used in the creation of a random simulated sample.

| Type   | $L^\ast/M^\ast$ (erg s$^{-1}$)(—) | $\phi^\ast$ (Mpc$^{-3}$) | $\alpha$ | Type of EW dist. | $w_0$ ($\AA$) | $u_{\text{EW,LAE}}$ |
|--------|----------------------------------|---------------------------|----------|------------------|--------------|-------------------|
| LAEs   | 42.66                            | $1.28 \times 10^{-3}$     | $-1.36$  | Exp              | 69           | -30               |
| LBGs   | $-21.12$                         | $1.12 \times 10^{-3}$     | $-1.85$  | Exp              | 29           | -15               |

Note. Luminosity function parameters are from Gronwall et al. (2007) for LAEs and from Reddy et al. (2008) for LBGs. Widths of EW distributions ($w_0$) are the one parameter fits to the total samples of LAEs and LBGs as described in the text.

(ii) two-dimensional Kolmogorov–Smirnov test.

In test (i), we merely find the largest difference between the simulated sample and the data. We calculate the errors on the ratios of test and observed samples and can thus determine how dissimilar the two distributions are by calculating the difference in the ratios and the significance in the same. In test (ii), we perform the two-dimensional Kolmogorov–Smirnov test as described in Peacock (1983). The significance of the two distributions being similar is determined by

$$P(> Z_\infty) = 2 \exp \{-2(Z_\infty - 0.5)^2\},$$

where $n_1$ and $n_2$ are the numbers of objects in the two respective samples and $D_n$ is the largest difference found in one quadrant. We end up with a set of simulated samples, one for each $u_{\text{EW}}$, each with a measure of how likely this sample resembles the real data. With these, we can find the distribution that best fits the data, and thus the best-fitting value of $u_{\text{EW}}$.

Doing this once on the total sample of data will only reveal the best-fitting $u_{\text{EW}}$, without any understanding of the biases in the observed sample or on the error bars. To understand the full probability function of the $u_{\text{EW}}$ parameter from the data, we employ a jackknife technique to the observed data. For each data set (LAEs and LBGs), 3000 random subsets of data are created with the total number of galaxies in the total data set minus 10. For each of these data subsets, a new $w_0$ has to first be fitted for, after which the previously explained analysis can be repeated. Thus, a best-fitting $u_{\text{EW}}$ is determined for each of these 3000 data subsets, allowing an analysis of the distribution of $u_{\text{EW}}$. 

$$Z_\infty = \frac{\sqrt{n}D_n}{1 - 0.53n^{-0.5}}$$

$$n = \frac{n_1n_2}{n_1 + n_2}$$
3 RESULTS

3.1 Lyα emitters

To test the dependence of EW and Lyα luminosity in LAEs, the observed samples of $z \sim 3$ LAEs of Gronwall et al. (2007), Nilsson et al. (2007), Venemans et al. (2007) and Grove et al. (2009) are used. A lower limit of rest-frame 20 Å EW is set as this is typically the limiting EW for selection in narrow-band surveys. A lower limit to the Lyα luminosity is also set to be equal to that of Gronwall et al. (2007); log $L_{Ly\alpha} = 42.07$ erg s$^{-1}$. After rejecting objects in these catalogues with EW $\lesssim 20$ Å and log $L_{Ly\alpha} < 42.07$ erg s$^{-1}$, and known active galactic nuclei, we are left with a total sample of 232 LAEs with recorded Lyα EW and luminosity. The $u_{EW,LAE}$ parameter is fit with values between $-30$ and 30 in steps of one. In Fig. 2, the histogram of best-fitting $u_{EW,LAE}$ to each of the 3000 random data subsets is shown.

The median of the distribution is $u_{EW,LAE} = -4$ and the mean is $u_{EW,LAE} = -3.66$. Based on the skewed appearance of the histogram, the error bars are calculated by separately integrating the histogram to 68.3 per cent of each wing, split in the position of the median. The best-fitting $u_{EW,LAE}$ is then $u_{EW,LAE} = -4 \pm 7$.

3.2 Lyman-break galaxies

The largest sample of emission-line properties of LBGs has been published in Shapley et al. (2003). This is the sample that will be used here. An upper absolute UV magnitude is set to $-20.0$. EWs are constrained to be larger than 20 Å in order to ensure spectroscopic completeness. A total of 128 LBGs have been observed at redshifts $2.7 < z < 3.3$ with EW $\gtrsim 20$ and $M_{UV} < -20.0$. This population of galaxies is fit by selecting an absolute UV magnitude from the luminosity function of Reddy et al. (2008; see also Table 1), and then an EW from an exponential function (see equations 2 and 4). The $u_{EW,LBG}$ parameter is fit with values between $-30$ and 30 in steps of 1. In Fig. 2, the histogram of best-fitting $u_{EW,LBG}$ to each of the 3000 random data subsets is shown. The median of the distribution is $u_{EW,LBG} = 10$ and the mean is $u_{EW,LBG} = 10.23$. The error bars are calculated in the same way as for LAEs, resulting in $u_{EW,LBG} = 10 \pm 10$.

3.3 On the proposed lack of high-EW, UV-bright high-redshift galaxies

The random Lyα luminosities and EWs drawn for the sample of test galaxies can also be converted to the rest-frame UV absolute magnitude, $M_{UV}$, or vice versa. Thus, it is possible to reproduce the EW versus $M_{UV}$ plot (Ando et al. 2006) also for LAEs. In Fig. 3, we show this plot for the LAE and LBG samples and for $u_{EW} = 0$. The region of high-EW, UV-bright objects proposed by Ando et al. (2006) to lack objects was $M_{UV} < -21.5$ and $EW > 20$ Å. Second column gives the percentages in the simulated samples with $u_{EW} = 0$, third column in the observed samples used in this paper and fourth column those of Ando et al. (2006).

Based on the results for the sample from Shapley et al. (2003), there is a weak dependence between the EW and the UV flux, in the sense that there is a smaller fraction of high-EW objects at brighter $M_{UV}$, but $u_{EW,LBG} = 0$ is only ruled out to 1.1r or 73 per cent. To confirm a real deficiency in objects in a quadrant would ideally require of the order of 100 objects in that quadrant, in this case requiring a total sample of $> 500$ LAs or $> 1000$ LBGs with confirmed fluxes and EWs. It is important to note that the analysis performed here was made at redshift $z = 3$ as most of the data exist at this redshift. Samples at redshifts $z \sim 5–6$ are much smaller, and would produce a much weaker result. Several other factors make the higher redshift range more unsuitable for this test. First, the measurement of the EW in very high redshift galaxies becomes very uncertain due to the increasingly faint UV continuum, in some cases resulting in lower limits on the measured EW. Secondly, all line emission surveys, that are not spectroscopically confirmed, contain some fraction of low-redshift interlopers. This fraction is expected to increase with increasing redshift (cf. Kakazu, Cowie & Hu 2007).

Table 2. Percentages in high-EW, UV-bright corner in different samples.

| Type       | Simulations ($u_{EW} = 0$) | Samples       | Ando        |
|------------|---------------------------|---------------|-------------|
| LAE        | 24 per cent               | 31 ± 4 per cent | 25 ± 18 per cent |
| LBG        | 11 per cent               | 9 ± 3 per cent  | 18 ± 10 per cent |

Note: Percentages of objects in the quadrant with $M_{UV} < -21.5$ and $EW > 20$ Å. The probability to find such an object is thus very small. In the example of $u_{EW} = 0$, and for galaxies with fluxes brighter than our simulation limits, the fraction of the total sample of galaxies in the quadrant with $M_{UV} < -21.5$ and $EW > 20$ Å is 24 per cent for LAs and 11 per cent for LBGs (with $M_{UV} < -20.0$ and $EW > 20$ Å). The results of Ando et al. (2006) show two LAEs in this quadrant from a total of eight and three LBGs out of 17 in the total sample. This corresponds to percentages 25 ± 18 for LAs and 18 ± 10 for LBGs, including very large error bars based on small number statistics, i.e. consistent with the simulated results (see also Table 2 for a summary on these results). Based on the results for the sample from Shapley et al. (2003), there is a weak dependence between the EW and the UV flux, in the sense that there is a smaller fraction of high-EW objects at brighter $M_{UV}$, but $u_{EW,LBG} = 0$ is only ruled out to 1.1r or 73 per cent. To confirm a real deficiency in objects in a quadrant would ideally require of the order of 100 objects in that quadrant, in this case requiring a total sample of $> 500$ LAs or $> 1000$ LBGs with confirmed fluxes and EWs. It is important to note that the analysis performed here was made at redshift $z = 3$ as most of the data exist at this redshift. Samples at redshifts $z \sim 5–6$ are much smaller, and would produce a much weaker result. Several other factors make the higher redshift range more unsuitable for this test. First, the measurement of the EW in very high redshift galaxies becomes very uncertain due to the increasingly faint UV continuum, in some cases resulting in lower limits on the measured EW. Secondly, all line emission surveys, that are not spectroscopically confirmed, contain some fraction of low-redshift interlopers. This fraction is expected to increase with increasing redshift (cf. Kakazu, Cowie & Hu 2007).
It is also uncertain if some neutral gas still remains at $z \sim 6$, which could affect the measurements of Ly$\alpha$ EW/flux in unpredictable ways. For the sample studied here, at $z \sim 3$, these effects are not serious. Until larger samples have been collected at either redshift ranges, no conclusion can be drawn on whether there is a lack of high-EW, UV-bright galaxies in the Universe.

4 DISCUSSION

How can the $u_{\text{EW}}$ parameter be interpreted? A large positive $u_{\text{EW}}$ would indicate that there are fewer galaxies with large Ly$\alpha$ EWs at brighter UV fluxes. A large negative $u_{\text{EW}}$ indicates that it is more likely to find large-EW UV-bright galaxies. The next question is then what could cause this inflation or deflation of the EW distribution in the brighter UV flux slices? As Ando et al. (2006) argue, there could be several reasons for why there should be a dependence between these two measurable quantities. What is clear is that the time-scale on which the two quantities are sensitive to are different. The Ly$\alpha$ flux, and thus EW, is only large in the first $\sim 50$ Myr, assuming a single stellar population. The UV flux on the other hand can stay large for several hundred Myr. In each galaxy, the UV and Ly$\alpha$ flux are integrated over several star-forming regions with different time-scales, with more massive galaxies having more star-forming regions. If a larger fraction of these regions are in or out of their Ly$\alpha$ emitting phase, this could cause the EW distribution to inflate or deflate for UV-bright galaxies. Dust, metallicity, halo mass, infall rate, SFR, gas dynamics, and detailed gas morphology are also ingredients which could easily work to modify $u_{\text{EW}}$.

In this paper, we have searched for evidence of such an effect. We have done this in two ways. First, we used a simple null-hypothesis of a single luminosity function and a constant $u_{\text{EW}}$ for all luminosities. For a well-defined sample of 232 LAEs, the null-hypothesis predicts that 56 of those should be in the (EW > 20 Å, $M_{\text{UV}} < -21.5$) section of parameter space. We find 72, which is 2σ more than predicted by the simple model. This result is at variance with earlier suggestions that this section of the EW–$M_{\text{UV}}$ plane is underpopulated, if anything there might be marginal evidence that it is overpopulated. Secondly, in order to parametrize this analysis in a more global way, we defined a description of the EW distribution which allows it to change as a function of Ly$\alpha$ luminosity via a parameter $u_{\text{EW,LAЕ}}$. Following a Monte Carlo procedure, we determined the best fit of a large number of random realizations to our sample and found $u_{\text{EW,LAЕ}} = 4^{+9}_{-9}$. This means that in a global sense the $u_{\text{EW,LAЕ}}$ parameter is consistent with zero for the entire sample, i.e. consistent with a constant $u_{\text{EW}}$. For the LAEs, the results are similar, with $u_{\text{EW,LBG}}$ consistent with zero within 1σ.

It is of interest to ask how strong the limits set by this result are. We will use a simple comparison to set those limits into context. In a recent paper (Nilsson et al. 2009) it was shown that $u_{\text{EW}}$ is a function of redshift and that it has been found to drop from 69 Å at $z = 3$ to 48.5 Å at $z = 2.25$, i.e. a change of 20.5 Å. From equation (3), we see that the most extreme effect, reducing the $u_{\text{EW}}$, occurs when $u_{\text{EW,LAЕ}}$ is as largely positive as possible. If we then include $u_{\text{EW,LAЕ}} = 5$, the upper envelope of the 1σ probability for the LAEs, and compute what L$_{\text{Ly\alpha}}$ corresponds to a shift in $u_{\text{EW}}$ = 20.5 Å, we find that this happens at a minimum Ly$\alpha$ luminosity of $10^{43.11}$ erg s$^{-1}$, while 98.7 per cent of the sample have smaller luminosities than this. In conclusion, our analysis has constrained the dependence of $u_{\text{EW}}$ on the Ly$\alpha$ luminosity to be smaller than, or of the order of, the change observed as a function of redshift.

The dependence-free case of $u_{\text{EW}} = 0$ found here is intriguing, as it means that the Ly$\alpha$ EW distribution is independent on the Ly$\alpha$ flux of LAEs and the UV flux of LBGs, and is then independent to all parameters governing these fluxes (e.g. mass, age, metallicity, SFRs, etc.). In principle, the EW could still be correlated with the other respective parameter, i.e. the EW in LAEs could be dependent on $M_{\text{UV}}$ and vice versa, although the dependence between Ly$\alpha$ flux and $M_{\text{UV}}$ in the galaxies would then have to be contrived. We consider such a scenario to be unlikely. The fact that our results are consistent with no dependence between Ly$\alpha$ EW and the UV flux means that effects of varying the IMF, dust and age are not very important over the flux range that we probe in present-day surveys of high-redshift galaxies. There is no age dependence indicates that the light observed from these galaxies is integrated over many star-forming regions with varying ages. The analysis presented here would greatly improve by adding more samples of both types of high-redshift galaxies, but especially a larger sample of spectroscopically observed LBGs is necessary to finally draw any conclusions regarding the dependence between Ly$\alpha$ EW and UV flux in high-redshift galaxies.

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