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Unraveling the Properties of Intermediate Redshift Proxies for Proto-Galaxies with the LBT

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1. Context

The building blocks of the universe, i.e. high redshift dwarf galaxies, are nearly impossible to observe with today's instruments. Thus, a detailed analysis of the beginnings of galaxy evolution is very limited [1]. We search for proxies for these galaxies at intermediate redshifts to study their metallicities (via strong-line methods, e.g. [2]), star-formation rates and the nature of their highly ionized lines.

We use the LBT LBC and MODS to shed light onto the questions on early galaxy evolution and the origin of the hard continuum in these low-mass, low-metallicity systems.

2. Intermediate z Dwarf Galaxies

Galaxies just as SBS0335-052 (Fig. 1), the metal-poorest galaxy known, should be quite abundant in the intermediate redshift universe. Those galaxies should have low-metallicities, a strong radiation field, low-masses and extremely blue colours. In the local universe, they are extremely rare, but at higher redshift, heating by UV background radiation might have suppressed star-formation for some time so that these galaxies undergo their major star-forming period at intermediate redshifts [e.g. 3]. Thus they are the ideal proxies to study unevolved galaxies.

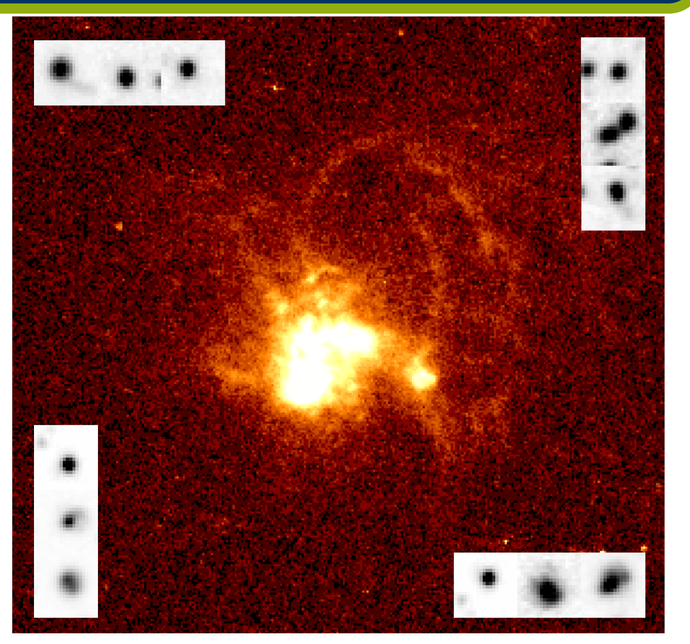

Figure 1: Background: Hubble Hα image of SBS 0335-052, one of the metal-poorest galaxies known. Overlayed are the optical images of galaxies from our sample with a variety of morphologies.

3. LBC Observations & Photometric Redshifts

With deep (9000 s) LBT LBC imaging of the SXDF in the narrowband F972N20 and U filter, we detect galaxies by their emission lines and extremely blue colour. Combining our data with deep multi-wavelength archival data we perform SED-fitting to derive the galaxies' redshifts with EAZY [4] and their masses and specific star-formation rates with FAST [5].

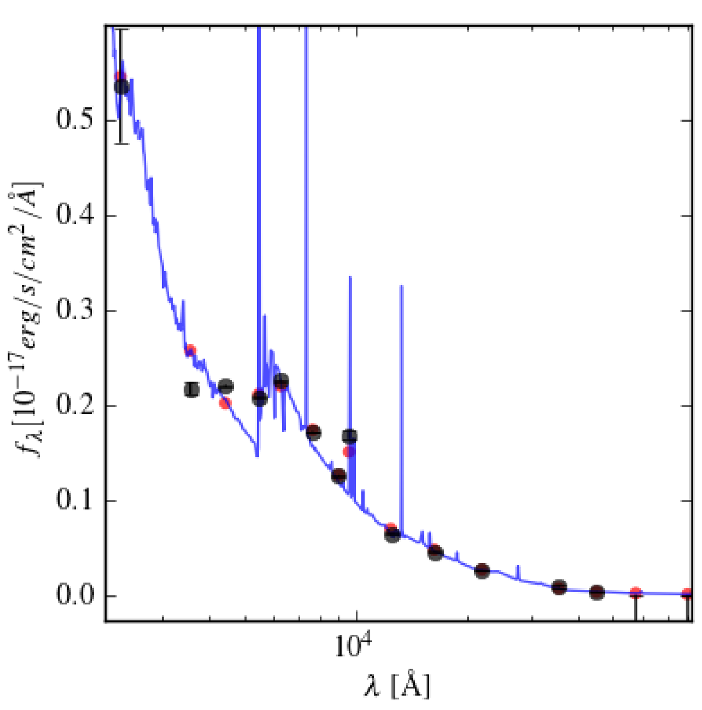

Figure 2: Fit of an Hα emitter. Model spectrum in blue, the corresponding fluxes at the measured wavelenghts in red, and the measured fluxes in black.

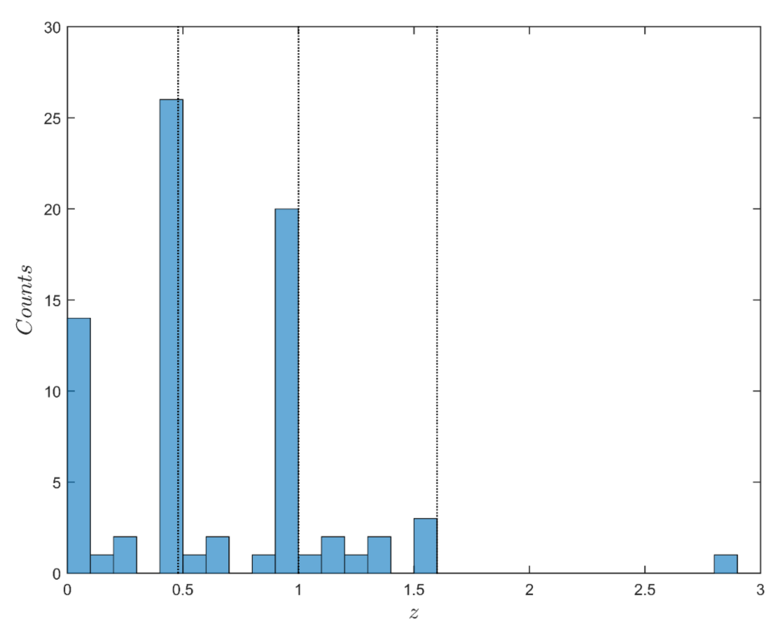

Figure 3: Histogram of the derived redshifts. The redshifts clearly peak around emission lines (marked as lines, from left to right: Hα, Hβ + [O III] and [O II].

We use PÉGASE templates because they take emission lines into account and obtain redshift fits as in Fig. 2. Our redshift distribution (Fig. 3) clearly peaks at redshifts where the strong lines ([OII], Hβ + [OIII] and Hα) fall into the narrow-band filter.

We identify 27 Hα, 22 Hβ +[OIII] and 3 [OII] emitters. 24 galaxies in the sample have exceptionally blue colours (U-V<0.8, V-J<0.3).

By selecting the low-mass systems in this extremely blue sample, we also select galaxies with low metallicities.

4. SED-Fitting with FAST & MODS Follow-up

Masses and Star Formation Rates

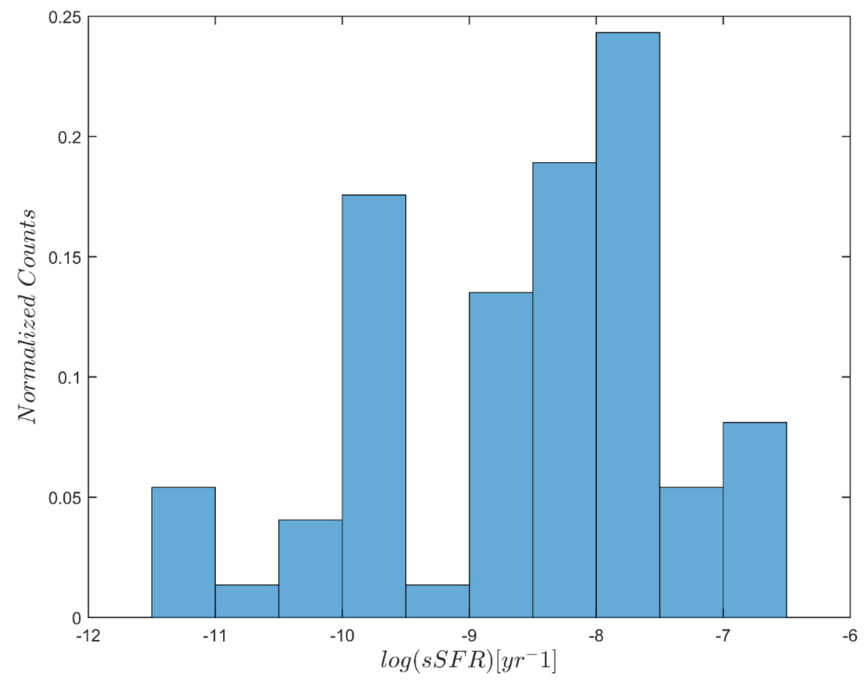

Figure 4: Histogram of the specific star formation rates of the selected galaxies.

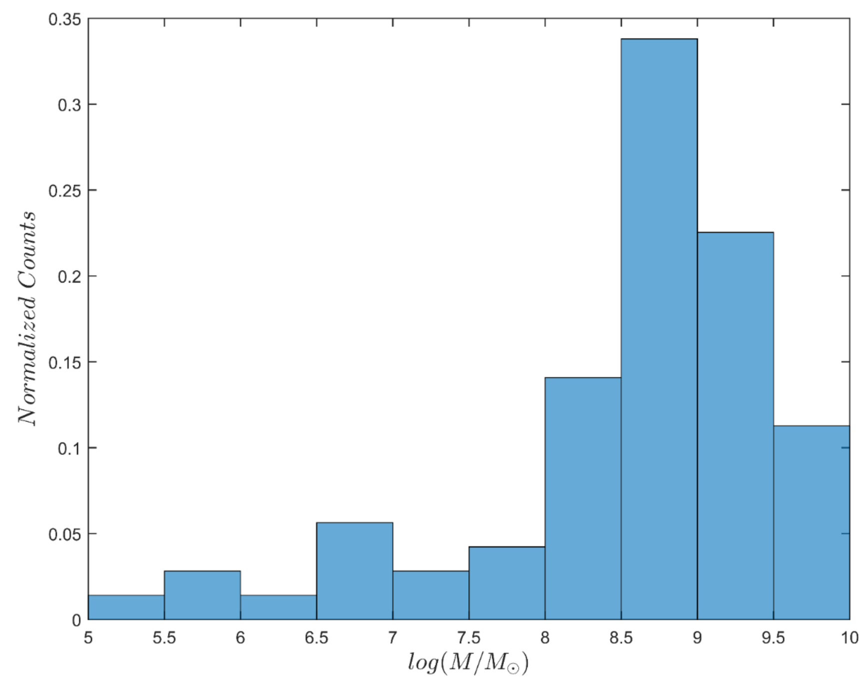

Figure 5: Histogram of the masses of the selected galaxies.

We find that most of our galaxies are of low masses and strongly star-forming. Figures 4 & 5 show the mass and specific star formation rate (sSFR) distributions of our galaxies. About 75% of the galaxies have strong sSFRs with

$\log(sSFR/yr) > -9$

and more than 50% of the selected galaxies have masses below

$\log(M/M_{sun}) < 9.5$.

Please note that nearly all galaxies with extremely blue colours are low mass galaxies.

Metallicities

From SED-fitting, we indirectly get hints at the metallicity regime of our galaxies as well. Fig. 6 shows the distribution of the metallicities of the best fitted SED. Clearly, more than half of the galaxies are fitted with lower metallicity SED models.

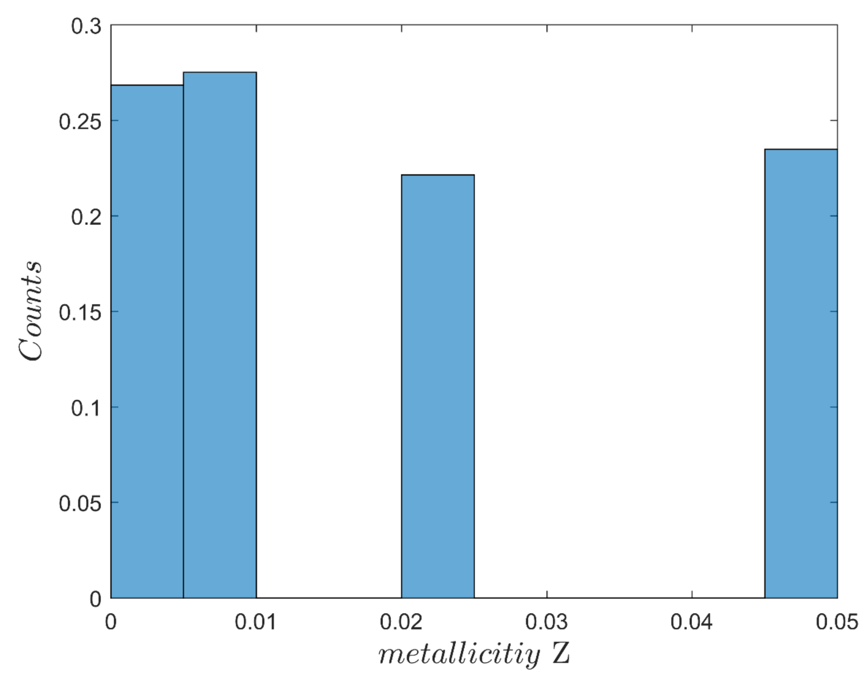

Figure 6: Distribution of the metallicities of the best-fit SED model

MODS Spectra

We selected the bluest dwarf galaxies with high sSFRs for MODS follow-up spectroscopy. A first look at our MODS data from 2015B (which still is not sufficiently deep for detailed analysis) in Fig. 7 shows that we detect the strongest lines clearly with one 1800 s exposure.

The excerpts of two red channel MODS MOS spectra clearly show emission lines without or with just weak underlying continuum (as we had expected).

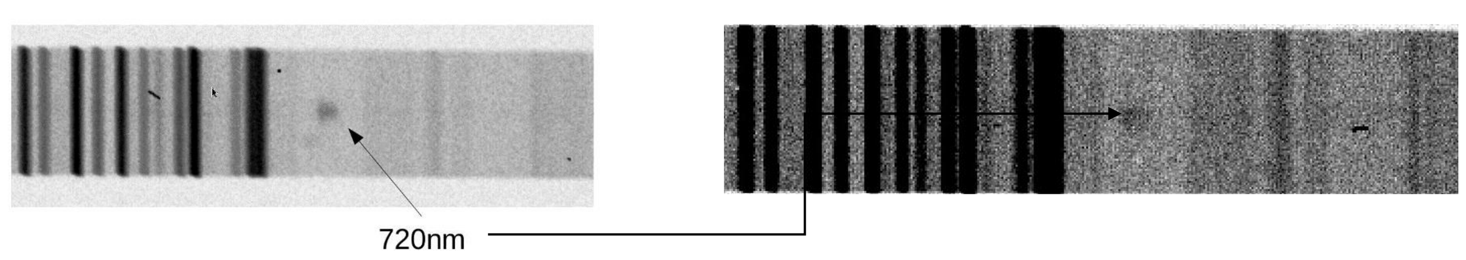

Figure 7: Excerpts from two red 1800 s raw MODS spectra observed in 2015B. Clear detection of emission lines at approximately 720 nm (corresponds to z=0.44 for [OIII] and z=0.93 for [OII]). Wavelength estimated from sky spectrum.

References

[1] Stark et al., 2017, MNRAS, 464,469
[2] Kewley and Dopita, 2002, ApJS,142,35
[3] Babul & Ferguson, 1996, ApJ, 458,100
[4] Brammer, van Dokkum & Coppi, 2008, ApJ, 686,1503
[5] Kriek et al., 2009, ApJ, 700,221