Star-forming galaxies in VIMOS UltraDeep Survey at z>5

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VUDS | VIMOS Ultra Deep Survey

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Motivation

A census of galaxies at high redshift is essential to contrain the number of photons driving the reionization of the Universe and to understand the evolution of galaxies in that time. However, most samples of high redshift galaxies rely on photometric redshifts. VIMOS UltraDeep Survey (VUDS, Le Fèvre et al. 2015) is one of the first surveys, which pushed the redshift limits of spectroscopic surveys into the epoch of reionization, right where it ended (at 5<z<6). Here, we present the properties of highest redshift galaxies in VUDS at 5.0<z<6.5. More details can be found in Khusanova et al. (2020).

Data

The wavelength coverage of the VUDS is from 3650 to 9350 Å. This enables robust redshift measurements up to redshift ~6.6. The total number of galaxies in VUDS with secure spectroscopic redshifts in the range 5.0<z<6.5 is 49. The median redshift is z=5.59. Thanks to ancillary photometric data, we were able to clean the sample from low redshift interlopers as well as robustly derive physical properties such as star formation rate (SFR), stellar masses and ages by SED fitting with a fixed redshift.

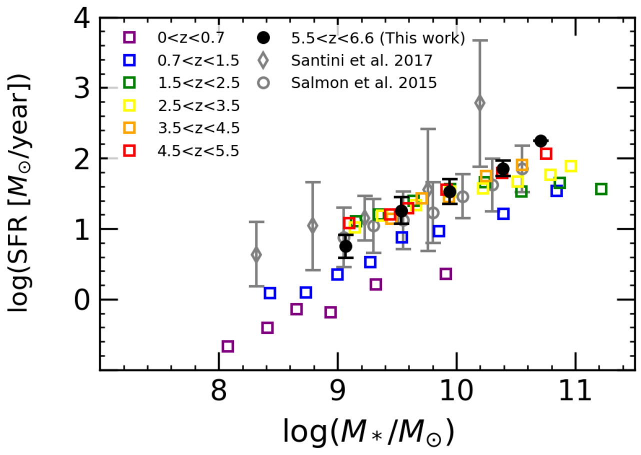

Fig. 1: Main sequence of VUDS galaxies at 0<z<6.5. The colored squares show the median SFR from Tasca et al. (2015). The black circles are median SFRs from this work at 5.5<z<6.6.

Main sequence

The SFRs are tightly correlated with stellar masses showing the existence of the main sequence. Fig. 1 shows the median SFRs in bins of stellar masses for galaxies in VUDS and other surveys in the literature (Santini et al. 2017, Salmon et al. 2015). Our measurements are complementary to the VUDS measurements at lower redshifts from Tasca et al. (2015) and show that the main sequence has little to no evolution at z>3.5. Moreover, the turnover at high masses observed at lower redshifts disappears at high redshifts.

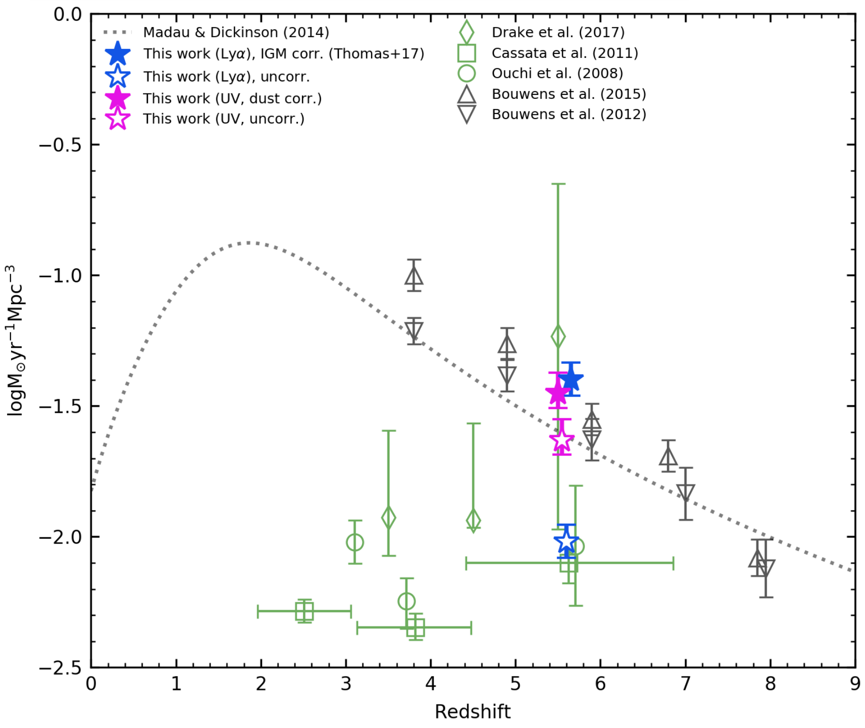

Fig. 4: SFRD vs. redshift. The stars are results from this work (unfilled before dust and IGM correction, filled – after). The light green points are Lyα luminosity function based measurements, the gray points are UV-based. The SFRDs from the literature are calculated from the luminosity functions using the same integration limits and conversion factors as in this work.

Luminosity functions

We used 1/Vmax method (Schmidt 1968) to determine the luminosity function. We assigned weights 1/(TSR•SSR) to each galaxy according to the target sampling rate (TSR) and the spectroscopic success rate (SSR). We fit the luminosity functions with Schechter or Double power law (DPL) function using MCMC.

UV luminosity function

Since VUDS sample is most reliable on the bright end, we fixed the slope of the faint end to values from the literature (Bouwens et al. 2015, Bowler 2015). We find a good agreement of our results with luminosity functions at z=5 and z=6 reported in the literature (McLure et al. 2009; Bouwens et al. 2015; Bowler et al. 2015). Bowler et al. (2015) reported that the UV luminosity functions at high redshift might be better represented by a DPL. Our results show an excess of number density consistent with DPL form.

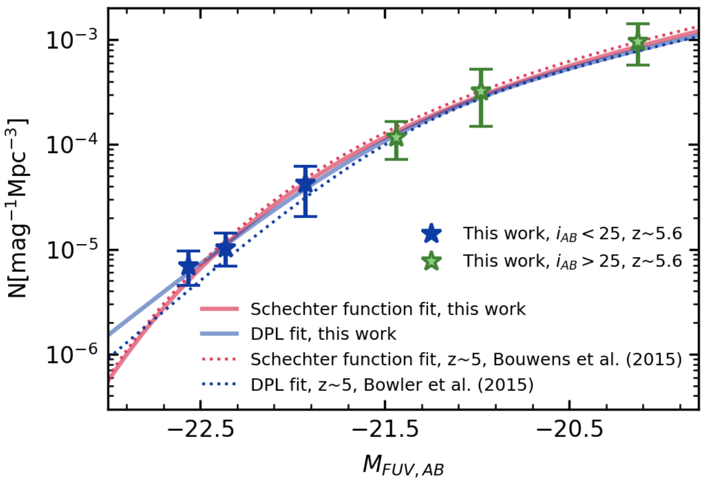

Fig. 2: UV luminosity function at z = 5.6 (filled stars) and the fit with a DPL (blue solid line) compared to a Schechter function (red solid line). The dotted lines of respective colors are fits from the literature.

Lyα luminosity function

We find a rapid decrease of number density on the bright end of the Lyα luminosity function at 5<z<6.5. We tested a wide range of faint end slope values from -1.5 to -2.3 (Cassata et al. 2011, Santos et al. 2016, Drake et al. 2017). We find that the Lyα luminosity function is best represented with slopes >-2.0 and Schechter function.

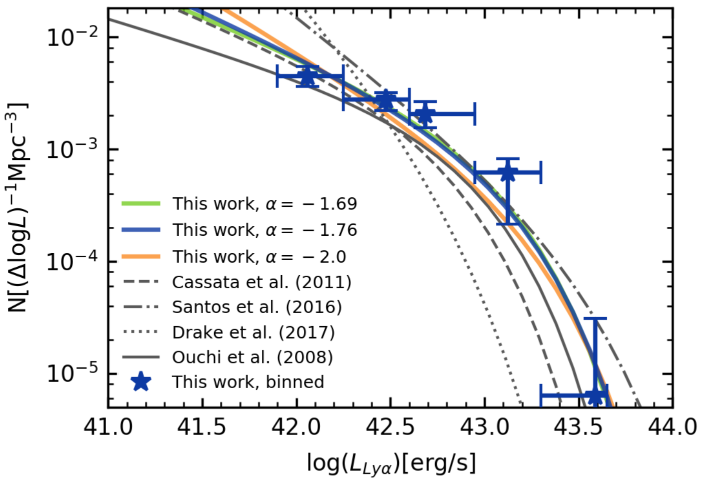

Fig. 3: Lyα luminosity function at $z = 5.6$ (blue stars) and the fit with a Schechter function. The colored solid lines are fits to our data with different faint end slopes, the gray lines are results from the literature.

Star formation rate density

We used both Lyα and UV luminosity functions to obtain constraints of star formation rate density (SFRD). We used conversion factors based on the Kennicutt (1998) relation and integration limits corresponding to the same values of SFR. The SFRD derived based on UV luminosity function was corrected for dust extinction based on the IRX-beta relation from Meurer et al. (1999). Since both luminosity functions are derived from the same sample, we can obtain robust constraints on $SFRD_{Ly\alpha}/SFRD_{UV}$ ratio. This ratio can be used as an estimate for volumetric Lyα escape fraction (Hayes et al. 2011). We find $f_{esc}(Ly\alpha) = 21 \pm 4$ %. In order to obtain the total SFRD estimates based on Lyα, we corrected our results to account for the intergalactic medium (IGM) transmission. The IGM transmission was estimated based on Madau (1995) models and VUDS spectra (Thomas et al. 2017). After these corrections, we find that $SFRD_{Ly\alpha}/SFRD_{UV}$ are in great agreement with each other.

References

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