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The star formation burstiness and ionizing efficiency of low-mass galaxies

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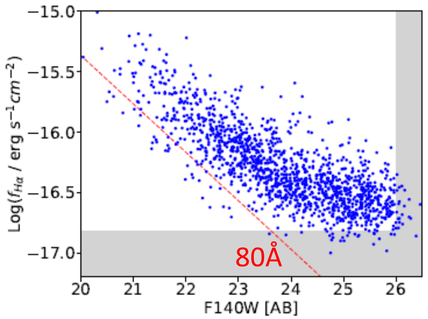
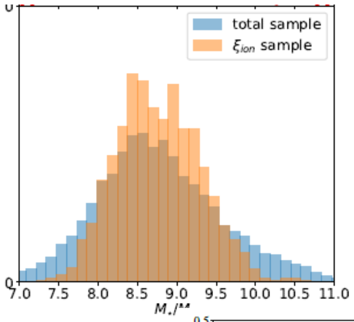
ABSTRACT
We investigate the burstiness of star formation and the ionizing efficiency of a large sample of galaxies at $0.7 < z < 1.5$ using *HST* grism spectroscopy and deep ultraviolet (UV) imaging in the GOODS-N and GOODS-S fields. The star formation history (SFH) in these strong emission line low-mass galaxies indicates an elevated star formation rate (SFR) based on the Hα emission line at a given stellar mass when compared to the standard main sequence. Moreover, when comparing the Hα and UV SFR indicators, we find that an excess in SFR$_{H\alpha}$ compared to SFR$_{UV}$ is preferentially observed in lower-mass galaxies below 10^9 M$_\odot$, which are also the highest-EW galaxies. These findings suggest that the burstiness parameters of these strong emission line galaxies may differ from those inferred from hydrodynamical simulations and previous observations. For instance, a larger burstiness duty cycle would explain the observed SFR$_{H\alpha}$ excess. We also estimate the ionizing photon production efficiency $\xi_{\rm ion}$, finding a median value of Log($\xi_{\rm ion}$/erg^{-1} Hz)= 24.80 ± 0.26 when adopting a Galactic dust correction for Hα and an SMC one for the stellar component. We observe an increase of $\xi_{\rm ion}$ with redshift, further confirming similar results at higher redshifts. We also find that $\xi_{\rm ion}$ is strongly correlated with $EW_{\rm H\alpha}$, which provides an approach for deriving $\xi_{\rm ion}$ in early galaxies. We observe that lower-mass, lower-luminosity galaxies have a higher $\xi_{\rm ion}$. Overall, these results provide further support for faint galaxies playing a major role in the reionization of the Universe.

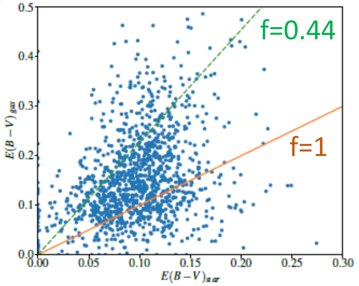
Target: Galaxies at $0.7 < z < 1.5$ down to a stellar mass of $10^8 M_\odot$

Observation: 3D-HST (Spectroscopy, Momcheva et al. 2016)
HDUV legacy survey (UV imaging, Oesch et al. 2018)

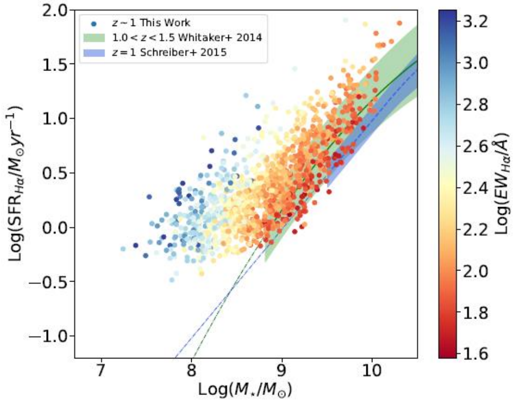


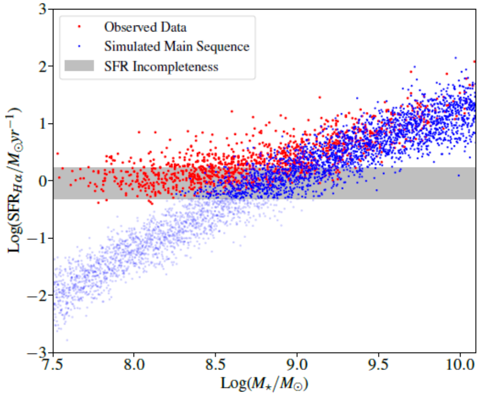


Dust attenuation correction:
Nebular, Domínguez et al. 2013:
Balmer decrements vs. galaxy stellar mass
Stellar, UV slope β:
Assuming an intrinsic UV slope of β_0=-2.62 (Reddy et al. 2018a)



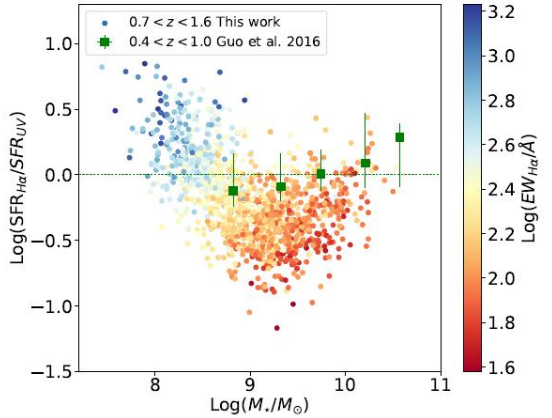
Star formation burstiness in low-mass galaxies:

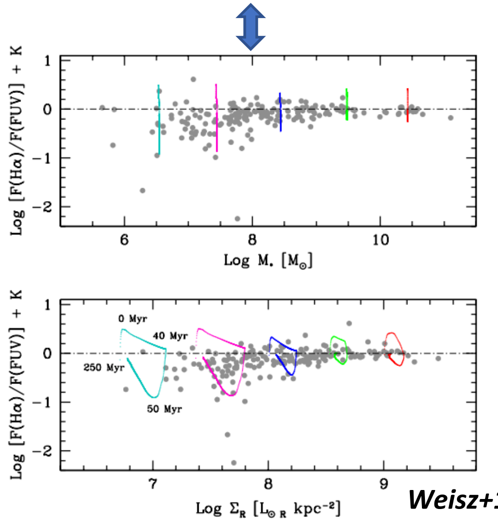




SFMS:
The observed flattening of the slope towards low-mass galaxies is likely the result of Hα flux incompleteness. However, the deviation from the main sequence is much larger at low mass, as the highest EWHα values are observed at lower masses.
↔ Other UV or SED-based SFR indicators found no evidence of increasing scatter towards lower masses, nor evidence for an enhanced Hα luminosity compared to UV

Hα v.s UV:
The SFR$H\alpha$/SFRUV ratio differ from the model in Weisz+12 with burst episodes lasting less than 10 Myr and a period of 250 Myr between bursts.
Also, high-EWHα galaxies have the highest SFR$H\alpha$/SFRUV
(i) a larger τ in the exponential SF; (ii) a shorter period between successive SF bursts.
(iii) IMF (binary stars, higher mass end)

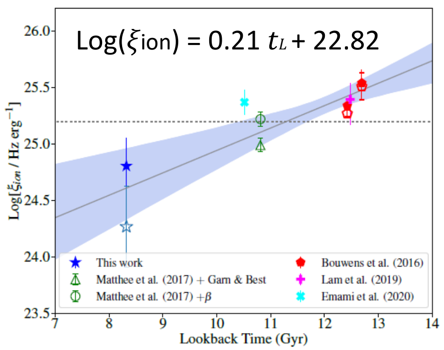


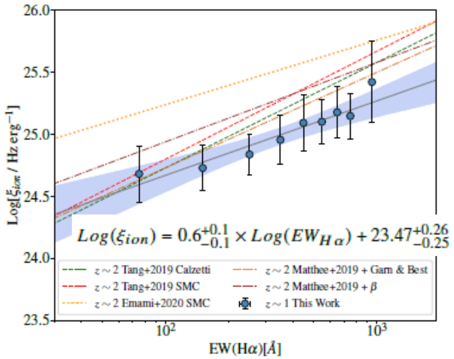


Weisz+12

ξ_{ion}: the production rate of Lyman-continuum photons (λ < 912 Å) per unit Ultra-Violet (UV) continuum luminosity measured at 1500 Å.

$$\xi_{\rm ion} = \frac{\dot{N}_{\rm ion}}{L_{UV}}\ [erg^{-1}\ Hz] \qquad L(H\alpha)\ [erg\ s^{-1}] = 1.36\times(1-f_{esc})\ 10^{-12}\ \dot{N}_{\rm ion}\ [s^{-1}]$$





It is also found that ξion is anti-correlated with stellar mass and absolute UV magnitude

Other Recent studies: low-mass galaxies are more representative of the galaxy population at the epoch of reionization and take charge of reionization.

Implication:
The classical value of Log(ξion) = 25.2, based on massive galaxies, may not hold in low-mass galaxies.
Variations of the escape fraction in low-mass galaxies, driven by supernovae explosions of massive stars