ISM Excitation and Metallicity of Star-forming Galaxies at $z \simeq 3.3$ from Near-IR Spectroscopy

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We study the relationship between stellar mass, star formation rate (SFR), ionization state, and gas-phase metallicity for a sample of 41 normal star-forming galaxies at $3 \lesssim z \lesssim 3.7$ [1]. The gas-phase oxygen abundance, ionization parameter, and electron density of ionized gas are derived from rest-frame optical strong emission lines measured on near-infrared spectra obtained with Keck/Multi-Object Spectrograph for Infra-Red Exploration (MOSFIRE). We remove the effect of these strong emission lines in the broadband fluxes to compute stellar masses via spectral energy distribution fitting, while the SFR is derived from the dust-corrected ultraviolet luminosity. The ionization parameter is weakly correlated with the specific SFR, but otherwise the ionization parameter and electron density do not correlate with other global galaxy properties such as stellar mass, SFR, and metallicity. The mass-metallicity relation (MZR) at $z \simeq 3.3$ shows lower metallicity by $\simeq 0.7$ dex than that at $z = 0$ [2,3] at the same stellar mass (Figure 1). Our sample shows an offset by $\simeq 0.3$ dex from the locally defined mass-metallicity-SFR relation [4], indicating that simply extrapolating such a relation to higher redshift may predict an incorrect evolution of MZR. Furthermore, within the uncertainties we find no SFR-metallicity correlation, suggesting a less important role of SFR in controlling the metallicity at high redshift. We finally investigate the redshift evolution of the MZR by using the model by Lilly et al. [5], finding that the observed evolution from $z = 0$ to $z \simeq 3.3$ can be accounted for by the model assuming a weak redshift evolution of the star formation efficiency.

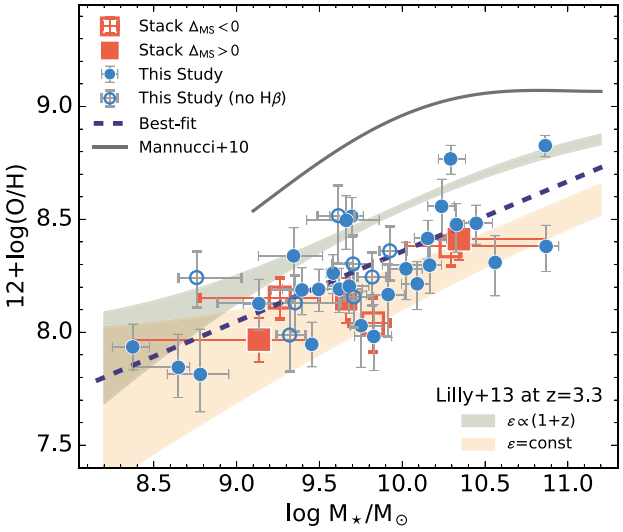

Figure 1: Mass–metallicity relation of our sample, shown with circles [1]. The filled and open circles are those with and without Hβ detection, respectively. Squares represent the measurements on the stacked spectra in bins of stellar mass and SFR. The bins above and below the best-fit main-sequence are shown with filled and open symbols, respectively. The best-fit linear relation for our sample is shown with a dashed line. The solid line is the $z = 0$ relation [4].

References

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