Star Formation Rate and Metallicity in Damped Lyman α System

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The conversion process of gas into stars in a hierarchically evolving galactic halo can be a key role in galaxy formation and evolution processes, and constrain structure formation scenarios. In this view, it is quite important to detect emissions from galaxies hosting Damped Lyα systems (DLAs) [$N_{\mathrm{HI}} \geq 2\times10^{20}\mathrm{cm}^{-2}$] (DLA galaxies), followed by the star formation rate (SFR) measurements of the large amount of HI gas reservoirs.

The survey for DLA galaxies reveals the origin of DLAs; at low-redshift ($z < 1$) , DLA galaxies consist of mixed morphological types of galaxies. However, at high-z, it is not easy to identify the DLA galaxies in the emission because they are often faint and/or compact. This requires selection strategies for identifying DLA galaxies. For DLAs, a relation between the velocity spread of the absorption line and the metallicity has been confirmed similarly to the mass-metallicity relation. This implies that the SFRs (or the stellar masses) of the host galaxies correlate with the metallicities. Recently, assuming the high-metallicity systems have the high SFRs, the survey for galaxies hosting high-metallicity systems has recently led to several new detections (e.g., [1]).

In Figure 1, we show the SFRs of DLA galaxies at $z > 2$ as a function of the metallicities based on the literature (*red dots*) and our results (*blue dots*) for DLA galaxies toward two QSOs (Q0216+08, J0803+1313), and a gamma-ray burst (GRB050730) with the Keck/OSIRIS, the Gemini/NIFS and the Subaru/MOIRCS (e.g., [2]). For DLA galaxies currently identified, the high metallicity systems have been successfully identified as bright DLA galaxies at $z > 2$. Indeed, we have not obtained any information about the DLA galaxies fainter than those with the SFR of $\sim 1 M_\odot \mathrm{yr}^{-1}$ except for an our detection ($\sim 0.97 M_\odot \mathrm{yr}^{-1}$) [3]. To reveal the origin of DLAs, the luck of low-SFR samples requires deep surveys for galaxies hosting low-metallicity systems. A semi-analytic DLA model also predicts a positive correlation between SFRs and metallicities at $z = 2$ (*contours*) [4].

Recent observation shows that Lyman Break Galaxies (LBGs) at $z = 1-3$ have median SFR of $\sim 15 M_\odot \mathrm{yr}^{-1}$ based on the median age ~125 Myr [5]. This indicates that *current* samples of the bright DLA galaxies likely arise from the LBG population. The faint end of Lyman α Emitters (LAE) (SFR $< 1 M_\odot \mathrm{yr}^{-1}$) could also give rise to DLAs at $z > 2$ because the number densities and the incident rates agree well with those of DLAs [6]. The consistency between the LBG/LAE populations and DLA galaxies indicates that there is indeed some overlap between them. The emission lines from DLAs provide the SFRs, the metallicities, and the number densities, which can be compared with those of LBGs/LAEs. This will remarkably improve our understanding of the origin of DLAs and the missing link between the absorption-selected population and the emission-selected ones.

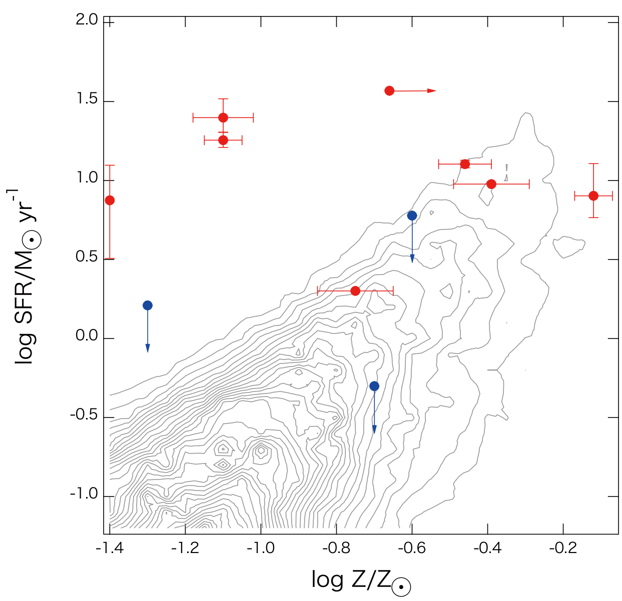

Figure 1: Star formation rates as a function of metallicities in DLA galaxies at redshift $z > 2$. The SFR estimations are shown in red (e.g., [1]) and blue dots (our results and [2]). The contour maps presents the SFRs of DLA galaxies at $z = 2$ predicted by a model for DLA galaxy [4].

References

[1] Fynbo, J. P. U., et al.: 2013, *MNRAS*, **436**, 361.
[2] Minowa, Y., et al.: 2012, *AJ*, **144**, 74.
[3] Kashikawa, N., et al.: 2014, *ApJ*, **780**, 116.
[4] Okoshi, K., Nagashima, M., Gouda, N., Minowa, Y.: 2010, *ApJ*, **710**, 1295.
[5] Hathi, N. P., et al.: 2013, *ApJ*, **765**, 88.
[6] Rauch., et al.: 2008, *ApJ*, **681**, 856.