The Mass-metallicity Relation and the Fundamental Metallicity Relation at $z \sim 1.4$ Revealed with the Subaru FMOS Galaxy Redshift Survey (FastSound)

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The gas-phase metallicity (hereafter, metallicity) is one of the key parameters required for understanding galaxy formation and evolution. Although enormous efforts on studying the correlation between the stellar mass and metallicity (hereafter mass-metallicity relation) and the dependence of star-formation rate (SFR) on the mass-metallicity relation (hereafter fundamental metallicity relation) have been made, those at $z>1$ still remain unclear because the sample size is still limited. FastSound is a galaxy redshift survey of galaxies at $z = 1.2$–1.5 with Fiber Multi-Object Spectrograph (FMOS) on the Subaru Telescope. Although the main goal of the project is the detection of the redshift space distortion (RSD) to test the general theory of relativity by measuring the growth rate of large-scale structure and to constrain modified gravity models for the origin of the accelerated expansion of the universe [1], the large sample of galaxies is very useful for the study of galaxies at this redshift.

Here, we present the results from the near-infrared sample of FastSound consisting of ~4,000 galaxies at $z \sim 1.4$ with significant Hα detection [2]. We measure the metallicity from the [N II]λ6583/Hα emission line ratio of the composite spectra in various stellar mass and SFR bins. The resulting mass-metallicity relation is generally in agreement with previous results obtained in a similar redshift range to that of our sample. Although no clear dependence of the mass-metallicity relation with SFR is found, our result at $z \sim 1.4$ roughly agrees with the fundamental metallicity relation at $z \sim 0.1$ with fiber aperture corrected SFR [3,4].

We detect significant [S II]$\lambda\lambda$6716,6731 emission lines from the composite spectra. The electron density estimated from the [S II]$\lambda\lambda$6716,6731 line ratio ranges from 10 – 500 cm^{-3}, which generally agrees with that of local galaxies. The distribution of our sample on [N II] λ6583/Hα vs. [S II]$\lambda\lambda$6716,6731/Hα is different from that found locally. From the obtained N2S2 index, we estimate the nitrogen-to-oxygen abundance ratio (N/O), and find that the N/O in galaxies at $z \sim 1.4$ is significantly higher than the local values at a fixed metallicity and stellar mass (Figure 1). The metallicity at $z \sim 1.4$ recalculated with this N/O enhancement taken into account decreases by 0.1 – 0.2 dex and the resulting metallicity is lower than the local fundamental metallicity relation.

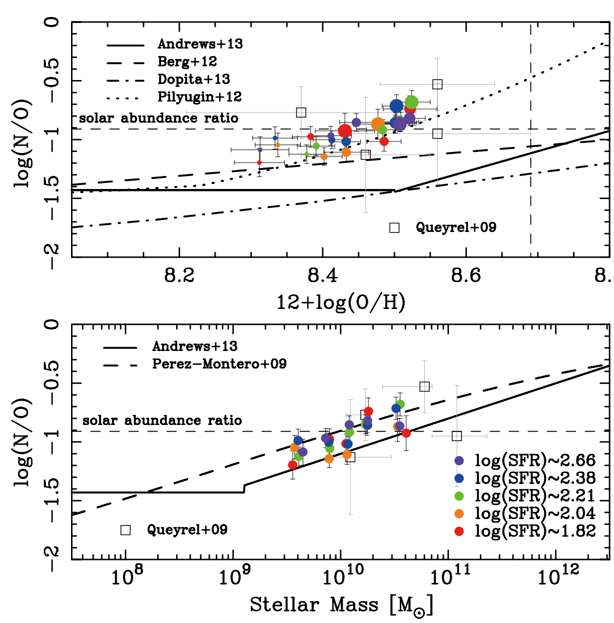

Figure 1: The N/O against the metallicity (top panel) and the stellar mass (bottom panel). The color of symbols of our sample represents SFR. Solid, dashed, dotted and dashed curves show the location of local galaxies at $z < 0.3$. The vertical and horizontal dashed line indicate the solar abundance and the solar abundance ratio, respectively.

References

[1] Tonegawa, M., et al.: 2015, *PASJ*, **67**, 81.
[2] Yabe, K., et al.: 2015, *PASJ*, **67**, 102.
[3] Andrews, B. H., Martini, P.: 2013, *ApJ*, **765**, 140.
[4] Zahid, H. J., et al.: 2014, *ApJ*, **792**, 75.