The Ages, Metallicities, and Element Abundance Ratios of Massive Quenched Galaxies at $z \simeq 1.6$

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We studied the ages, metallicities ([Z/H]), and α-element abundance ratios ([α/Fe]) of stellar populations in quenched and passively evolving galaxies by using MOIRCS on Subaru Telescope [1]. The sample galaxies were selected in the COSMOS field and their spectroscopic redshifts range in $1.25 < z < 2.09$ with a mean of 1.6. Since these galaxies are extremely faint, it is difficult to study stellar population properties spectroscopically for individual objects. Therefore, we carried out our analysis by stacking 24 spectra to obtain an adequate S/N ratio, resulting in a stacked spectrum with an equivalent integration time of 200 hours.

We measured a set of Lick indices [2, 3] and compared them with the prediction from stellar population synthesis models [4] to obtain the stellar population parameters of $z \simeq 1.6$ passively evolving galaxies. The resulting stellar population parameters are $\log_{10}$ age/Gyr = $0.04^{+0.10}_{-0.08}$, [Z/H] = $0.24^{+0.20}_{-0.14}$, and [α/Fe] = $0.31^{+0.12}_{-0.12}$. In particular, this is the first time that stellar [α/Fe] is measured at $z > 1$.

Comparing the stellar population parameters above with low redshift counterparts of our sample at $0 < z < 1$, all of them show excellent agreement with passive evolution of the stellar populations, and we found the formation redshift of them as $z_{\mathrm{f}} \simeq 2.3$. This supports a scenario that these passively evolving galaxies have formed by $z \simeq 2.3$ and evolved passively since then. The [α/Fe] ratio indicates a short formation timescale, at most 1 Gyr.

We then investigated star-forming precursors of the passively evolving galaxies we studied. Since the age of the sample is well constrained to be $\simeq$ 1 Gyr, progenitors must be star-forming galaxies at $z \simeq 2.3$. Indeed, star-forming galaxies at $z \simeq 2.3$ with similar stellar masses show star formation rates of a few hundred solar masses per year, which agrees well with that expected from the stellar population parameters we derived above. If these star-forming galaxies form stars at this rate, they will grow in mass with which no corresponding counterpart exists in the local Universe. Therefore, they must soon be quenched due to some physical mechanisms and follow passive evolution to present.

References

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