Nature of Hα Selected Galaxies at z > 2.
II. Clumpy Galaxies and Compact Star-forming Galaxies

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In the present Universe, there are a lot of galaxies with a variety of morphologies (elliptical, disk, and lenticular, etc.). How did they evolve into the present-day galaxies with different morphologies? Or, do we just look galaxies in a different evolutionary phase? Snapshots of galaxy morphologies in the distant Universe would give us hints to answer these questions. For understanding the evolution of galaxy morphologies, it would be especially important to observe galaxies at $z \sim 2$ when the cosmic star formation rate density peaks. High-resolution images are needed to spatially resolve distant galaxies. *Hubble Space Telescope* (HST) is the best instrument for such studies.

We have already constructed a clean sample of Hα emitter at $z = 2.2$ and $z = 2.5$ with MOIRCS on Subaru Telescope in CANDELS-SXDF field, where high-resolution optical and near-infrared images are publicly available [1]. We present their morphological properties such as clumps and compactness [2].

We found that about 42% of star-forming galaxies at $z > 2$ have clumps and their morphologies are significantly different from those of the present-day galaxies. The clumps near the galaxy center tend to be red compared to outer clumps. They are likely to be a protobulge component. We can not clearly tell whether the origin of the red color is caused by dust extinction or old stellar population at the moment. But the presence of mid-infrared emission in the galaxies with a red clump suggests dusty star formation is occurring in the red clumps because blue clumps should be less dusty. For a few sample, we found clear evidence of high Hα/UV ratio in the red clump, supporting dusty star formation in the galaxy center (Figure 1). These results suggest that a bulge component of galaxies is formed at $z \sim 2$.

We also study the stellar mass-size relation for our sample. While the most of Hα emitters at $z \sim 2$ follow the local relation, suggesting that many galaxies have already obtained disks as extended as the local ones, there are two massive, compact star-forming galaxies, which are called “blue nugget” [3]. Massive quiescent galaxies at similar redshift are also known to be extremely compact (they are called “red nugget” [4]). Blue nuggets are likely to be a direct progenitor of red nuggets. To reveal the evolutionary path from blue nuggets to red nuggets, we need to construct a statistical sample of blue nuggets.

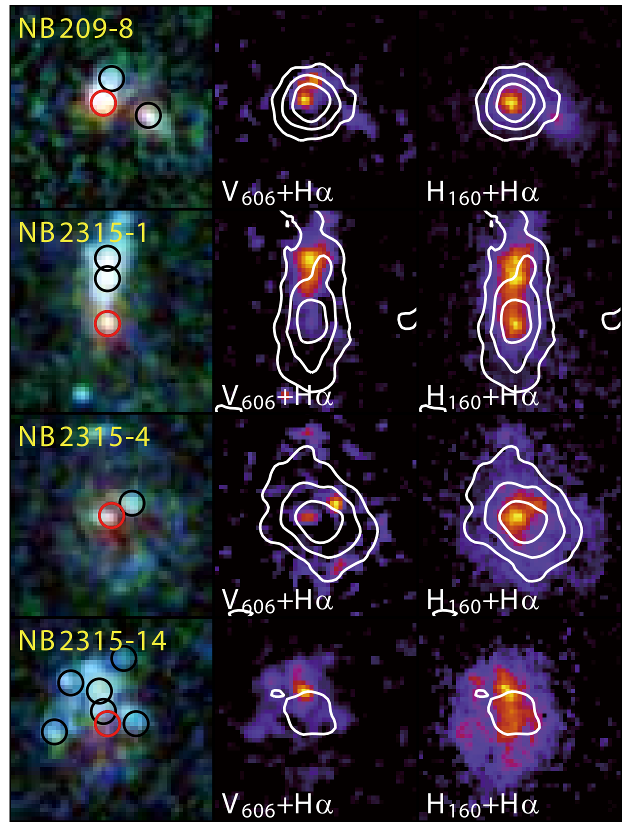

Figure 1: HST images of four Hα emitters at $z > 2$.

References

[1] Tadaki, K., et al.: 2013, *ApJ*, **778**, 114.
[2] Tadaki, K., et al.: 2014, *ApJ*, **780**, 77.
[3] Barro, G., et al.: 2013, *ApJ*, **765**, 104.
[4] van Dokkum, P. G., et al.: 2008, *ApJ*, **677**, L5.