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Massive and dusty Hα emitters in protocluster revealed by ALMA and JVLA

Minju Lee[1,2] and 4C23.56 Protocluster team

[1]Department of Astronomy, Graduate school of Science, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 133-0033, Japan, email: minju.lee@nao.ac.jp

[2]National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

Abstract. We investigate the physical properties of Hα emitters (HAEs) associated to the protocluster 4C23.56 at z $\sim$ 2.5 using continuum observations at submm (270 GHz) and radio (3 GHz) frequencies with Atacama Large Mm/submm Array (ALMA) and K. Jansky Very Large Array (JVLA). For more details see Lee *et al.* (in prep).

Keywords. galaxies: evolution—galaxies: structure—galaxies: high-redshift—radio continuum: galaxies—submillimeter

1. Summary

Protoclusters, the structures of unvirialized overdensities of massive galaxies in early universe, are expected to be the progenitors of massive clusters of galaxies. Protoclusters provide an unique opportunity to investigate how massive galaxies evolve under the effect of the environment in the early universe. We study the protocluster 4C23.56 at z$\sim$2.5 as a case study, that is identified as overdensities of Hα emitters (HAEs) using narrow band (NB) technique with MOIRCS/Subaru (Tanaka *et al.* 2011, in prep). The protocluster 4C23.56 is unique that the field is also reported as overdensities of galaxy populations other than HAEs (e.g., Knopp & Chambers 1997, Kajisawa *et al.* 2006, Mayo *et al.* 2012). Also, submmillimeter galaxy (SMG) survey with single dish AzTEC/ASTE finds that SMGs are overlapped with several HAEs, although the redshifts are poorly constrained (Suzuki *et al.*, in prep). We have performed deep and high resolution ($\sim$ 0$''$.6 - 0$''$.7) observations with ALMA and JVLA that reach r.m.s. level of $\sim$ 0.1 mJy at 1.1 mm and $\sim$1-4 μJy at 10 cm (1σ) to target 19 and 24 HAEs in the FoV of each observation.

Comparing the derived SFRs from submm, radio and Hα emission, and excluding HAEs having AGN signatures with a help of ancillary data sets, we find that the detected HAEs (4/19 in ALMA and 7/24 in JVLA) are all $\log(M_\star(M_\odot)) \gtrsim 10.5$, thus massive, and the amount of dust extinction is Av > 1.3. For extreme cases, Av is > 3, suggesting extremely dusty. These galaxies are scattered near the main sequence defined at z $\sim$ 2.5. Given the scatter in main sequence (e.g., Speagle *et al.* 2014), at least one of them is above the main sequence and likely experiencing starburst-like phase. Since the detection rate and the sample size are limited and the resolution is yet large to look in details of the galaxy structure, we need deeper higher resolution imaging toward this field.

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