Galaxies at High Redshift and Their Evolution Over Cosmic Time
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Toward unveiling internal properties of HII regions and their connections at the cosmic noon era

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Abstract. The redshift interval $z = 2$–3 is known as the cosmic noon that is the most active era of star formation across the Universe (Hopkins & Beacom 2006). In the past decade, many authors have investigated global properties of star-forming (SF) galaxies in this turbulent era, such as gas fractions and gaseous metallicities (e.g. Erb *et al.* 2006). With those achievements, we are going on to the next stage to understand more details i.e. those physical parameters in star-forming regions. Recent advent of near-infrared instruments typified by MOSFIRE on the Keck telescope, enable us with identifying the physical parameters of HII regions in 'typical' SF galaxies individually (Steidel *et al.* 2014). Recent highlights suggest higher electron densities, higher ionization parameters, and harder UV radiation fields may be common.

In order to know how galaxy evolution physically correlates with the natures of their star-forming regions, we have explored relationships between the electron density (n_e) of ionized gas from the oxygen line ratio and other physical properties, based on the deep spectra of Hα emitters at $z = 2.5$ by the MOSFIRE. MOSFIRE for the first time provides n_e of the galaxies at high-z with a high level of confidence. The result shows the specific star formation rate (sSFR) and the SFR surface density (ΣSFR) are correlated with n_e (Shimakawa *et al.* 2015). The n_e-ΣSFR relation could be linked to the star formation law in HII regions if we assume that hydrogen in HII regions is fully-ionized. Otherwise, more active star formation per unit area (higher ΣSFRs), may cause higher ionization states. However, we need some specific concerns that obtained physical parameters should depend on the scale dependence, since typical size of HII region is only <100 pc despite that we study physical states of entire galaxies. Thus we obtain surface-brightness-weighted and ensemble averaged line fluxes for the entire galaxy or the part that falls into the slit width (a few kpc scale size). The thirty meter telescope (TMT) is a powerful instrument to resolve such a difficulty, since its spatial resolution reaches <100 pc on the physical scale at $z \sim 2$ by AO assistance.

Keywords. galaxies: evolution, galaxies: high-redshift, galaxies: ISM

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