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An observational pursuit for Pop III stars in a Lyα emitter at $z > 6$ through He II emission

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Abstract. We report our on-going observational project to search for population III (Pop III) stars in high-z galaxies. We searched Lyα emitters (LAEs) with a large equivalent width (EW), by our new selection technique 'NB921-depressed i'-dropout selection'. We found eight photometric candidates and spectroscopically identified five LAEs with $EW_0(\mathrm{Ly}\alpha) > 100$ Å. We then carried out a very deep near-infrared spectroscopy for a LAE among the above five, to search for the redshifted He II λ1640 emission from Pop III stars in the galaxy, but obtained only an upper limit.

Keywords. early Universe, galaxies: evolution, galaxies: starburst, stars: early

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The detection and investigation of the first-generation stars, Population III (PopIII) stars, will be one of the main goals of astronomy in the next decade. Since galaxies with massive Pop III stars are expected to show a very strong Lyα emission and a detectable He II emission in their spectra (e.g., Schaerer 2002; Schaerer 2003), we are promoting a project to search for such spectroscopic signatures of Pop III stars.

We developed a new method to select Lyα emitters (LAEs) with a large equivalent width (EW) at a wide redshift range, $6.0 < z < 6.5$, by focusing 'NB921-depressed i'-dropout' objects (Nagao *et al.* 2004). Through the follow-up spectroscopic observations with Subaru and Keck telescopes, we identified five strong LAEs with $EW_0(\mathrm{Ly}\alpha) > 100$ Å among eight photometric candidates (Nagao *et al.* 2005; Nagao *et al.* 2007).

Among the identified NB921-depressed i'-dropout galaxies, we focused on a LAE at $z = 6.33$ and with $EW_0(\mathrm{Ly}\alpha) = 130$ Å and carried out a very deep J-band spectroscopic observation to search for the redshifted He II λ1640 emission from Pop III stars in this LAE. Even after 42 ksec of integration with the Subaru-OHS spectrograph, no emission-line features are detected in the J-band. We obtained a $2\,\sigma$ upper limit of $9.06 \times 10^{-18}\,\mathrm{erg\,s^{-1}cm^{-2}}$ on the He II λ1640 flux, which corresponds to a luminosity of $4.11 \times 10^{42}\,\mathrm{erg\,s^{-1}}$. This upper limit implies that the upper limit on the Pop III star formation rate is in the range 4.9 - 41.2 $\mathrm{M_\odot yr^{-1}}$ if Pop III stars suffer no mass loss, and in the range 1.8 - 13.2 $\mathrm{M_\odot yr^{-1}}$ if strong mass loss is present. The non-detection of He II in the target LAE may thus disfavor weak feedback models for Pop III stars.

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