High-z star-forming galaxies in the epoch of reionization (EoR) have been usually detected via their Lyα lines or UV continua. However, as UV light traces only ionized gas/stars, we have seen merely a portion of star formation in galaxies. Another aspect yet unexplored is dust-obscured star formation, and rest frame far-infrared (FIR) lines and continuum can probe it as they reflect fuel for star formation and light from stars once absorbed and re-emitted by dust, respectively. FIR lights from EoR galaxies are redshifted to (sub)millimeter and observable from the ground by Atacama Large Millimeter/submillimeter Array (ALMA). Among many FIR lines, 158 μm [CII] is the strongest line of an interstellar medium and suited for probing faint distant galaxies.

We conducted ALMA observations of the [CII] line and FIR continuum of a normally star-forming galaxy in EoR, a z=6.96 Lyα emitter (LAE) IOK-1 [1]. We found it undetected in both [CII] and continuum to $\sigma_{\text{line}} = 240 \mu\text{Jy beam}^{-1} (40 \text{ km s}^{-1} \text{ channel})$ and $\sigma_{\text{cont}} = 21 \mu\text{Jy beam}^{-1}$. Comparison of UV–FIR spectral energy distribution (SED) of IOK-1, including our ALMA limit, to those of several types of galaxies suggests that IOK-1 is similar to local dwarf/irregular galaxies in SED shape rather than highly dusty/obscured galaxies (Figure 1). Moreover, our 3σ FIR continuum limit implies intrinsic dust mass $M_{\text{dust}} < 6.4 \times 10^7 M_\odot$, FIR luminosity $L_{\text{FIR}} < 3.7 \times 10^{10} L_\odot$ (42.5–122.5 μm), total IR luminosity $L_{\text{IR}} < 5.7 \times 10^{10} L_\odot$ (8–1000 μm) and dust-obscured star formation rate (SFR) < 10 $M_\odot \text{ yr}^{-1}$, if we assume that IOK-1 has a dust temperature and emissivity index typical of local dwarf galaxies. This SFR is 2.4 times lower than one estimated from the UV continuum, suggesting that < 29% of the star formation is obscured by dust. Meanwhile, 3σ [CII] flux limit converts to luminosity $L_{\text{[CII]}} < 3.4 \times 10^{7} L_\odot$. Locations of IOK-1 and previously observed LAEs on the $L_{\text{[CII]}}$ vs. SFR and $L_{\text{[CII]}}/L_{\text{FIR}}$ vs. $L_{\text{FIR}}$ diagrams imply that LAEs in EoR have significantly lower gas and dust enrichment than AGN-powered systems and starbursts at similar/lower redshifts as well as local star-forming galaxies (Figure 2).

**ALMA Observation of 158 μm [CII] Line and Dust Continuum of a z = 7 Normally Star-Forming Galaxy in the Epoch of Reionization**

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**Reference**