X01a Early dust enrichment in a Y-dropout galaxy at z = 8.312 revealed by ALMA observations of the far-infrared [O III] and dust emission

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We present the results from ultraviolet-to-far infrared (IR) spectral energy distribution (SED) modeling of a Y-dropout Lyman break galaxy at $z = 8.3118 \pm 0.0003$, MACS0416_Y1, in which we have recently detected the [O III] 88 μm line and rest-frame 90 μm dust continuum emission using ALMA. The observed 850 μm flux density of 137 ± 26 μJy corresponds to a de-lensed total IR luminosity of $L_{\rm IR} = (1.7 \pm 0.3) \times 10^{11}\, L_\odot$, yielding a large dust mass of $4 \times 10^6 M_\odot$. The SED modeling where the [O III] emissivity model is incorporated suggests the presence of a young ($\tau_{\rm age} \approx 4$ Myr), star-forming (SFR $\approx 60\ M_\odot\ {\rm yr}^{-1}$), moderately metal-polluted ($Z \approx 0.2 Z_\odot$) stellar component with the mass of $M_{\rm star} = 3 \times 10^8 M_\odot$. The SED fits reasonably account for the far-IR dust emission *if the dust mass pre-exists*, while it is yet to be assessed. An analytic dust mass evolution model with a single episode of star-formation reproduces neither the metallicity nor the dust mass in $\tau_{\rm age} \approx 4$ Myr. We find that a passively-evolved stellar component with $M_{\rm star} \sim 3 \times 10^9\ M_\odot$ and $\tau_{\rm age} \sim 0.3$ Gyr reproduces the metallicity and dust mass without any substantial change in the SED shape, suggesting the presence of such a mature stellar component as the origin of dust.