X18a Observation of the [O III] 52 micron emission from a z=7.2 galaxy

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Investigating galaxies at $z > 6$ is crucial to understand the Epoch of Reionization. Even with the advent of JWST, the [O III] 52 μm emission is indispensable to better constrain the physical properties of the interstellar medium (ISM) of high redshift galaxies and has great potential for probing the most distant galaxies. Here, we report the observation of the [O III] 52 μm emission from a $z = 7.212$ galaxy, SXDF-NB1006-2. The [O III] 52 μm emission was observed by ALMA band 9 (Cycle 8: 2021.1.01323.S, PI: Yi Ren) for 787.5 minutes in June and August 2022. With a resultant angular resolution of $0.15'' \times 0.12''$, we have obtained a non-detection and $3\,\sigma$ upper limits of the luminosity. After applying the uv-taper procedure, we find the best constraint on the [O III] 52/88 luminosity ratio (L_{52}/L_{88}) of < 1.9. Using the upper limit of L_{52}/L_{88}, the [O III] 88 μm luminosity (L_{88}) of our updated measurement (Ren et al. 2023), and the star formation rate (SFR) in the literature, we have constrained the ISM properties of SXDF-NB1006-2. We find the electron density of $< 350\,\mathrm{cm}^{-3}$ and the gas-phase metallicity of $0.01 - 0.42\,\mathrm{Z}_{\odot}$ (95% CI), which are 1 dex and 0.4 dex tighter, respectively, compared with the measurement using L_{88} and SFR only. We also find that the new metallicity constraint agrees with the mass-metallicity relation from the FIRE suite of high redshift galaxy formation simulations near $z = 6$.