

X09a Deep CO Observations for Luminous Lyman-break Galaxies at $z = 6.0293\text{--}6.2037$

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We present our new ALMA observations targeting CO(6–5) from three luminous LBGs at $z_{\text{spec}} = 6.0293\text{--}6.2037$ found in the Subaru/HSC survey, whose [OIII]88 μm and [CII]158 μm have been detected with ALMA. We find the CO(6–5) line from one of our LBGs, J0235–0532, at the $\simeq 4\sigma$ level and obtain upper limits for the other two LBGs. Our $z = 6$ luminous LBGs are consistent with the previously found correlation between the CO luminosity and the IR luminosity. The unique ensemble of the multiple FIR lines and underlying continuum fed to a PDR model reveal that J0235–0532 has a relatively high n_{H} that is comparable to those of low- z (U)LIRGs, quasars, and Galactic star-forming regions with high n_{H} values, while the other two LBGs have lower n_{H} consistent with local star-forming galaxies. By carefully taking account of various uncertainties we obtain total gas mass and gas surface density constraints from their CO luminosity measurements. We find that J0235–0532 locates below the Kennicutt-Schmidt (KS) relation, comparable to the previously CO(2–1) detected $z = 5.7$ LBG, HZ10, while dusty starbursts at similar redshifts locate above the KS relation, indicating that the scatter of the KS relation may increase with increasing redshift at least at large gas surface densities of $\sim 10^4 M_{\odot} \text{pc}^{-2}$, and the KS relation at $z = 5\text{--}6$ is on average consistent with the local one.