

X11a ALMA observations of a submillimeter galaxy at $z = 6$ II: Lens modeling, gas kinematics and CO excitation

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Bright submillimeter galaxies (SMGs) are expected to evolve into compact quiescent galaxies through a strong and short burst of star formation. Recent ALMA observations have revealed that SMGs at $z = 4 - 5$ ubiquitously have a rotation-supported disk, but it becomes increasingly difficult to spatially resolve line emission in galaxies at higher redshift due to a lack of sensitivity and angular resolution. Here we present [OIII] $88\mu\text{m}$, [NII] $205\mu\text{m}$, and CO(12-11) line observations from a strongly-lensed SMG at $z = 6.03$, G09-83808, with the angular resolution of $0.8''$. Owing to the magnification, this source is spatially-resolved (~ 1.5 kpc scale in the source plane on average). Reconstructed sources show a monotonic velocity gradient over the galaxy. Together with the fact that the brightness distribution of the source is well fitted with an exponential disk profile, this gradient suggests the existence of a rotating disk extended over a radius of $R \sim 1.2$ kpc. In addition, non-LTE radiative transfer analysis using CO rotational transition lines ($J_{\text{up}} = 2, 5, 6, 12$) indicates that there is warm ($T_{\text{kin}} \sim 320$ K) and dense ($n_{\text{H}_2} \sim 10^{5.4} \text{ cm}^{-3}$) gas in the compact region at the galactic center ($R \sim 0.6$ kpc). And also, the high ratio of $L_{\text{CO}(12-11)}/L_{\text{CO}(6-5)} = 1.1 \pm 0.3$ is consistent with local AGN-host galaxies and $6 < z < 7$ quasars, which may indicate the existence of an obscured AGN.