Rotating Starburst Cores in Massive Galaxies at $z = 2.5$

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We present spatially resolved ALMA observations of the CO J=3–2 emission line in two massive galaxies at z=2.5 on the star-forming main sequence. Both galaxies have compact dusty star-forming cores with effective radii of R_e=1.3±0.1 kpc and R_e=1.2±0.1 kpc in the 870 μm continuum emission. The spatial extent of star-forming molecular gas is also compact with R_e=1.9±0.4 kpc and R_e=2.3±0.4 kpc, but more extended than the dust emission. Interpreting the observed position-velocity diagrams with dynamical models, we find the starburst cores to be rotation-dominated with the ratio of the maximum rotation velocity to the local velocity dispersion of $v_{\rm max}/\sigma_0 = 7.0^{+2.5}_{-2.8}$ ($v_{\rm max}$=386^{+36}_{-32} km s^{-1}) and $v_{\rm max}/\sigma_0 = 4.1^{+1.7}_{-1.5}$ ($v_{\rm max}$ = 391^{+54}_{-41} km s^{-1}). Given that the descendants of these massive galaxies in the local universe are likely ellipticals with v/σ nearly an order of magnitude lower, the rapidly rotating galaxies would lose significant net angular momentum in the intervening time. The comparisons among dynamical, stellar, gas, and dust mass suggest that the starburst CO-to-H$_2$ conversion factor of $\alpha_{\rm CO} = 0.8\,M_\odot$ (K km s^{-1} pc^{-2}) s^{-1} is appropriate in the spatially resolved cores. The dense cores are likely to be formed in extreme environments similar to the central regions of local ultraluminous infrared galaxies. Our work also demonstrates that a combination of medium-resolution CO and high-resolution dust continuum observations is a powerful tool for characterizing the dynamical state of molecular gas in distant galaxies.

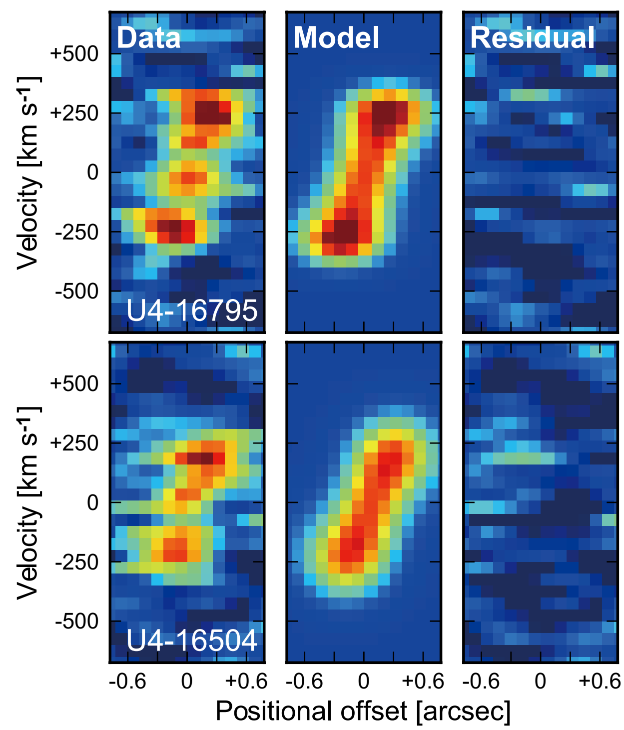

Figure 1: Observed position-velocity diagrams of the CO spectra (left). The middle and right panels show the best-fit dynamical model and the residuals between the data and the model, respectively.

Reference

[1] Tadaki, K. et al.: 2017, *ApJ*, **841**, L25.