to the integrated spectrum as initial parameters. We required the fit to the one-dimensional spectrum to be significant at $>5\sigma$.

We measured a projected velocity difference over the galaxies of $111 \pm 28\,\mathrm{km\,s^{-1}}$ and $54 \pm 20\,\mathrm{km\,s^{-1}}$ for COS-3018555981 and COS-2987030247, respectively, using the minimum and maximum central frequencies taken from the fits that are significant at $>5\sigma$. Galaxies with $\Delta v_{\mathrm{obs}}/2\sigma_{\mathrm{tot}}$ ratios greater than 0.4 (using the measured line widths in Extended Data Table 1 to estimate the integrated velocity dispersion) can be classified as probable rotation-dominated systems in cases where the data quality prevents reliable kinematic modelling[25]. This is an approximate diagnostic based on simulations of disk galaxies with a wide range of intrinsic properties. The observed limit of $\Delta v_{\mathrm{obs}}/2\sigma_{\mathrm{tot}}$ at around 0.4 corresponds to the intrinsic ratio of $v_{\mathrm{rot}}/\sigma_0 = 1$ (ref. 25). We tested the robustness of the observed velocity gradient by re-imaging the ALMA data with CASA, using a Briggs weighting with a robustness parameter of 0.5, which produces images of the [C II] emission at a lower signal-to-noise ratio but slightly improved spatial resolution ($0.9'' \times 0.7''$). We confirmed that the same analysis on the higher-resolution data still produced a velocity gradient with the same projected velocity difference over the two galaxies.

We assumed that these galaxies can be described as symmetric rotating disks. This is a reasonable assumption given the consistent prediction of high-resolution hydrodynamic zoom simulations, which show that cool gas indeed settles into regular rotating disks[27,43–45], and given the prevalence of disks among star-forming galaxies at lower redshifts[46–48]. To derive a dynamic mass for these systems, we adopted two methods. First, we use used the approximation that the dynamic mass is estimated from $M_{\mathrm{dyn}}(r < r_{1/2}) = (v_{\mathrm{d}}^2 r_{1/2})/G$, where $r_{1/2}$ is the half-light radius of [C II], G is the gravitational constant, and v_{d} is derived from the average of the observed velocity gradient over the galaxy, $v_{\mathrm{d}}\sin(i) = 1.3\Delta v_{\mathrm{obs}}$ (where i is the disk inclination), and the integrated velocity dispersion, $v_{\mathrm{d}}\sin(i) = 0.99\sigma_{\mathrm{tot}}$ (ref. 25). We estimated a half-light radius ($r_{1/2}$) and the inclination of the system ($\sin(i)$) from an ellipsoidal fit to the [C II] emission line map using CASA (corrected for the beam), and found $r_{1/2}$ values of 2.6 ± 0.8 kpc and 3.1 ± 1.0 kpc, and $\sin(i)$ values of 0.59 ± 0.15 and 0.88 ± 0.06, for our sources. We derived dynamic masses of $(25.3 \pm 15.4) \times 10^9 M_\odot$ and $(3.4 \pm 1.7) \times 10^9 M_\odot$ for COS-3018555981 and COS-2987030247, respectively.

To obtain a second mass estimate, we modelled the velocity field by assuming that the gas is rotating in a circularly symmetric thin disk, with a gravitational potential that depends only on the disk mass and assuming an exponential distribution of the surface mass density. The circular velocity is projected along the line of sight, weighted by the profile of the intrinsic line surface brightness, and convolved with the beam size of the observations. Free parameters of our model are the inclination of the disk, the position angle of the disk line of nodes, the systemic velocity of the galaxy, and the dynamic mass, measured in a radius of 5 kpc. Our method has been successfully applied to ALMA observations of [C II] emitting sources at redshifts of around 5 (refs 49, 50). Our free parameters were simultaneously constrained from the velocity maps using least-squares fitting. Furthermore, we fitted the coordinates of the disk centre on the basis of the surface brightness maps, which are a minor uncertainty to our final results. We estimated uncertainties from the χ^2 parameter space, which was constrained with Monte Carlo Markov chain simulations. The best-fitting model describes our velocity field well, leaving small residuals (Extended Data Fig. 1). The best-fit parameters indicate half-light radii of $1.7^{+0.4}_{-0.3}$ kpc and $2.1^{+2.1}_{-1.1}$ kpc, inclination angles of $\sin(i) = 0.87^{+0.07}_{-0.10}$ and $0.64^{+0.22}_{-0.30}$, and dynamic masses of $1.0^{+0.3}_{-0.2} \times 10^{10} M_\odot$ and $0.4^{+0.9}_{-0.3} \times 10^{10} M_\odot$ for COS-3018555981 and COS-2987030247, respectively. These values are all consistent (within the uncertainties) with the estimates derived above. We therefore adopted this more sophisticated method for our fiducial dynamic mass estimates.

In the methods described above, the effect of turbulence on the estimated dynamic masses is not included[51,52]. For dispersion-dominated galaxies, the dynamic mass (including pressure support) can be estimated by $M_{\mathrm{dyn}} = 2R_{1/2}(v_{\mathrm{rot}}^2 + \sigma_0^2)/G$ (ref. 53), where v_{rot} is the inclination-corrected velocity gradient, and we estimate σ_0 values of $55\,\mathrm{km\,s^{-1}}$ and $30\,\mathrm{km\,s^{-1}}$. The resulting dynamical masses are 0.3 dex and 0.4 dex higher than our previous estimates for COS-3018555981 and COS-2987030247, respectively. To study the effect of asymmetric drift on the rotation curve in more detail, higher-resolution observations will be required.

Code availability. The data used here were reduced and partly analysed with the public code CASA, available at https://casa.nrao.edu/casa_obtaining.shtml. The reduction pipeline for this source can be downloaded as part of the ALMA observations with project code 2015.1.01111.S, available in the archive at https://almascience.nrao.edu/alma-data/archive. The kinematic models used for this study are available from the corresponding author upon request.

Data availability. The data used in this publication are publicly available in the data archive https://almascience.nrao.edu/alma-data/archive, and can be retrieved with the project code 2015.1.01111.S or using the name of the principal investigator, 'Smit, Renske'.

31. Chabrier, G. Galactic stellar and substellar initial mass function. *Publ. Astron. Soc. Pac.* **115,** 763–795 (2003).
32. Oke, J. B. & Gunn, J. E. Secondary standard stars for absolute spectrophotometry. *Astrophys. J.* **266,** 713–717 (1983).
33. McMullin, J. P., Waters, B., Schiebel, D., Young, W. & Golap, K. CASA architecture and applications. In *Astronomical Data Analysis Software and Systems XVI* (eds Shaw, R. A., Hill, F. & Bell, D. J.) 127–130 (*Astron. Soc. Pac. Conf. Ser.* Vol. 376, 2007).
34. Dunlop, J. S. *et al.* A deep ALMA image of the Hubble ultra deep field. *Mon. Not. R. Astron. Soc.* **466,** 861–883 (2017).
35. Narayanan, D. *et al.* The IRX-beta dust attenuation relation in cosmological galaxy formation simulations. Preprint at https://arxiv.org/abs/1705.05858 (2017).
36. Koprowski, M. P. *et al.* A resolved map of the infrared excess in a Lyman break galaxy at $z = 3$. *Astrophys. J.* **828,** L21 (2016).
37. Kennicutt, R. C. & Evans, N. J. Star formation in the Milky Way and nearby galaxies. *Annu. Rev. Astron. Astrophys.* **50,** 531–608 (2012).
38. Brammer, G. B. *et al.* 3D-HST: a wide-field grism spectroscopic survey with the Hubble space telescope. *Astrophys. J. Suppl. Ser.* **200,** 13 (2012).
39. Stark, D. P. *et al.* Keck spectroscopy of $3 < z < 7$ faint Lyman break galaxies: the importance of nebular emission in understanding the specific star formation rate and stellar mass density. *Astrophys. J.* **763,** 129 (2013).
40. Smit, R. *et al.* Inferred Hα flux as a star formation rate indicator at $z \sim 4$–5: implications for dust properties, burstiness, and the $z = 4$–8 star formation rate functions. *Astrophys. J.* **833,** 254 (2016).
41. da Cunha, E., Charlot, S. & Elbaz, D. A simple model to interpret the ultraviolet, optical and infrared emission from galaxies. *Mon. Not. R. Astron. Soc.* **388,** 1595–1617 (2008).
42. da Cunha, E. *et al.* An ALMA survey of sub-millimeter galaxies in the extended Chandra deep field south: physical properties derived from ultraviolet-to-radio modeling. *Astrophys. J.* **806,** 110 (2015).
43. Feng, Y. *et al.* The formation of Milky Way-mass disk galaxies in the first 500 million years of a cold dark matter universe. *Astrophys. J.* **808,** L17 (2015).
44. Katz, H., Kimm, T., Sijacki, D. & Haehnelt, M. G. Interpreting ALMA observations of the ISM during the epoch of reionization. *Mon. Not. R. Astron. Soc.* **468,** 4831–4861 (2017).
45. Pallottini, A. *et al.* Zooming on the internal structure of $z \sim 6$ galaxies. *Mon. Not. R. Astron. Soc.* **465,** 2540–2558 (2017).
46. Stott, J. P. *et al.* The KMOS redshift one spectroscopic survey (KROSS): dynamical properties, gas and dark matter fractions of typical $z \sim 1$ star-forming galaxies. *Mon. Not. R. Astron. Soc.* **457,** 1888–1904 (2016).
47. Wuyts, S. *et al.* KMOS3D: dynamical constraints on the mass budget in early star-forming disks. *Astrophys. J.* **831,** 149 (2016).
48. Mason, C. A. *et al.* First results from the KMOS lens-amplified spectroscopic survey (KLASS): kinematics of lensed galaxies at cosmic noon. *Astrophys. J.* **838,** 14 (2017).
49. Carniani, S. *et al.* Strongly star-forming rotating disks in a complex merging system at $z = 4.7$ as revealed by ALMA. *Astron. Astrophys.* **559,** A29 (2013).
50. Williams, R. J. *et al.* Constraining the nature of two Lyα emitters detected by ALMA at $z = 4.7$. *Mon. Not. R. Astron. Soc.* **439,** 2096–2101 (2014).
51. Burkert, A. *et al.* High-redshift star-forming galaxies: angular momentum and baryon fraction, turbulent pressure effects, and the origin of turbulence. *Astrophys. J.* **725,** 2324–2332 (2010).
52. Burkert, A. *et al.* The angular momentum distribution and baryon content of star-forming galaxies at $z \sim 1$–3. *Astrophys. J.* **826,** 214 (2016).
53. Newman, S. F. *et al.* The SINS/zC-SINF survey of $z \sim 2$ galaxy kinematics: the nature of dispersion-dominated galaxies. *Astrophys. J.* **767,** 104 (2013).