X38a Morphological Demographics of Galaxies at $z \sim 10$–16: Log-Normal Size Distribution and Exponential Profiles Consistent with the Disk Formation Scenario

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We homogeneously investigate the morphological properties of 169 galaxies at $z \sim 10$–16 with deep JWST NIRCam images employing our established techniques of GALFIT modeling and uncertainty evaluation (systematics+statistics) . We obtain effective radii $r_{\rm e}$ ranging 20–500 pc, with a distribution significantly broader than the scatter made by the uncertainties. We find that the $r_{\rm e}$ distribution is well described by a log-normal distribution with a mean of $r_{\rm e} = 133^{+13}_{-12}$ pc and a standard deviation of $\sigma_{\ln r_{\rm e}} = 0.52 \pm 0.08$. The standard deviation is comparable to that of local galaxies, indicating no significant evolution over $z \sim 0$–10. We estimate the virial radius $r_{\rm vir}$ from the stellar masses via the star-formation main sequence and stellar-to-halo mass relation, obtaining a stellar-to-halo size ratio $r_{\rm e}/r_{\rm vir} = 0.015^{+0.015}_{-0.005}$, which is comparable to those of star-forming galaxies in the low-z Universe. Our results of 1) the log-normal $r_{\rm e}$ distribution, 2) the standard deviation value, and 3) a mean radial profile consistent with an exponential profile ($n = 1.3 \pm 0.6$) suggest that galaxies at $z \sim 10$–16 generally follow the classical galaxy disk formation scenario with a specific disk angular momentum fraction of $j_{\rm d}/m_{\rm d} \sim 0.5$–$1$. Interestingly, we identify two remarkable outliers GN-z11 and GHZ2 with $r_{\rm e} = 55^{+5}_{-6}$ pc and 39 ± 11 pc, respectively, that may not be explained by disk structures but by AGN or compact star-forming galaxies merging underway in short periods of time, as reproduced in numerical simulations.