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A New Nonparametric Approach to Galaxy Morphological Classification

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Abstract

We present two new nonparametric methods for quantifying galaxy morphology: the relative distribution of the galaxy pixel flux values (the Gini coefficient or G) and the second-order moment of the brightest 20% of the galaxy's flux (M_{20}). We test the robustness of G and M_{20} to decreasing signal-to-noise ratio (S/N) and spatial resolution and find that both measures are reliable to within 10% for images with average S/N per pixel greater than 2 and resolutions better than 1000 and 500 pc, respectively. We have measured G and M_{20} , as well as concentration (C), asymmetry (A), and clumpiness (S) in the rest-frame near-ultraviolet/optical



wavelengths for 148 bright local "normal" Hubble-type galaxies (E–Sd) galaxies, 22 dwarf irregulars, and 73 $0.05 < z < 0.25$ ultraluminous infrared galaxies (ULIRGs). We find that most local galaxies follow a tight sequence in G - M_{20} - C , where early types have high G and C and low M_{20} and late-type spirals have lower G and C and higher M_{20} . The majority of ULIRGs lie above the normal galaxy G - M_{20} sequence because of their high G and M_{20} values. Their high Gini coefficients arise from very bright nuclei, while the high second-order moments are produced by multiple nuclei and bright tidal tails. All of these features are signatures of recent and on-going mergers and interactions. We also find that in combination with A and S , G is more effective than C at distinguishing ULIRGs from the "normal" Hubble types. Finally, we measure the morphologies of $491.7 < z < 3.8$ galaxies from *HST*NICMOS observations of the Hubble Deep Field North. We find that many of the $z \sim 2$ galaxies possess G and A higher than expected from degraded images of local elliptical and spiral galaxies and have morphologies more like low-redshift ULIRGs.

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