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Unveiling the hidden universe: studying low-surface-brightness galaxies using the New Horizon cosmological simulation

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Galaxy evolution studies have been dominated by objects that lie above the surface brightness (SB) limit of current wide surveys like the SDSS (23 mag/arcsec^2). However, hints of a much larger population of low-surface-brightness galaxies (LSBGs) have recently been discovered. State-of-the-art cosmological simulations, and new deep wide surveys, have begun to show that these galaxies might dominate the local number density, indicating that our current understanding of galaxy evolution is incomplete. We use New Horizon, a cosmological hydro-dynamical simulation, to quantify the origin of LSBGs. We show that the majority of galaxies occupy a fairly tight LSB locus in the SB vs stellar mass plane, which is invisible in past surveys. However, some galaxies scatter off this locus, and these are the ones that are visible in past datasets and on which our theoretical paradigm is predicated. Key to understanding galaxy evolution, therefore, is to understand both the formation of the LSB locus and the objects that lie off it. We show that on-locus LSB galaxies form more of their stellar mass at higher redshift. More intense supernova feedback and mergers at early epochs flatten their gas profiles. This gas then produces diffuse LSB galaxies. The off-locus population exhibits milder supernova feedback at high redshift, which enables them to progressively deepen their potential wells, continue to form stars more vigorously to later epochs, thus attaining high SBs that make them visible in past surveys. We make testable predictions for the next generation of deep-wide surveys, such as LSST.

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