Predictions for the low surface-brightness Universe from the Horizon-AGN simulation

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Abstract

Our understanding of galaxy evolution is underpinned by the parts of the galaxy population that we can see within the surface brightness limits current surveys. While modern instruments have allowed us to probe deeper into the low surface-brightness (LSB) regime ($\mu > 23$ mag arcsec$^{-2}$), a majority of the LSB objects in the Universe remain poorly studied. Using the Horizon-AGN simulation, we identify a large sample of LSB galaxies including a population of ultradiffuse galaxies (UDGs). We perform a comprehensive study of properties, origin and evolution of these objects, across a wide range of environments. Our predictions indicate that a majority (> 85%) of galaxies should reside in the LSB regime and that significant populations of UDGs exist across all environments. We also show that LSB and UDG galaxies are descended from populations with almost identical properties to their high surface-brightness (HSB) counterparts at high redshift ($z > 1.5$). UDGs are produced principally as a consequence of tidal interactions, regardless of environment and tidal heating and harassment play an important role in expanding the stellar distributions of UDG progenitors and quenching their star-formation by heating cold gas. Although ram-pressure stripping is also able to efficiently remove gas from LSB progenitors, we show that tidal heating alone is sufficient to produce the low surface brightness characteristics of UDGs. The effect of supernova feedback and mergers early on in their formation history, may allow tidal processes to work more efficiently.