Diversity of galactic discs at high redshift in cosmological simulations

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Abstract

Galactic morphology is fundamental to understanding how galaxies form, interact with their environments and evolve across cosmic time. Recent observations have revealed a surprisingly large population of disc-like galaxies at redshifts as high as $z = 8$, which appears in tension with galaxy formation models. Thus, understanding the structures and evolutionary paths of these early galaxies is crucial for interpreting findings of observatories like JWST. While current simulations have demonstrated that gaseous disc-like structures exist in star-forming galaxies up to $z \sim 5$, their characteristics at earlier times are not yet fully understood. In this study, we aim to explore the presence of discs in cosmological simulations at high redshift to confront the mismatch between the models and the observations.

To investigate this further, we use the high resolution cosmological simulation 'Obelisk', to study the morphology of galaxies at $z > 6$. We fit surface density profiles to distinguish between the disc and spheroidal components of the galaxy, employing indicators like bulge-to-total ratio (B/T) and disk-to-total ratio(D/T), which can provide information regarding the formation history of a galaxy. In addition to morphological profiling, we perform a kinematic decomposition to characterize rotationally supported discs. This decomposition identifies cold and warm discs, bulges and stellar halo. A key parameter is the determination of rotation-to-dispersion ratio V/σ that serves as an indicator of the dynamical support within the galaxy, as higher ratios represent disc-like structures. Our study aims to bridge the gap between observations and simulations, enhancing our comprehension of early galaxy formation.

Keywords: morphology, kinematics, galaxy formation and evolution, cosmological simulations