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Can we link galaxy assembly times to the assembly times of their host halos?: A perspective from Mutual Information

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The Next Generation Illustris simulations (IllustrisTNG) have shown a remarkable match with the observed clustering properties of galaxies, providing us with a unique opportunity to study the relationship between the assembly times of galaxies, the color $(g - i)$ and the specific Star Formation Rate (sSFR) with the assembly times of their host dark-matter (DM) haloes. To quantify this dependence, we used the Mutual Information (MI) statistic, which assesses the dependence between two continuous or discrete variables. MI is a powerful tool that allows us to capture complex and nonlinear relationships. In our context, MI statistics enable us to identify the subtle correlations for galaxies in the stellar mass range of $10^9 \leq M_\star \leq 10^{11.5}$ \Msunh between the assembly times, the sSFR and color $(g - i)$ with the assembly times of their DM haloes. Our results show that the MI between the assembly times of central galaxies and their host haloes is moderate for galaxies with stellar masses below $M_\star$

$lesssim 10^{10.25}$\Msunh, decreasing for higher stellar masses. Also, we found that the MI between the assembly time of DM haloes and color $(g-i)$ show a weak correllation for central galaxies with stellar masses below $M_\star$

$lesssim 10^{10.5}$ and negligible for galaxies with higher stellar masses. The sSFR for central galaxies shows a negligible correlation with the assembly time of their haloes. For satellite galaxies, the MI is close to zero for all stellar masses and variables. Overall, our study highlighted the nature of these connections and the challenges of uncovering them.

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