Inferring the assembly and merger histories of galaxies with the IllustrisTNG simulations and machine learning

Lukas Eisert*[1], Annalisa Pillepich[1], Dylan Nelson[2], and Ralf Klessen[2]

[1]Max Planck Institute for Astronomy – Germany
[2]University of Heidelberg – Germany

Abstract

One of the main predictions of CDM-cosmology is the hierarchical buildup of structure and therefore also the successive merging of galaxies to more massive ones. As one can only observe galaxies at one specific time in cosmic history, this merging history remains in principle unobservable. By using the well-resolved and large-statistics galaxy populations simulated within the IllustrisTNG project (www.tng-project.org), we want to show how it is possible to infer the unobservable stellar assembly/merging history of galaxies from observable properties of the main galaxy body and the topology of the faint stellar halo surrounding it.
While it is difficult to quantify by hand the complex connections between observables and assembly histories, we are using cutting-edge machine learning techniques to model these. This allows not only to better understand and visualize those relationships, but also to ultimately transfer the learned knowledge to observational data from current and future galaxy surveys.

In a first approach, we choose a set of 7 observable integral properties of galaxies (like the total stellar mass, redshift, etc.) and try to infer from those the stellar exsitu fraction, the average merger lookbacktimes/mass ratios and the lookbacktime of the latest major merger.

By applying a conditional Invertible Neural Network (cINN), we are able to infer the posterior distribution of IllustrisTNG galaxies for these parameters. As result, we find that especially the stellar exsitu fraction is already well constrained by our set of observables and the posterior distribution decodes well the remaining unexplained scatter.

Based on this, we are now working towards a network, which is able to infer these quantites directly from images of galaxies or their stellar halos.

Slides: in PDF

Videos: https://youtu.be/OJtsv0SuS4Q

Keywords: Galaxy Evolution, Galaxy Merger, Simulations, Theory

*Speaker