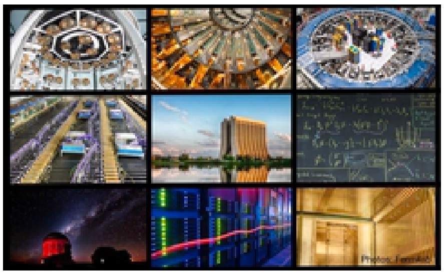

Contribution ID: **13** Type: **not specified**

Fast Inference of Star Formation Histories of Galaxies with Spectra and Simulation-Based Inference (SBI)

This contribution describes our efforts to study assembly of stellar mass in galaxies using cutting-edge inference methods.

A pressing question in the field of cosmological structure formation is how the long-term assembly and evolution of baryonic matter occurs in galaxies, and how this is related to the underlying dark matter distribution. Key signatures of mass assembly can be derived from a galaxy's spectral energy distribution (SED) – essentially its fingerprint. Unfortunately, traditional methods like Bayesian MCMC are prohibitively time consuming (~1-10 hours per object), especially as we are entering the age of cosmic surveys (DECaLS, DESI, Rubin), which are collecting images and spectra of galaxies across large cosmological volumes.). To exhaust the information from these surveys and evaluate all spectra, it is imperative that we have access to efficient methods for measuring galaxy characteristics.

Due to its speed and flexibility, simulation-based inference (SBI) is a promising path forward to measure galaxy SEDs in next-generation surveys . SBI allows inference of galaxy parameters (e.g., metallicity, star formation rate, etc.) from galaxy SEDs, accelerated by fast machine learning-based estimates of parameter posterior distributions – at a fraction of the cost of a few MCMC fits. In this work, we show initial results from our SBI analysis, in which we perform Sequential Neural Posterior Estimation (SNPE) to obtain 1- and 2-parameter SED fits. In our proof-of-concept analysis on simulated galaxy observations, we demonstrate that SBI is capable of inferring galaxy stellar masses and metallicities with accuracy and precision comparable to traditional MCMC-based inverse-modeling. We compare SBI to Bayesian Neural Network-based inference of these parameters. We also demonstrate the efficacy of our framework with photometry of cluster galaxies and gravitationally lensed systems; observations of these galaxies in the next decade are bound to help solve the question of stellar mass assembly and the evolution of the underlying dark matter distribution in galaxies.

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Session Classification: Cosmic Physics