Contribution ID: **4**

Type: **Flashtalk with Poster**

Analyzing ML-enabled Full Population Model for Galaxy SEDs with Unsupervised Learning and Mutual Information

Wednesday, 1 May 2024 16:00 (3 minutes)

The next generation of observatories such as the Vera C. Rubin Observatory and Euclid are posing a massive data challenge. An obstacle we need to overcome is the inference of accurate redshifts from photometric observations that can be limited to a handful of bands. We addressed this challenge with a forward modeling framework, pop-COSMOS, calibrated by fitting a population model to observations on the photometry space. This high-dimensional fitting, complete with data-driven noise modeling and flexible selection effects, is achieved via a novel use of simulation-based inference. Sampling from our fitted model provides the full spectral energy densities (SEDs) which encode the integrated information from all the stars, gas and dust in galaxies. pop-COSMOS therefore unlocks a medium for the study of galaxy evolution science that was not possible before, as it far surpasses the scope of current spectroscopic catalogs and their wavelength coverage. Analyzing the SEDs of high volume galaxy populations sampled from pop-COSMOS will be the focus of this talk, presenting analysis on the SEDs directly and on their lower-dimensional representations constructed by unsupervised learning algorithms. First, I will demonstrate how key galaxy evolution diagnostics are captured by variational autoencoders (VAE). I will then present our work using mutual information in two directions, (i) to measure the correlations between derived quantities and direct measures from galaxy SEDs, and (ii) to interpret the compressed latent representations constructed within the VAE. (i) paves the way for robust predictions of galaxy properties when only limited observations are available. (ii) provides a path for astrophysical discovery in an interpretible way on latent spaces.

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Session Classification: 4.2 Simulation-based inference

Track Classification: Session B