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AI-enabled Insights Into Galaxy Evolution

Understanding the properties of galaxy populations and their evolution is directly linked to the success of large-scale surveys such as The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST). Galaxy spectral energy densities (SEDs) encode these properties, but SED observations for a broad wavelength range via spectroscopy is a time consuming practice. LSST will perform photometric observations measuring the integrated light through a handful of bandpasses, effectively trading information loss for observational speed. An early obstacle we need to overcome is the inference of accurate distances (redshifts) from these limited photometric observations. We addressed this challenge with a forward modeling framework, pop-cosmos, utilizing AI to infer redshifts jointly with constraining galaxy properties. The complex space of galaxy properties is calibrated by fitting a population model parametrized by a diffusion model to photometric data. This high-dimensional fitting, complete with data-driven noise modeling and flexible selection effects, is achieved via a novel use of simulation-based inference. We fit this model to photometric data from one of the deepest extragalactic surveys, COSMOS2020. As a result samples from our trained model are realizations of the galaxy population within the survey limiting magnitude and up to a redshift of 4, capturing 90% of cosmic time. Therefore pop-cosmos unlocks a medium for the study of galaxy evolution that was not possible before. I will be presenting population-level results, specifically a comprehensive look at the star formation histories of galaxies inferred from our model. This will entail a detailed picture of the stellar mass assembly of galaxies together with the evolution of their metallicity and colors. I will showcase key results like the cosmic star formation rate density we derive using our model, and how these compare with results from the extensive literature.

AI keywords

simulation-based inference, diffusion models, generative models

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