Z209a A Flexible Galaxy Formation Model for Field-level Inference

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There is a strong motivation to extract the maximal information from observed images of telescopes. In traditional analysis, however, we discard most of the observations due to the difficulty in handling the high-dimensional image data. With recent advancements in machine learning architectures, we can perform inference at the pixel level (**field-level inference**). To accomplish this, I am developing a flexible galaxy-halo connection model that simulates galaxy field images by modeling consistent galaxy growth histories within cosmological structure formation. This model builds on the UniverseMachine (Behroozi et al. 2019) and adds dark matter halo property-dependent dust, metallicity and morphology to derive galaxy field images from dark matter-only simulations. SEDs are calculated using a Stellar Population Synthesis code, and SED-conditioned galaxy images are produced by a conditional denoising diffusion model. Key outcomes of the model include a fully physical, self-consistent picture of galaxy stellar masses, star formation histories, dust, and metallicity from z = 0 to 15; significantly reduced uncertainties on the evolution of galaxies in dark matter halos; and mock catalogs and images for arbitrary current and future surveys that match the latest observations.