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pop-cosmos: comprehensive forward modelling of photometric galaxy survey data

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Projects such as the imminent Vera C. Rubin Observatory are critical tools for understanding cosmological questions like the nature of dark energy. By observing huge numbers of galaxies, they enable us to map the large scale structure of the Universe. To do this, however, we need reliable ways of estimating galaxy redshifts from only photometry. I will present an overview of our pop-cosmos forward modelling framework for photometric galaxy survey data, a novel approach which connects photometric redshift inference to a physical picture of galaxy evolution. Within pop-cosmos, we model galaxies as draws from a population prior distribution over redshift, mass, dust properties, metallicity, and star formation history. These properties are mapped to photometry using an emulator for stellar population synthesis (speculator/photulator), followed by the application of a learned model for a survey's noise properties. Application of selection cuts enables the generation of mock galaxy catalogues. This naturally enables us to use simulation-based inference to solve the inverse problem of calibrating the population-level prior on physical parameters from a deep photometric galaxy survey. The resulting model can then be used to derive accurate redshift distributions for upcoming photometric surveys, for instance for facilitating weak lensing and clustering science. We use a diffusion model as a flexible population-level prior, and optimise its parameters by minimising the Wasserstein distance between forward-simulated photometry and the real survey data. I will show applications of this framework to COSMOS data, and will demonstrate how we are able to extract the redshift distribution, and make inference about galaxy physics, from our learned population prior. I will also discuss validation approaches applicable to simulation based fitting approaches.

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