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Galaxy modeling with physical forward models and generative neural networks

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Detection, deblending, and parameter inference for large galaxy surveys have been and still are performed with simplified parametric models, such as bulge-disk or single Sersic profiles. The complex structure of galaxies, revealed by higher resolution imaging data, such as those gathered by HST or, in the future, by Euclid and Roman, makes these simplifying assumptions problematic. Biases arise in photometry and shape measurements, and I will discuss examples for both.

On the other hand, non-parametric modeling also has a long history in many fields of image processing. But it is limited to signal-to-noise regimes that are high by the standards of most astrophysical surveys. This weakness can be overcome by specifying priors over the space of galaxy images. I will present a new codebase, scarlet2, written entirely in jax, for modeling complex extragalactic scenes. I will also discuss how to integrate data-driven priors in the form of score models, and show examples of sampling from posteriors to assess the uncertainties in heavily blended configurations. I will conclude with an outlook of how these tools need to be extended to fully exploit the data from the combination of optical surveys that will shape astrophysics in the 2020s.

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