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Towards reconstructing the halo clustering and halo mass function of N-body simulations using neural ratio estimation

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High-resolution cosmological N-body simulations are excellent tools for modelling the formation and clustering of dark matter haloes. These simulations suggest complex physical theories of halo formation governed by a set of effective physical parameters. Our goal is to extract these parameters and their uncertainties in a Bayesian context. In this talk, I will explain how we make a step towards automatising this process by directly comparing dark matter density projection maps extracted from cosmological simulations, with density projections generated from an analytical toy halo model. To accomplish this we use marginal neural ratio estimation, an algorithm for simulation-based inference that allows marginal posteriors to be estimated by approximating marginal likelihood-to-evidence ratios with a neural network. In this case, we train a neural network with mock images to identify the correct values of the physical parameters that produced a given image. Using the trained neural network on cosmological N-body simulation images we are able to reconstruct the halo mass function, to generate mock images similar to the N-body simulation images and to identify the lowest mass of the haloes of those images, provided that they have the same clustering with our training data.

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