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Learning Optimal and Interpretable Summary Statistics of Galaxy Catalogs with SBI

How much cosmological information can we reliably extract from existing and upcoming large-scale structure observations? Many summary statistics fall short in describing the non-Gaussian nature of the late-time Universe and modelling uncertainties from baryonic physics. Using simulation based inference (SBI) with automatic data-compression from graph neural networks, we learn optimal summary statistics for galaxy catalogs in the context of cosmological parameter estimation. By construction these summaries do not require the ability to write down an explicit likelihood. We demonstrate that they can be used for efficient parameter inference, outperforming existing (ML) methods for the same parameter estimation. These summary statistics offer a new avenue for analyzing different simulation models for baryonic physics with respect to their relevance for the resulting cosmological features. The learned summary statistics are low-dimensional, feature the underlying simulation parameters, and are similar across different network architectures. To link our models, we identify the relevant scales associated to our summary statistics (e.g. in the range of modes between) and we are able to match the summary statistics to underlying simulation parameters across various simulation models. Furthermore, we compare different baryonic feedback models in latent space and find differences in the flexibility of their parametrizations.

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