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Cosmological Density Field Emulation and Gravitational Wave Inference based on Dimensionality Reduction and Supervised Machine Learning

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Two major challenges in modern cosmology are the understanding of the origin and growth of cosmic structure and the progenitors of Gravitational Waves. Both scenarios require heavy computational resources to perform simulations and inference. In this work, we propose to adopt Machine Learning to alleviate these requirements, to enable significantly faster sampling and inference. We show that using Dimensionality Reduction and Supervised Learning, it is possible to generate high precision emulations of Dark Matter Density Fields given a set of cosmological parameters (the dark matter density and redshift). This led to orders of magnitude improvement in execution time and far less computational resources than running N-Body simulations. We also show that using the same approach it is possible to generate fast inferences of Chirp Masses from Binary Black Hole systems. The methods we present here may provide an important key to enabling fast and accurate data analysis for upcoming surveys like Euclid, LSST/Rubin, and LISA.

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