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Field-level Emulator within Bayesian Origin Reconstruction from Galaxies (BORG)

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Unlocking the full potential of next-generation cosmological data requires navigating the balance between sophisticated physics models and computational demands. We propose a solution by introducing a machine learning-based field-level emulator within the HMC-based Bayesian Origin Reconstruction from Galaxies (BORG) inference algorithm. The emulator, an extension of the first-order Lagrangian Perturbation Theory (LPT), achieves remarkable accuracy compared to N-body simulations while significantly reducing evaluation time. Leveraging its differentiable neural network architecture, the emulator enables efficient sampling of the high-dimensional space of initial conditions. To demonstrate its efficacy, we use the inferred posterior samples of initial conditions to run constrained N-body simulations, yielding highly accurate present-day non-linear dark matter fields compared to the underlying truth used during inference.

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