

# Towards a Quasi-Universal Field-Level Cosmological Emulator

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We train convolutional neural networks to correct the output of fast and approximate N-body simulations at the field level. Our model, Neural Enhanced COLA, -NECOLA-, takes as input a snapshot generated by the computationally efficient COLA code and corrects the positions of the cold dark matter particles to match the results of full N-body Quijote simulations. We quantify the accuracy of the network using several summary statistics, and find that NECOLA can reproduce the results of the full N-body simulations with sub-percent accuracy down to  $k \simeq 1 \text{ hMpc}^{-1}$ . Furthermore, the model, that was trained on simulations with a fixed value of the cosmological parameters, is also able to extrapolate on simulations with different values of  $\Omega_m$ ,  $\Omega_b$ ,  $h$ ,  $n_s$ ,  $\sigma_8$ ,  $w$ , and  $M_\nu$  with very high accuracy: the power spectrum and the cross-correlation coefficients are within  $\simeq 1\%$  down to  $k = 1 \text{ hMpc}^{-1}$ . Our results indicate that the correction to the power spectrum from fast/approximate simulations or field-level perturbation theory is rather universal. Our model represents a first step towards the development of a fast field-level emulator to sample not only primordial mode amplitudes and phases, but also the parameter space defined by the values of the cosmological parameters.

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