ID de Contribution: **24** Code de contribution: **Confirmed** Type: **Talk (shorter)**

# Towards a Quasi-Universal Field-Level Cosmological Emulator

*mercredi 20 avril 2022 16:22 (7 minutes)*

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 $k \simeq 1\ h\mathrm{Mpc}^{-1}$. 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 $\Omega_\mathrm{m}$, $\Omega_\mathrm{b}$, $h$, $n_s$, $\sigma_8$, $w$, and $M_\nu$ with very high accuracy: the power spectrum and the cross-correlation coefficients are within $\simeq 1\%$ down to $k = 1\ h\mathrm{Mpc}^{-1}$. 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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**Classification de Session:** Talks