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Extracting cosmological information from galaxy peculiar velocities using machine learning

A powerful approach to constraining cosmological parameters from galaxy peculiar velocities is to train graph neural networks (GNNs) for field-level likelihood-free inference without scale restrictions. We developed models that robustly infer the value of $\Omega_{\rm m}$ using only the positions and radial velocities of galaxies, achieving resilience to various astrophysical complexities, sub-grid models, and galaxy/sub-halo finders. However, real-world observations present significant challenges, such as (i) masking, (ii) uncertainties in peculiar velocities and radial distances, and (iii) diverse galaxy population selections. Additionally, observational data are limited to redshifts, where radial positions and velocities become entangled. In this talk, I will present how we trained and tested these GNN models on synthetic galaxy catalogs from thousands of state-of-the-art hydrodynamic simulations generated by different codes within the CAMELS project, with and without observational effects. Despite the challenges, our results show that over 90% of galaxy catalogs retain high performance and robustness, underscoring the potential of this approach for real-world data applications.

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