Z117a Forward Modeling and Cosmological Inference of Galaxy Clustering the Field Level

Nhat-Minh Nguyen (Kavli IPMU)

Discovering new physics from large galaxy surveys remains challenging due to limitations in current modeling and inference methods. Examples include our inability to simulate realistic galaxies and model the galaxy power spectrum at small scales, hampered by uncertainties in galaxy formation. To robustly marginalize over astrophysical complexities while maximally extracting cosmological information, I will present a new program for cosmological analyses of galaxy surveys: field-level inference of large-scale structure grounded in effective field theory, `LEFTfield`. `LEFTfield` leverages forward-modeling and differentiable-programming techniques to extract not only cosmological information, but also the entire underlying, unobserved dark-matter field. In the case of galaxy clustering, `LEFTfield` delivers up to $\times 5$ improvement in constraining power—a leap between two survey generations when translated to survey volume. The byproduct dark-matter field enables constrained simulations of our local Universe, opening new windows to study astrophysical processes, including galaxy formation, in our cosmic neighborhood.