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Diagnosing Systematic Effects Using the Inferred Initial Power Spectrum

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The next generation of galaxy surveys has the potential to significantly deepen our understanding of the Universe, though this potential hinges on our ability to rigorously address systematic uncertainties. This was previously beyond reach in field-based implicit likelihood cosmological inference frameworks. We aim at inferring the initial matter power spectrum after recombination to diagnose a variety of systematic effects in galaxy surveys prior to inferring the cosmological parameters. Our approach is built upon a two-step framework. First, we employ the SELFI algorithm to infer the initial matter power spectrum, which we utilise to comprehensively investigate and disentangle how systematic effects influence the power spectrum reconstruction, using a single set of N-body simulations. Second, we obtain posterior cosmological parameters via implicit likelihood inference, recycling the simulations from the first step for data compression. We rely on a model of large-scale spectroscopic galaxy surveys that incorporates fully non-linear gravitational evolution and simulates multiple systematic effects typically encountered in astrophysical surveys. We demonstrate along with a practical guide how the SELFI posterior can be utilised to thoroughly assess the impact of misspecified linear galaxy bias parameters, selection functions, survey masks and inaccurate redshifts on the initial power spectrum after recombination. We show that a subtly misspecified model can lead to a bias greater than 2σ in the (Ωm, σ8) plane, which we are able to detect and avoid using SELFI prior to inferring the cosmological parameters. This framework has the potential to significantly enhance the robustness of physical information extraction from full-forward models of large-scale galaxy surveys such as DESI, Euclid, and LSST.

Astrophysics Field

cosmology, large-scale structure, statistical methods

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