2-Loop Power Spectrum for Lensing: A Forecast for Roman Space Telescope Cosmic Shear

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Introduction

The EFTofLSS provides a perturbative method to compute the matter power spectrum in the mildly non-linear regime. This involves integrating out small scales at the expense of additional nuisance parameters. We perform a profile likelihood for S_8 using Roman real-space cosmic shear with the CMB first peak as a "prior" on $\Omega_m h$ to control the perturbation theory.

MPS at Two-Loops

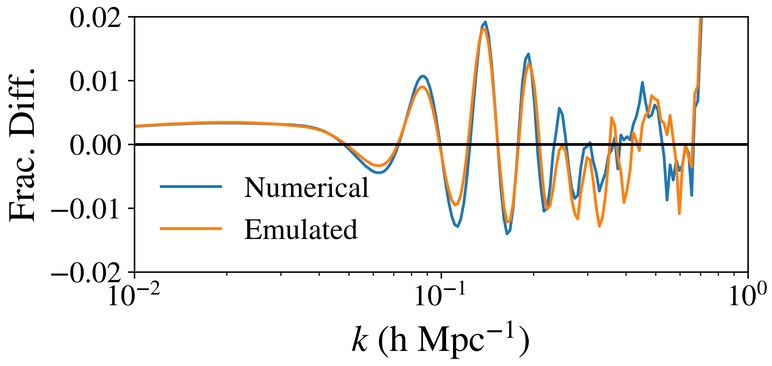
At two loops, there are ***five*** redshift-dependent nuisance parameters. Schematically, it is given by

$$P(k,z) \sim P_0(k,z) + P_1(k,z,\Lambda) + P_2(k,z,\Lambda) - [c^2_{s\,(1)}(z,\Lambda) + c^2_{s\,(2)}(z,\Lambda)]k^2 P_0(k,z) - [c^4_{s\,(1)}(z,\Lambda) - 2c_4(z,\Lambda)]k^4 P_0(k,z) - c^2_{s\,(1)}(z,\Lambda)k^2 P_1(k,z,\Lambda) - c_{\rm quad}(z,\Lambda)k^2 P_{\rm quad}(k,z) + c_{\rm stoch}k^4$$

The integrals in the EFT were computed to 0.1% accuracy using CUBA.

These integrals are expensive! Thus we train a neural network to map the cosmological parameters to the loop corrections. These loop integral emulators are also accurate to 0.1% of the numerical calculation.

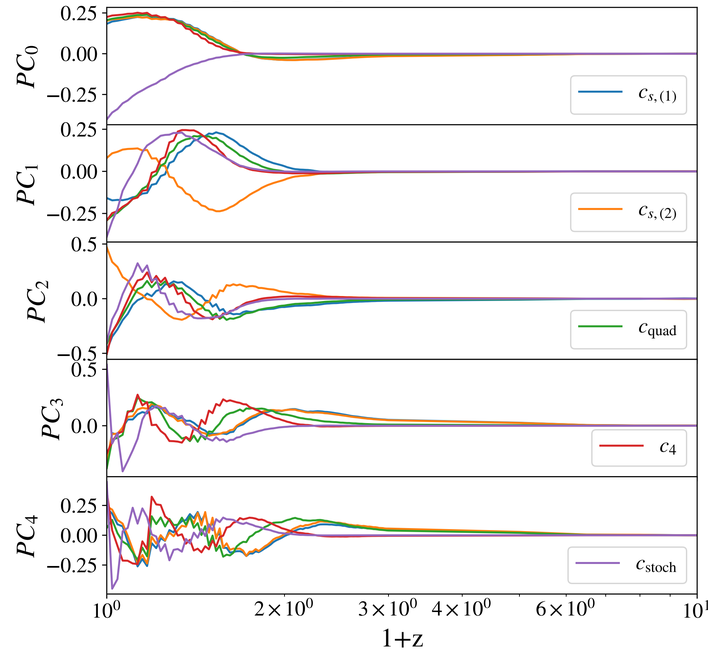
The resulting full calculation is a two-loop power spectrum accurate to EE2 at the percent level up to $k = 0.7/D(z)$. Improvements can be made to the damping term in the IR resummation to avoid the oscillatory errors



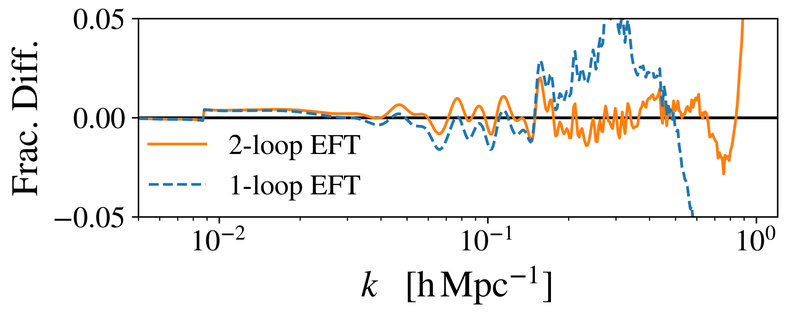
Redshift Dependence

Lensing information requires integration of the MPS along the entire line of sight. As such, it is crucial that we can model the MPS across a range of redshifts.

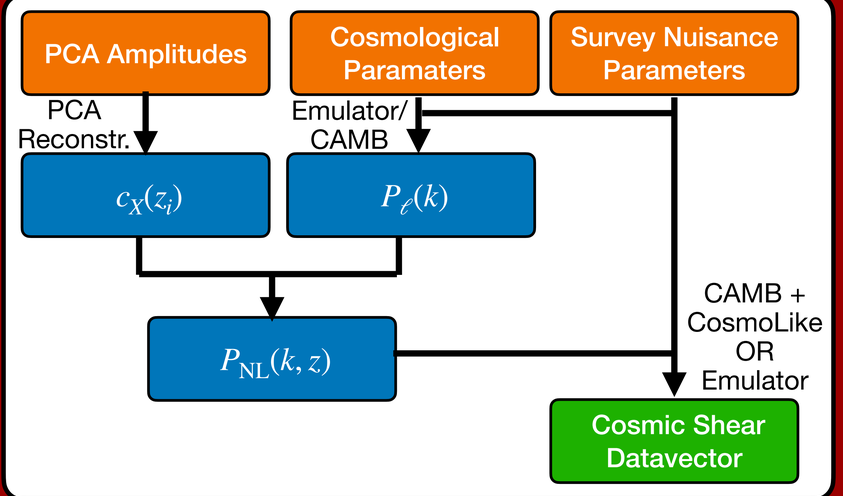
We first sample 1000 cosmologies within the CMB first peak. Then we fit the EFT power spectrum to EE2 at a 100 redshifts in the range $z \in [0,10]$ and perform a PCA on the result Wilson coefficients to compress the redshift dependence to a few parameters. Our remaining results use the first five principle components.



A persistent challenge is to allow enough freedom in the functional form of the Wilson coefficients without introducing too many nuisance parameters. This is an ongoing investigation for us.

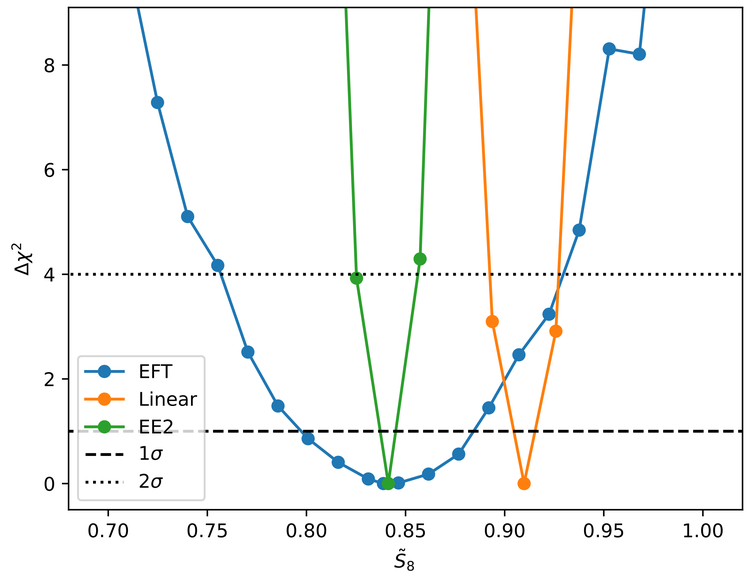


We get an increase from a $k_{\rm max}$ of 0.15 to 0.7 when including the two loop contributions within the CMB first peak prior.



Profile Results

We lose some constraining power, but are not biased compared to EE2. This is contrasted to using the linear power spectrum, which contributes a significant bias on S_8.



We are working to improve the constraints by using Theory-based priors on the Wilson coefficients as well as getting better compression of the redshift dependence. Such improvements could allow more aggressive scale cuts and also reduce the number of nuisance parameters, leading to improved constraints. However, there is always a delicate balance between constraining power and parameter biases that we need to be cautious of. But if we modify beyond LCDM, we can know we are doing the modeling correctly by using EFTofLSS.