The LIM Super Sample Covariance

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What Is the Super Sample Covariance and Do We Care?

- Nonlinear evolution of matter → non-Gaussianities
- Contributions of tri spectrum to covariance
- Super survey modes

  → different evolution of nonlinearities

  → Super sample covariance

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What Is the Super Sample Covariance and Do We Care?

- Well studied for galaxy redshift surveys
- Effects larger for smaller surveys
- Especially important at small scales

⇒ Study the effect for typical LIM surveys

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The Sample Covariance without a Window

The non-Gaussian part is related to
the connected 4-point function

$$\mathrm{Cov}(k_1, k_2) = \mathrm{Gaussian}(k_1)\,\delta_{k_1,k_2} + \mathrm{nonGaussian}(k_1, k_2)$$

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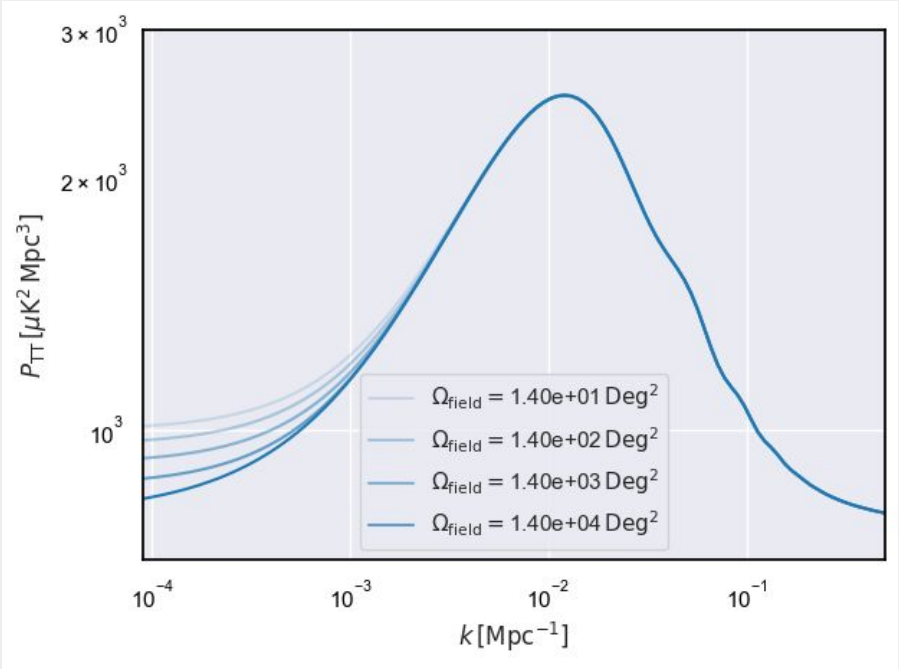
Effect of the Survey Window

In Fourier space:

- Perturbations are smoothed over characteristic scale
- Smaller surveys have larger smoothing scales
- Effect on power spectrum



Effect of the Survey Window

For the tri spectrum:

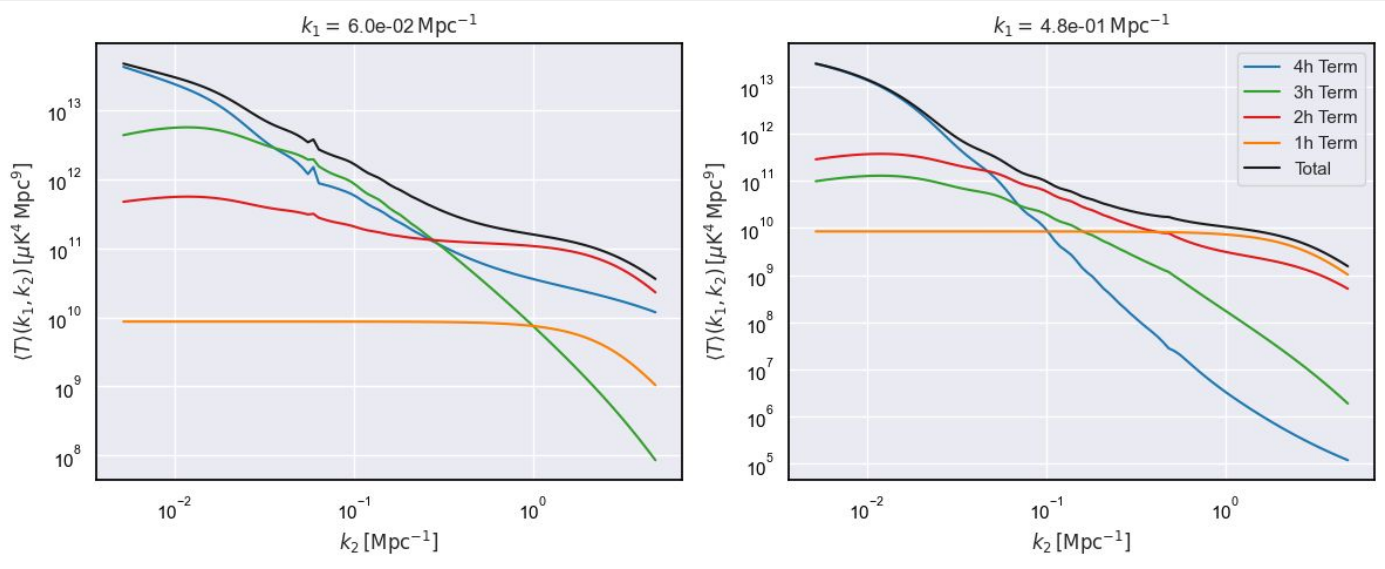
We expand the non-Gaussian covariance in k_i over smoothing scale

$$\widehat{\mathrm{nonGaussian}} = \mathrm{nonGaussian} + \mathrm{SSC}$$

Non Gaussian Covariance

Compute the tri spectrum using

LIM halo model × standard perturbation theory



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The Super Sample Covariance

$$\mathrm{SSC}(k_1, k_2) = \frac{\sigma^2}{V_{\mathrm{field}}} R(k_1) P_{\mathrm{TT}}(k_1)\, R(k_2) P_{\mathrm{TT}}(k_2)$$

Variance of δ smoothed over the window

Response of P to large scale modes

The Super Sample Covariance

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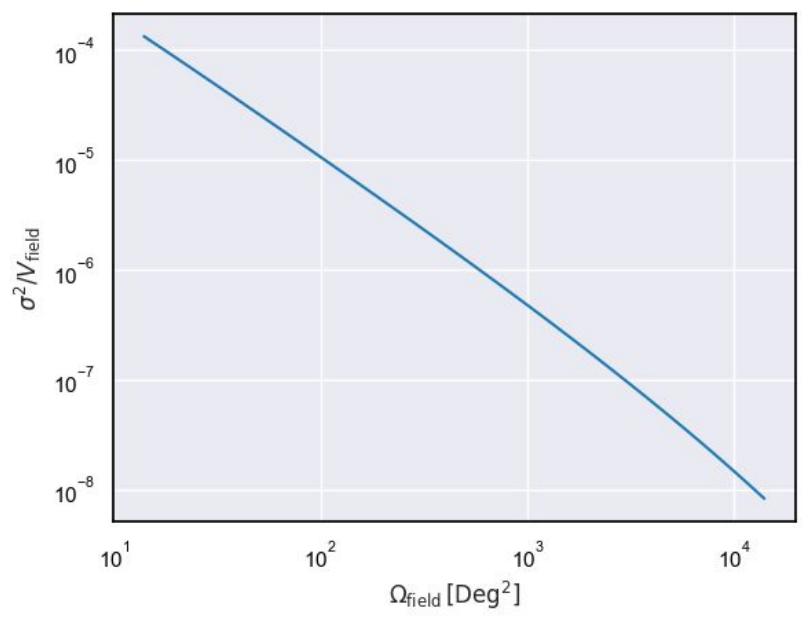
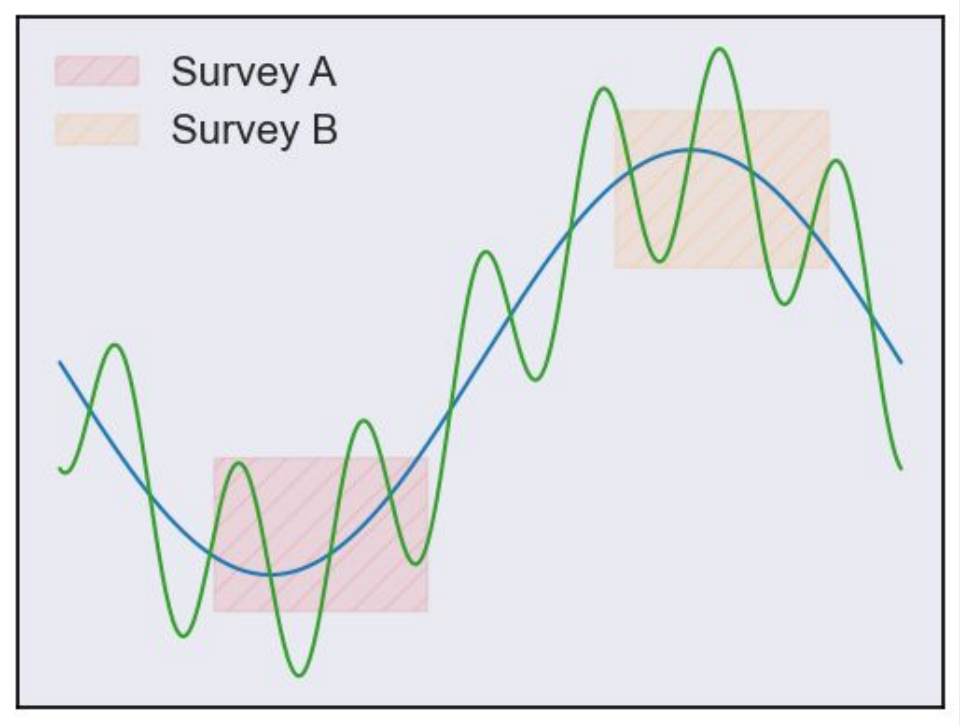


The Super Sample Covariance

The LIM observables depend on the particular large wavelength modes within a particular survey



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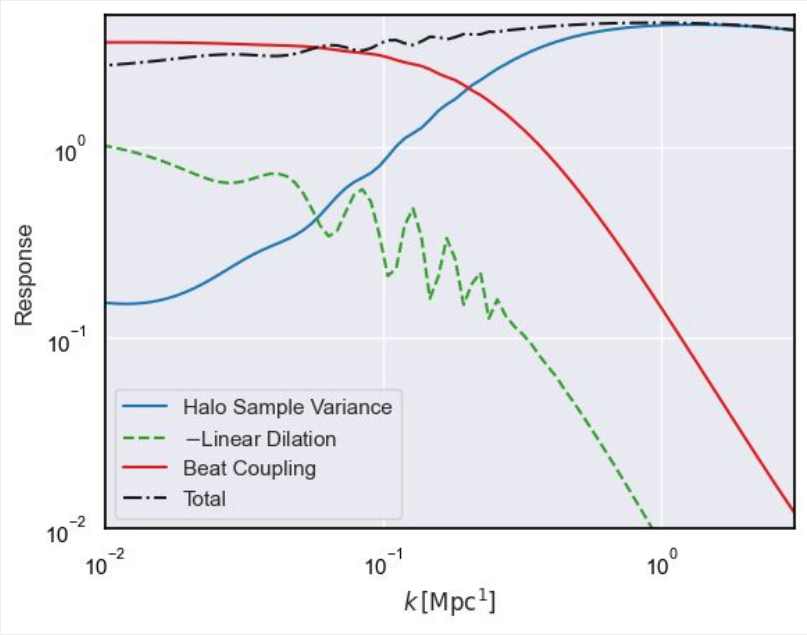
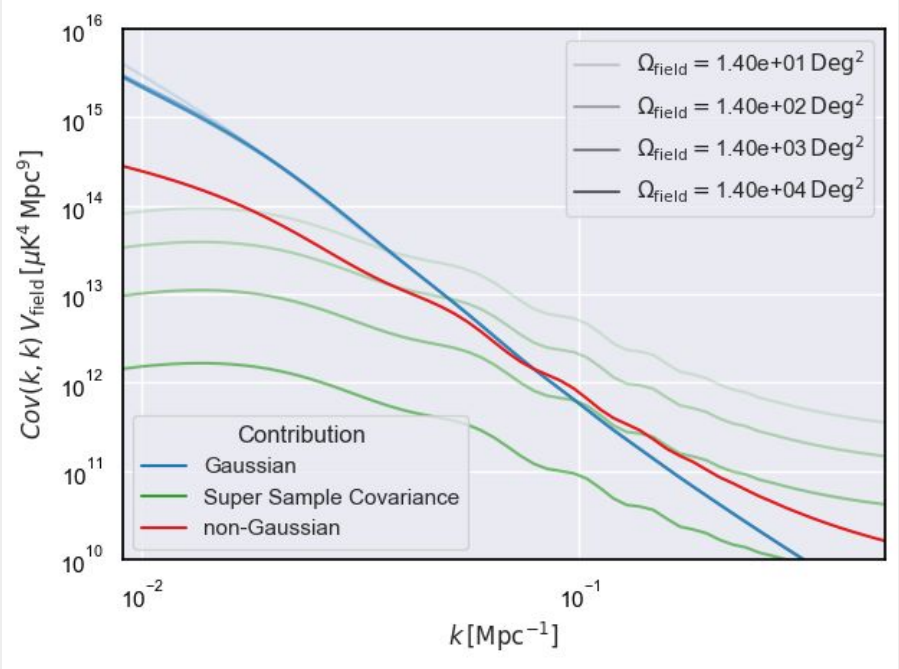


The Full Sample Covariance

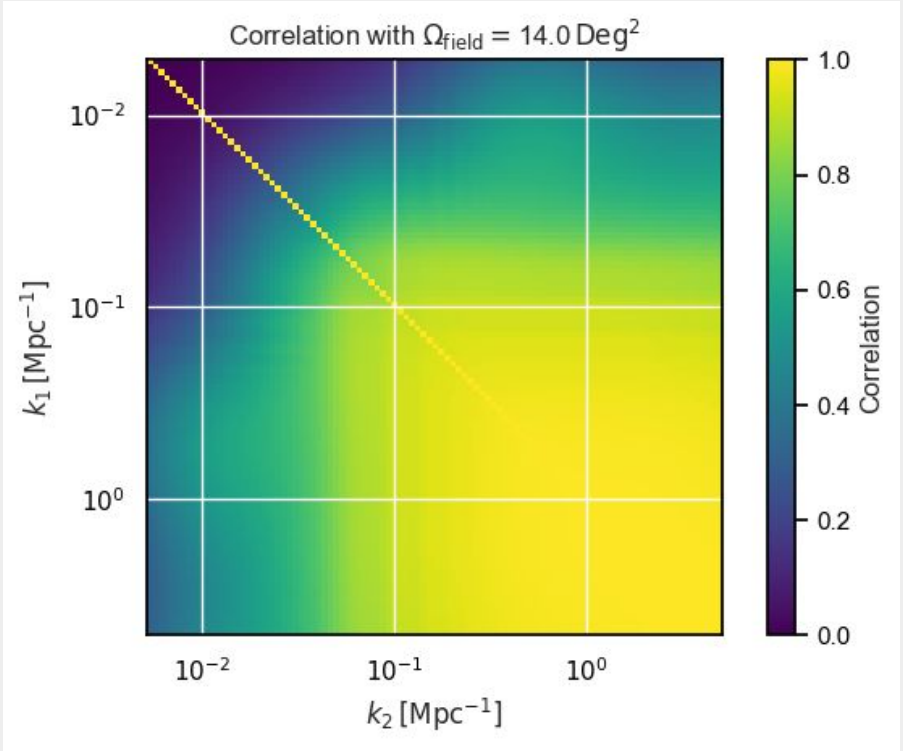
1. Small survey volumes
   → Dominant SSC already at large scales

2. Larger survey volumes
   → tri spectrum contribution becomes significant



The Full Sample Covariance

3. Non-Gaussianities introduce significant off diagonal terms



Non-Analytic Covariance Estimates

- Only (non-)Gaussian can be estimated from data
- For the SSC super survey modes have to be considered
- Can be extracted from simulations (Field-to-Field Variance)

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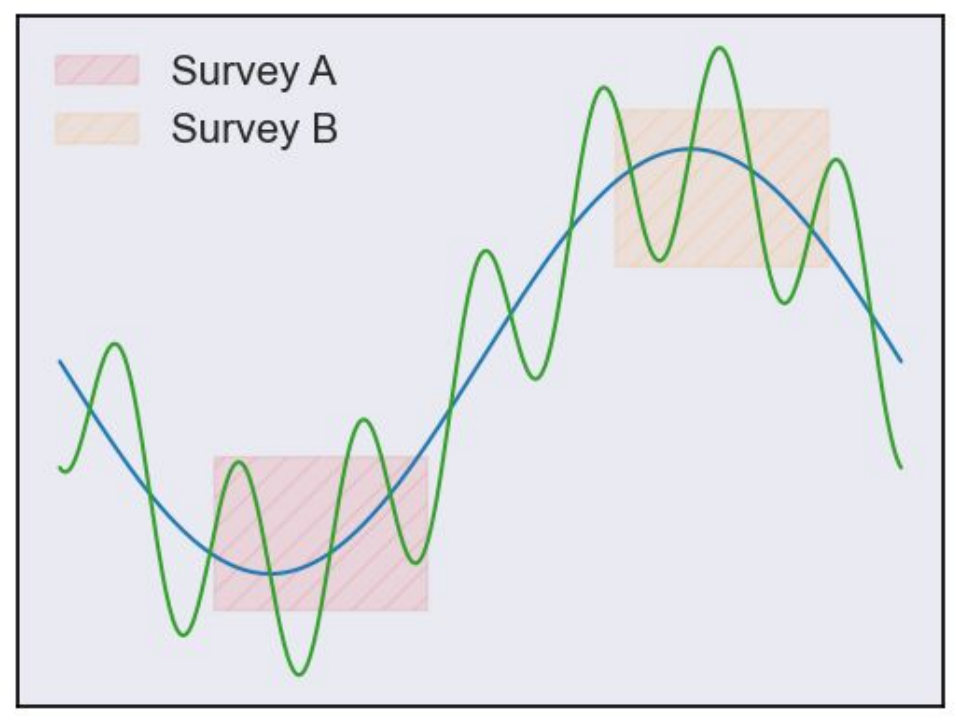
Interpretation

Detections: SSC is measure for deviation from cosmological average

Parameter inference: SSC adds additional uncertainty to measurements



Key Takeaways

Nonlinear evolution leads to strong non-Gaussianities

Small volumes have additional source of super survey uncertainty

Could be important vor LIM!

With the detection era on the horizon we want to be ready to interpret the data

Find the code at Github →

https://github.com/Sefa76/SSLimPy

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