The Galaxy Bispectrum as a Probe of Primordial non-Gaussianity

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Motivation to Study LSS Effects of non-Gaussianity

Goals

- learn about the dynamics of the inflaton field
- LSS provides constraints independent of CMB constraints

Approach

- bispectrum as a measure of interactions between short and long modes
- perturbation theory to derive shape and scale dependence
- additional difficulties: non-linear clustering, biased tracers

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Primordial non-Gaussianity from Inflation

Models of Inflation

- slow-roll single-field Inflation - small non-Gaussianity
- non-standard single-field Inflation - equilateral and orthogonal non-Gaussianity
- multifield Inflation - local non-Gaussianity

Local non-Gaussianity

$$\Phi_{nG}(\mathbf{x}) = \varphi(\mathbf{x}) + f_{NL}\left(\varphi^2(\mathbf{x}) - \langle\varphi^2\rangle\right) + g_{NL}\varphi(\mathbf{x})^3$$

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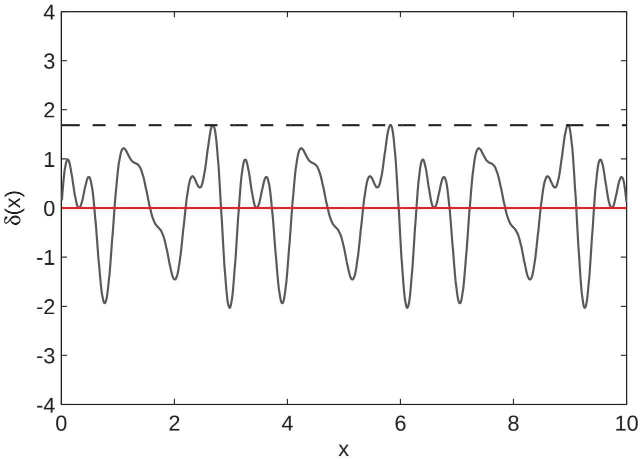
Clustering with local non-Gaussianity



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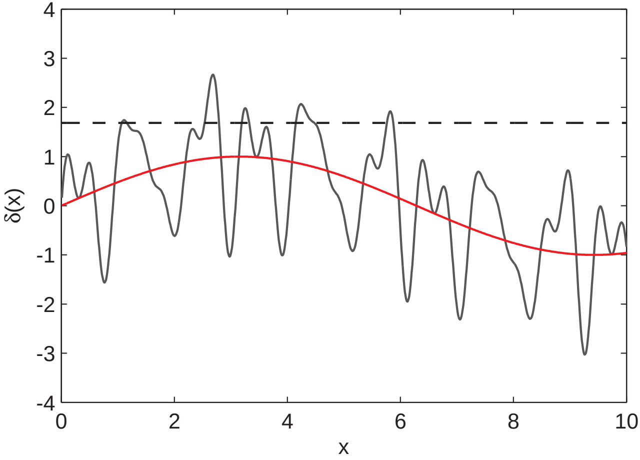
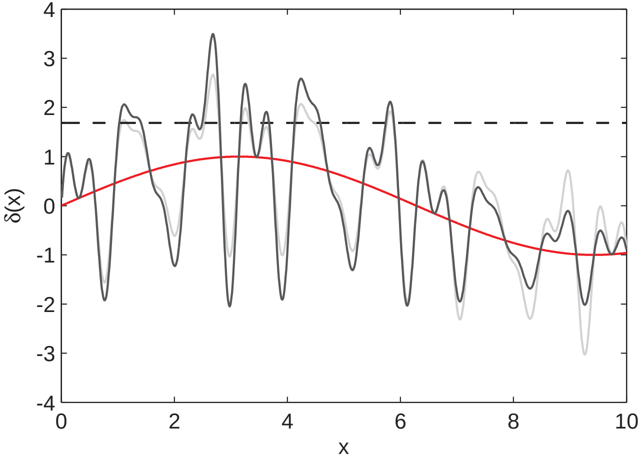


Clustering with local non-Gaussianity



Ingredients

- galaxy/halo density field δ_{g}
- matter density field δ_{m}
- primordial gravitational potential φ
- power spectrum $P_{\delta\delta}(k) = \alpha(k) P_{\delta\varphi}(k) = \alpha^2(k) P_{\varphi\varphi}$

Local non-Gaussianity

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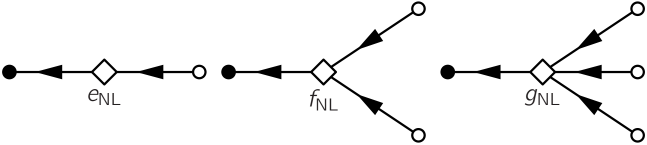
$$\begin{aligned}\delta(\mathbf{k}) =& \alpha(k)\Phi_{nG}(\mathbf{k})\\ =& \alpha(k)\varphi(\mathbf{k}) + \alpha(k) f_{NL}\int d^3q\,\delta^{(D)}(\mathbf{k}-\mathbf{q}_1-\mathbf{q}_2)\varphi(\mathbf{q}_1)\varphi(\mathbf{q}_2) + \dots\end{aligned}$$



Non-linear Clustering

Fluid equations

$$\frac{\partial \delta(\mathbf{x},\tau)}{\partial \tau} + \theta(\mathbf{x},\tau) = 0$$

$$\frac{\partial \theta(\mathbf{x},\tau)}{\partial \tau} + \mathcal{H}(\tau)\theta(\mathbf{x},\tau) + \frac{3}{2}\Omega_{\mathrm{m}}\mathcal{H}^2(\tau)\delta(\mathbf{x},\tau) = 0$$

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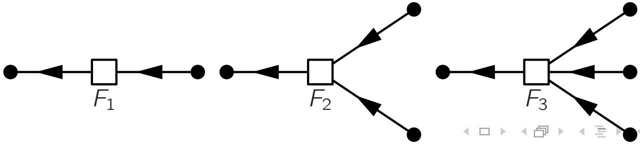
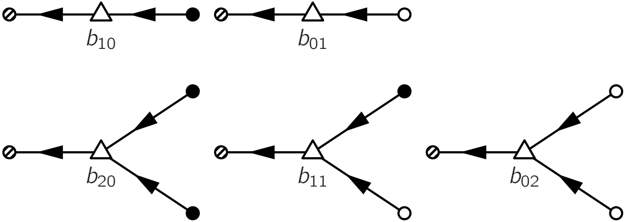
$$\delta_n(\mathbf{k}) = \int d^3q_1 \ldots \int d^3q_n \, \delta^{(\mathrm{D})}\left(\mathbf{k} - \sum_s \mathbf{q}_s\right) F_n(\mathbf{q}_1, \ldots, \mathbf{q}_n)\delta_0(\mathbf{q}_1)\ldots\delta_0(\mathbf{q}_n)$$



Multivariate Biasing[1]

$$\delta_{\rm g}(\mathbf{x}) = \sum_{i,j} b_{ij}\delta^i(\mathbf{x})\varphi^j(\mathbf{x})$$

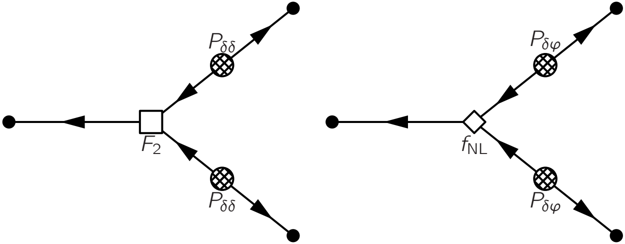
$$\delta_{{\rm g},ij}(\mathbf{k}) = b_{ij}\int d^3q_1 \ldots \int d^3q_{i+j}\,\delta^{(\rm D)}\Big(\mathbf{k}-\sum_s \mathbf{q}_s\Big)\delta_1(\mathbf{q}_1)\ldots\varphi_j(\mathbf{q}_{i+j})$$



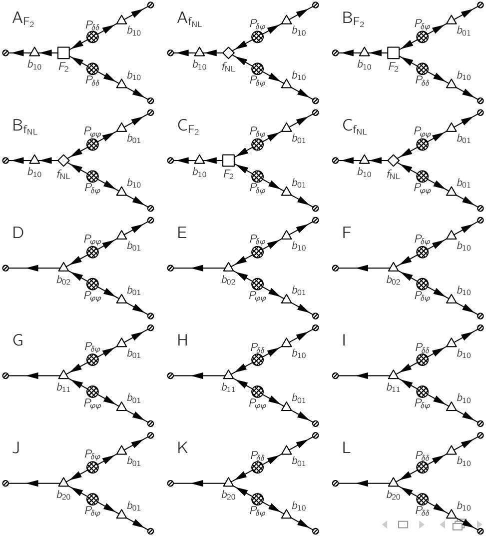
1 [Giannantonio & Porciani 2010]

Example: Matter Bispectrum

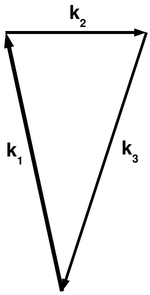
$$B_{\rm mmm}(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3) = \left(2P(k_1)P(k_2)F_2(\mathbf{k}_1,\mathbf{k}_2)+2\ \text{cyc.}\right)+ \left(2f_{\rm NL}\frac{P(k_1)P(k_2)\alpha(k_3)}{\alpha(k_1)\alpha(k_2)}+2\ \text{cyc.}\right) = B_{F_2}(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)+B_{f_{\rm NL}}(\mathbf{k}_1,\mathbf{k}_2,\mathbf{k}_3)$$

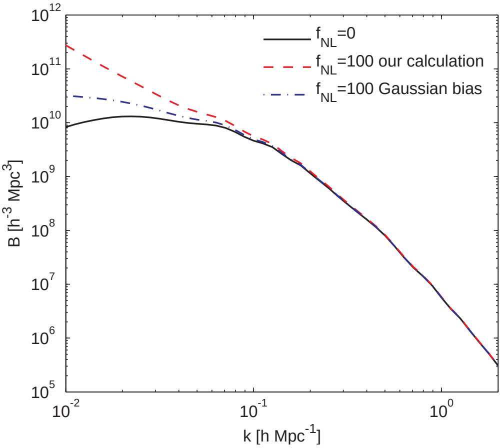


Galaxy Bispectrum



Galaxy Bispectrum - Squeezed Configuration





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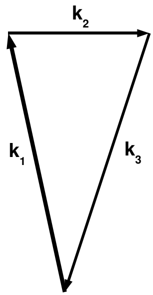
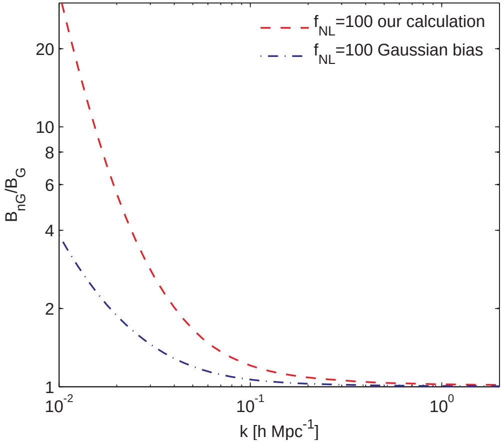
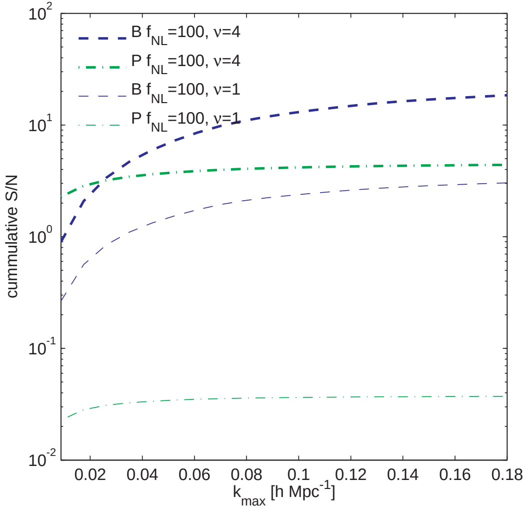




Galaxy Bispectrum - Signal-to-Noise



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- diagramatic prescription including effects of
  - clustering
  - biasing
  - non-Gaussianity
- corrections to existing calculations at tree level
- bispectrum has more information on nG than power spectrum

Outlook

- resummation and interpretation of loop contributions
- comparison with N-body simulations

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Thank you for your attention!