Non Gaussianity in two-field inflation

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Understanding inflation

- Inflation: period of accelerated expansion

  ➡ Flatness and Horizon problems

- Requires dynamical field(s) ➡ generates perturbations

- Specific details of inflation encoded in correlation functions

- Distinct imprint on the large scale structure: LSST, Euclid, SPHEREx,…

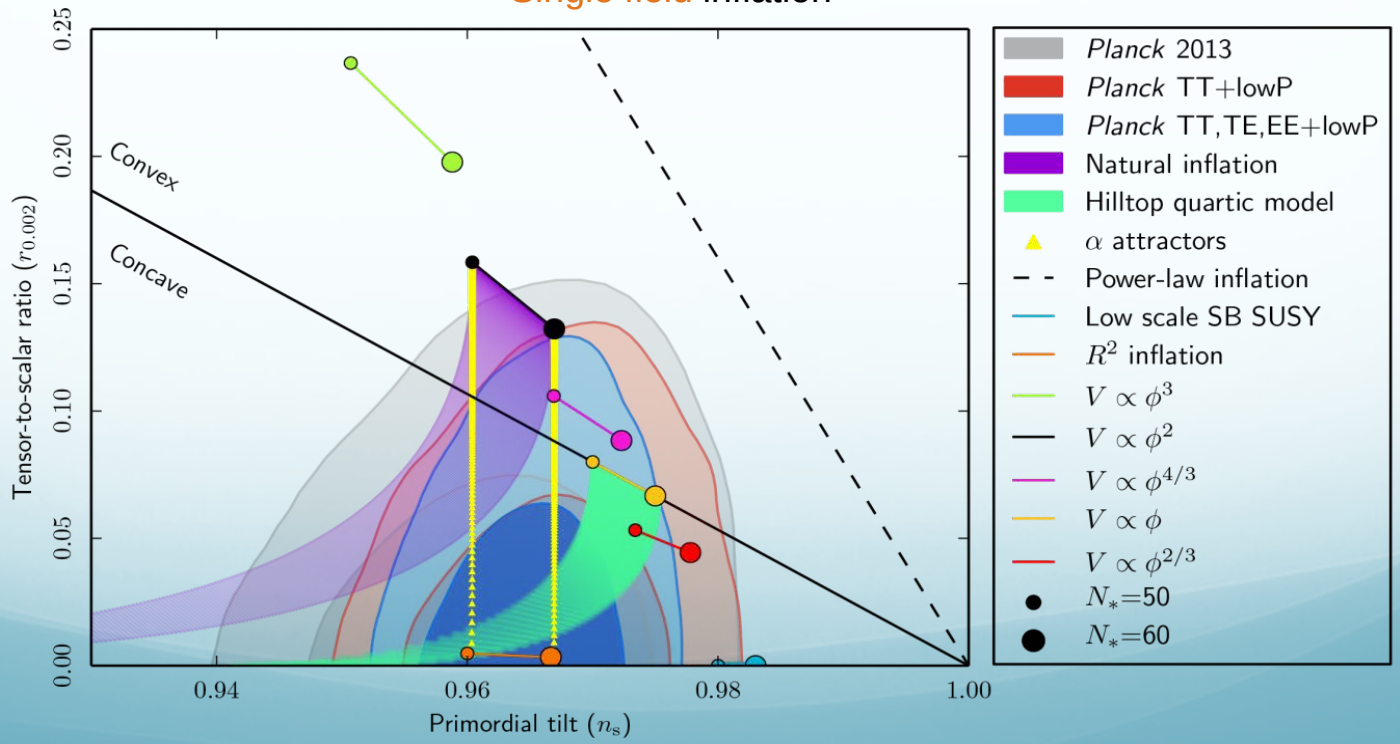
Why study Non Gaussianity?

Two-point → Scalar: $n_s - 1 = 0.9645 \pm 0.0049$ *Planck '15*

Tensor: $r < 0.12$ *Planck & BICEP2 '15*

$$(A_s, n_s - 1, r) \longrightarrow (V, V', V'')$$

Single field inflation



Planck '15

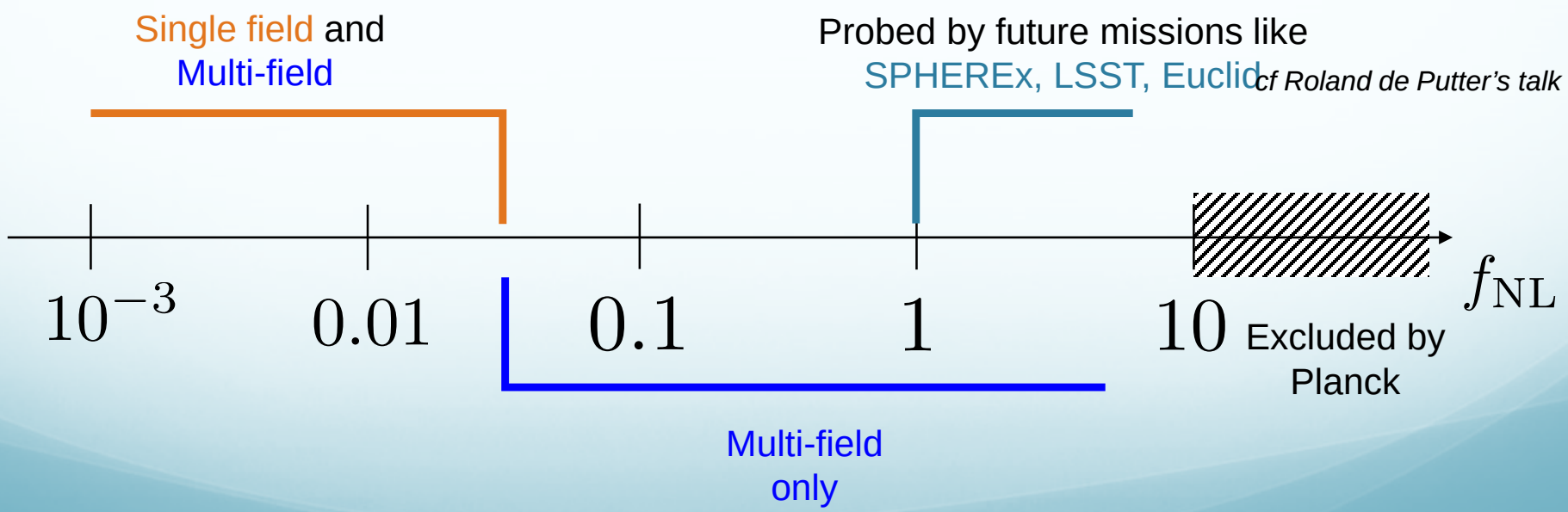
Why study Non Gaussianity?

Three-point → f_{NL} → $\mathcal{O}(n_s - 1)$ *Maldacena '02*

Single field inflation

→ ?

Multi-field inflation



How to get large $f_{\rm NL}$

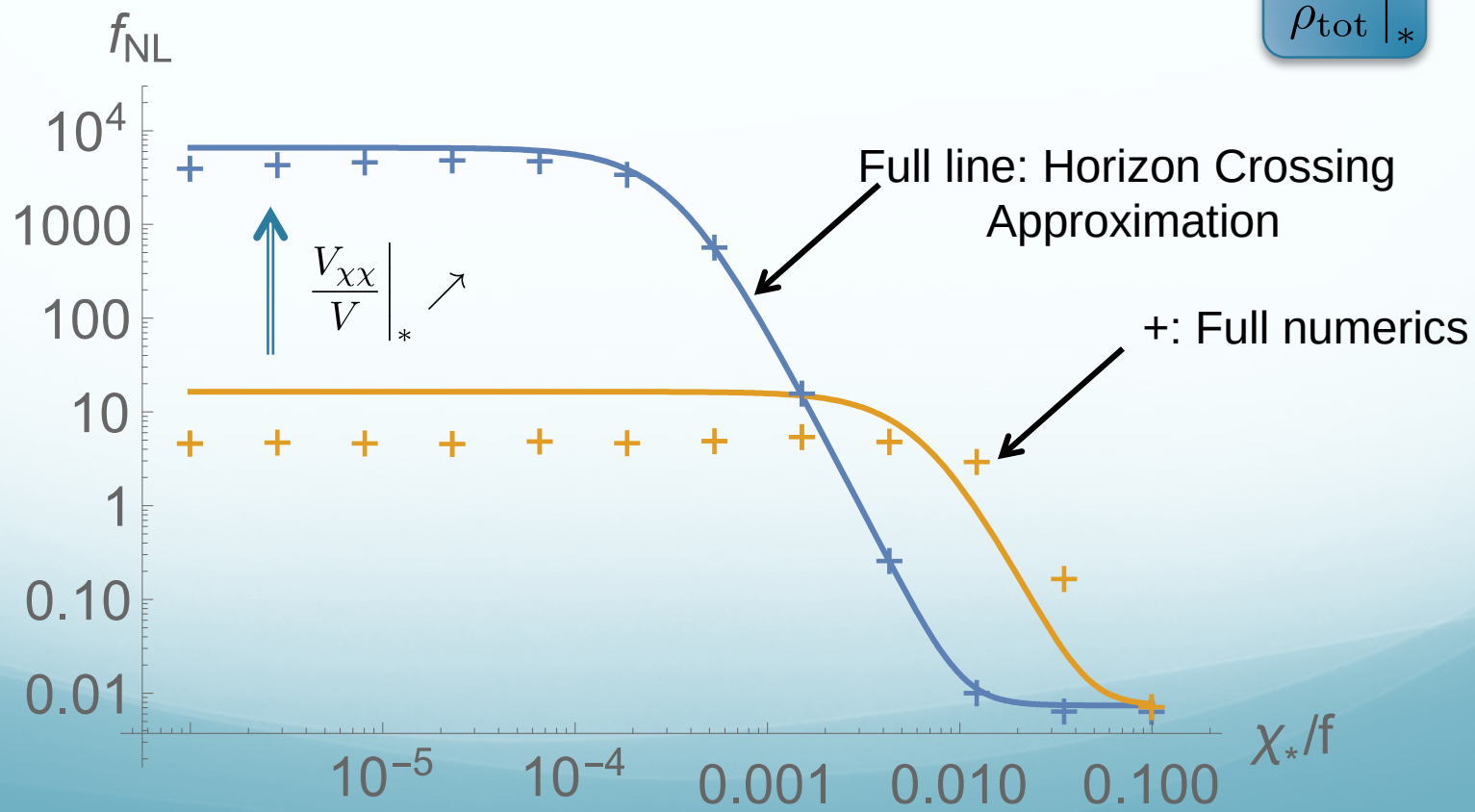
With de Putter and Doré, in prep

- From inflation with sum separable potential $V(\phi,\chi) = U(\phi) + V(\chi)$

Simple Analytics → $\left.\frac{V_{\chi\chi}}{V}\right|_* \gg 1$ → $f_{\rm NL} \sim \frac{P_\chi}{P_\zeta}\frac{n_s - 1 - n_T}{r_V}$

Vernizzi & Wands '06

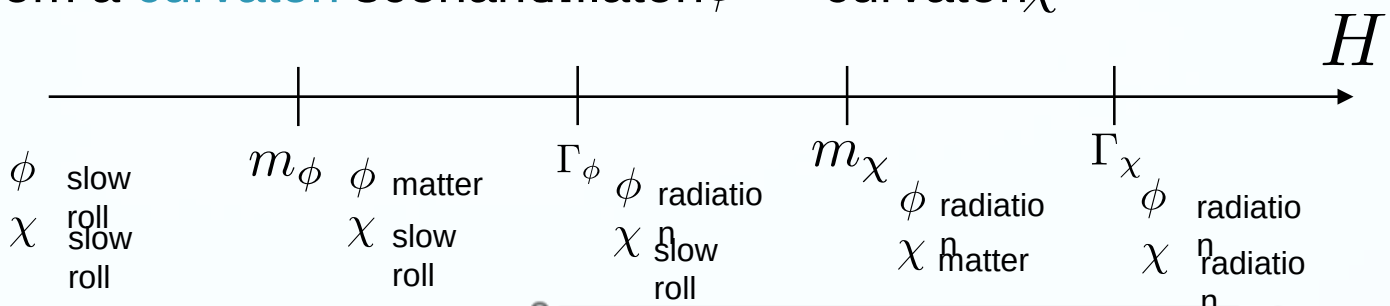
$\left.\frac{\rho_\chi}{\rho_{\rm tot}}\right|_*$



How to get large $f_{\rm NL}$

With de Putter and Doré, in prep

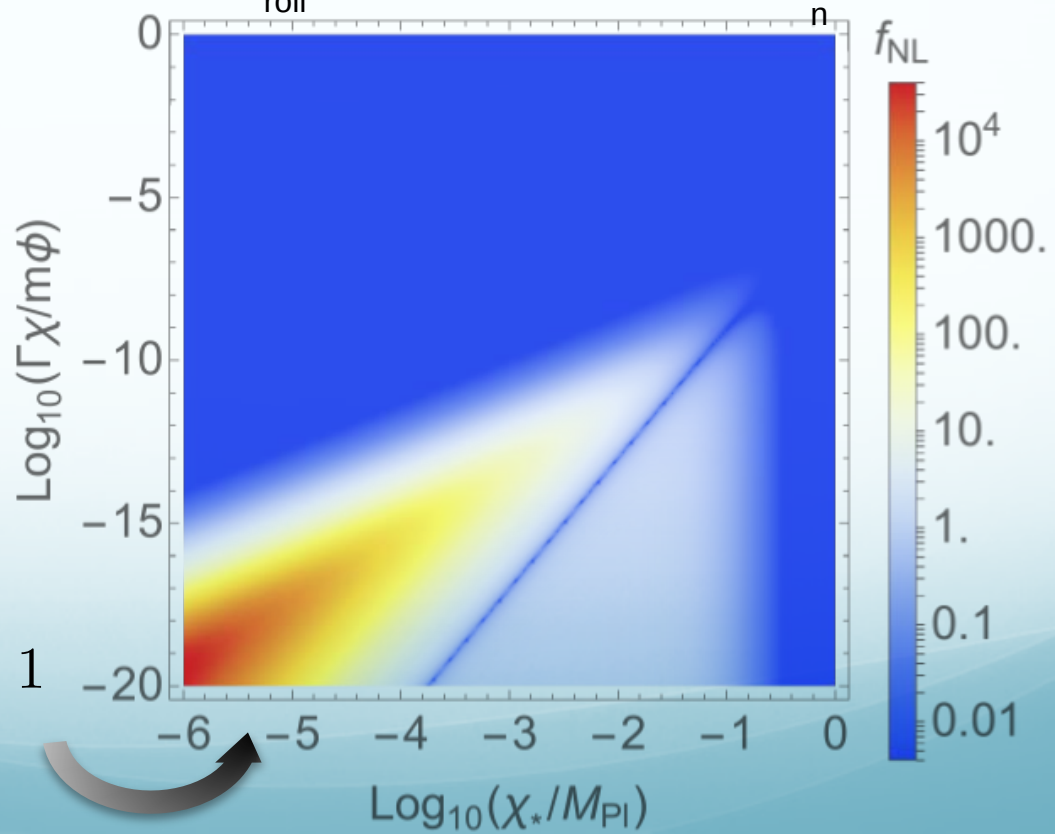
- From a curvaton scenario: inflaton ϕ + curvaton χ



$$U(\phi) = \frac{m_\phi^2}{2}\phi^2$$

$$V(\chi) = \frac{m_\chi^2}{2}\chi^2$$

$$\frac{V_{\chi\chi}}{V} \gg 1$$



Conclusions

Exciting time for non Gaussianity with large scale structure, like SPHEREx,

Measuring $f_{\mathrm{NL}} \geq 1$ rules out single field inflation.

Not necessarily generic in two field: requires tuning.

$f_{\mathrm{NL}} \ll 1$ constrains the shape of the potential.

Computing f_{NL} for a sum separable potential

$$W(\phi, \chi) = U(\phi) + V(\chi)$$

- Analytical expressions from Vernizzi & Wands '06

- Adiabatic limit: horizon crossing approximation (HCA) *Elliston et al '11*

  ⟶ Simple expressions depending only on horizon crossing *Kim and Liddle '06*

- Full numerical calculation

$$U(\phi) = \frac{m_\phi^2}{2}\phi^2 \qquad V(\chi) = V_0\left[1 + \cos\left(\frac{2\pi\chi}{f}\right)\right]$$

$$f_{\mathrm{NL,HCA}} = -\frac{5\pi^2}{3f^2}$$

Computing $f_{\rm NL}$ for two fields

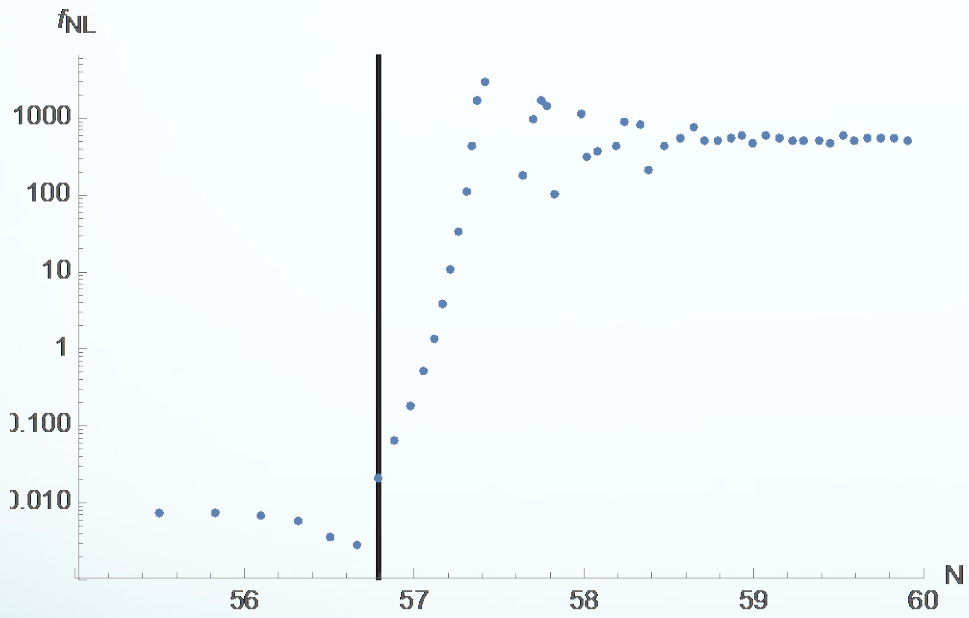
- Use the δN formalism to compute ζ on large scales *Sasaki & Stewart '95*

$$\zeta = \mathcal{N}(t_*, t_c, \mathbf{x}) - N(t_*, t_c) \qquad N(t_*, t_c) = \int_*^c H dt$$

$$\zeta = N_\phi \delta\phi + N_\chi \delta\chi + \frac{N_{\phi\phi}}{2}\delta\phi^2 + \frac{N_{\phi\chi}}{\delta}\phi\delta\chi + \frac{N_{\chi\chi}}{2}\delta\chi^2$$

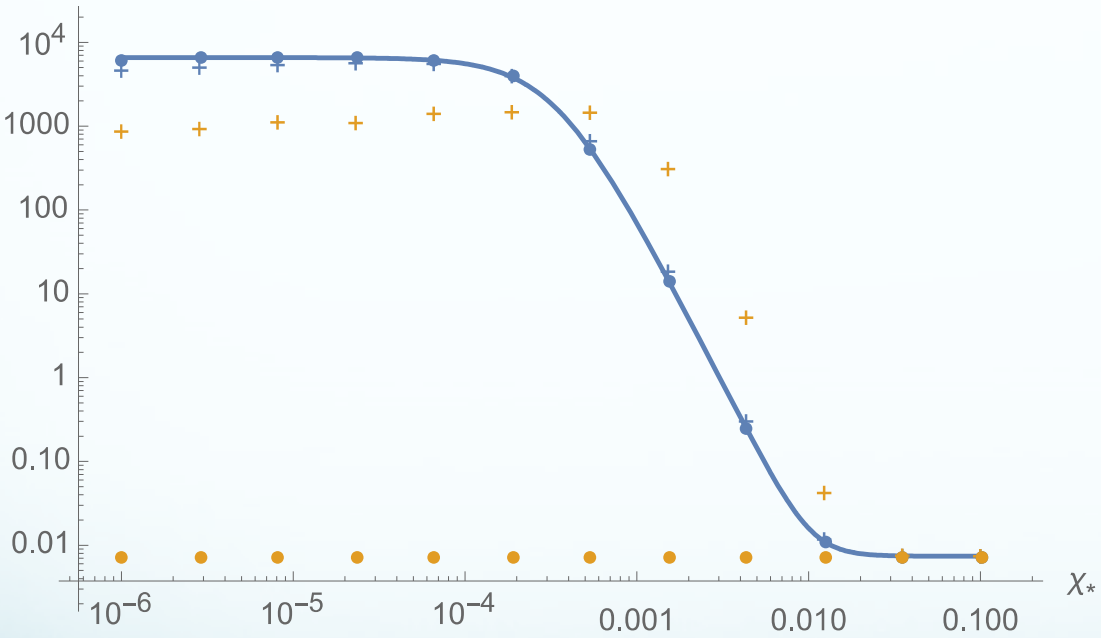
$$f_{\rm NL} \supset -\frac{5}{6}\frac{\sum N_I N_J N_{IJ}}{\left(\sum N_I^2\right)^2}$$

Time evolution



- f=0.1 M_{Pl}, V_0/m_ϕ^2=0.001 M_{Pl}^2, $\chi_*=10^{-5} M_{Pl}$, ϕ_*=15 M_{Pl}

Scaling with V0



- f=0.05, $V_0/m_\phi{}^2$=0.001 $M_{\rm Pl}{}^2$
- f=0.05, $V_0/m_\phi{}^2$=0.0001 $M_{\rm Pl}{}^2$