Theoretical Systematics in Large Scale Galaxy Surveys

Charuhas Shiveshwarkar[1]

May 8, 2024

[1]Work done in collaboration with Marilena Loverde, Drew Jamieson, Matthew McQuinn and Thejs Brinckmann

Local Primordial Non-Gaussianity and Scale dependent bias

Signature of additional light fields during inflation :

$$\Delta b_g \propto \frac{f_{NL}}{k^2}$$

Can only have a primordial origin

Non-primordial, horizon-scale effects can however impact measurement of f_{NL}^{local} !

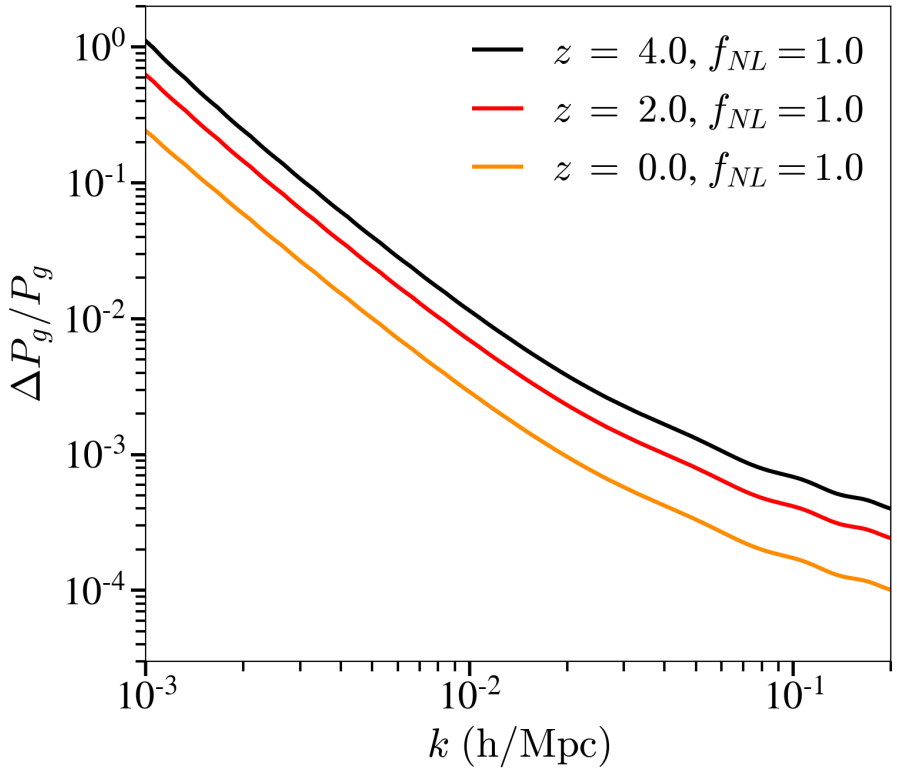


Figure: Fractional change in the galaxy power spectrum due to local $f_{NL} = 1$.

Effect of free-streaming light relics

- Scale-dependent galaxy bias due to free-streaming light relics :

$$\frac{b_g(k)}{b_g(k_{\rm max})} \to \text{const.} < 1.;\ \ k \to 0$$

- Can *negatively* bias f_{NL}
- For realistic neutrino masses, $|\Delta f_{NL}| \lesssim 0.2$

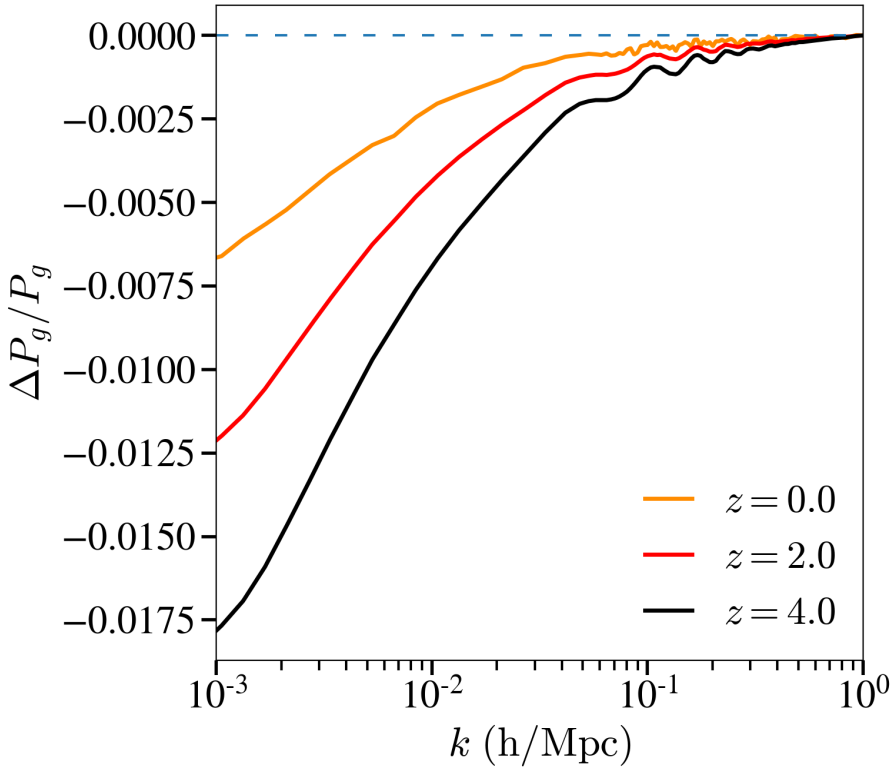


Figure: Fractional change in the galaxy power spectrum due to neutrino free-streaming. $M_\nu = 3 \times 0.02$ eV

Effect of Ionising Radiation Fluctuations

$$\delta_g = b_g \delta_m - b_J \delta_J$$

$$P_g = P_{mm} \left(b_g - b_J \frac{P_{mJ}}{P_{mm}} \right)^2 + b_J^2 P_{Jshot}$$

- $b_J \lesssim 0.1$ and P_{Jshot} is negligible for reasonable quasar lifetimes. (Sanderbeck et al. 2019)
- More important at higher redshifts

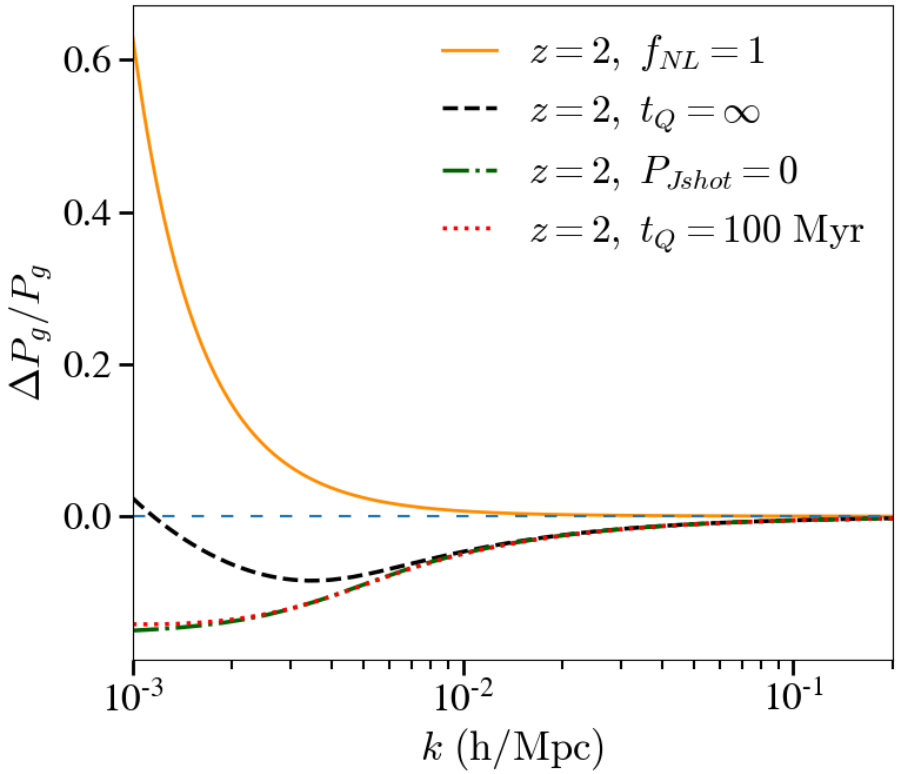
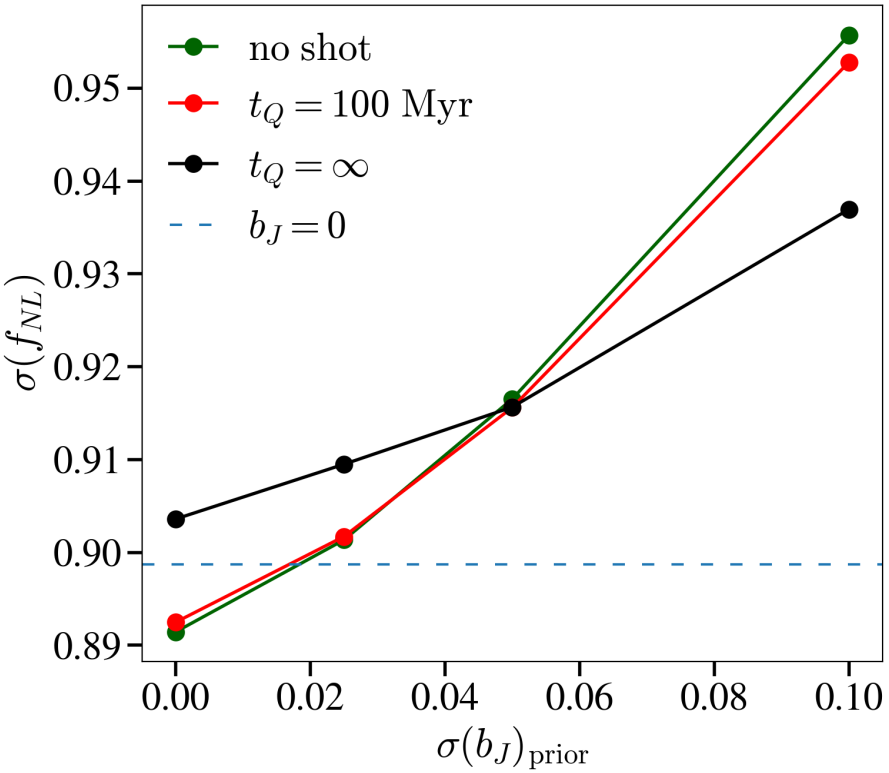
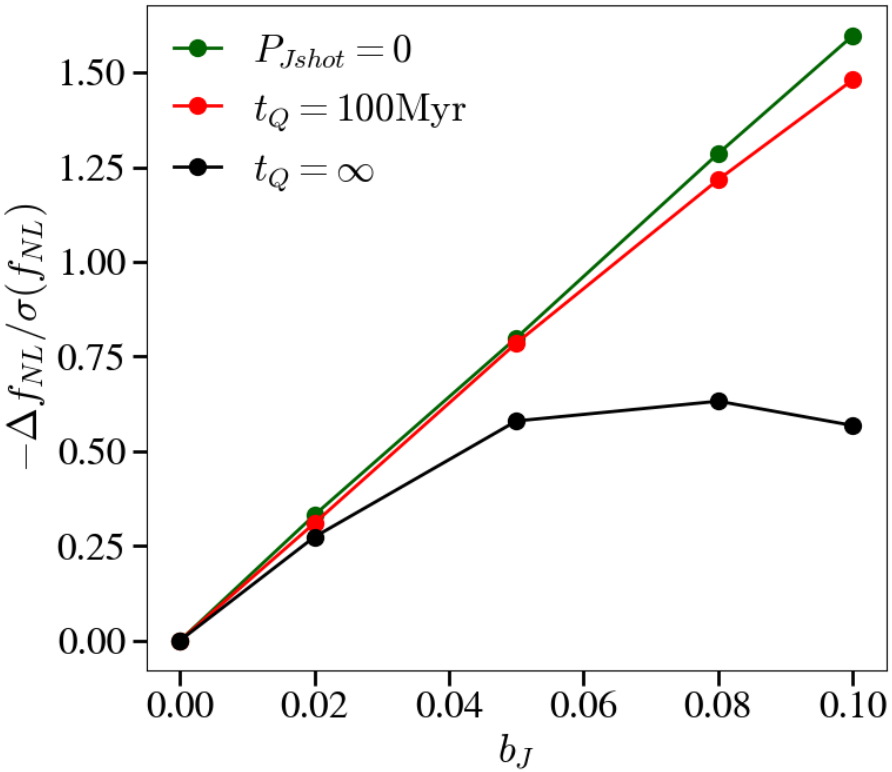


Figure: Effect of $b_J = 0.05$ in comparison to the effect of $f_{NL} = 1$ at $z = 2$

Effect of ionising radiation fluctuations on f_{NL} constraints





With appropriate priors,
$\Delta\sigma(f_{NL}) \approx 0$

$\Delta f_{NL} \approx -0.8\sigma$ for $b_J = 0.05$ and realistic quasar lifetime.

Larger effect for high-redshift surveys (like MegaMapper)

Beyond f_{NL} : f_{NL} and g_{NL}

Scale-dependent bias is a combined measure of f_{NL}, g_{NL}, etc.

$$\Delta b_{NG} \propto \frac{f_{NL}\beta_f + g_{NL}\beta_g + ..}{k^2}$$

Degraded constraint (SPHEREx forecast)

$$\sigma(f_{NL}) \sim \sigma(10^{-4} g_{NL}) \sim 2.5$$

$\mathrm{Cov}(f_{NL}, g_{NL}) \sim -0.9$.

Need to model $\beta_f(z)$ and $\beta_g(z)$!

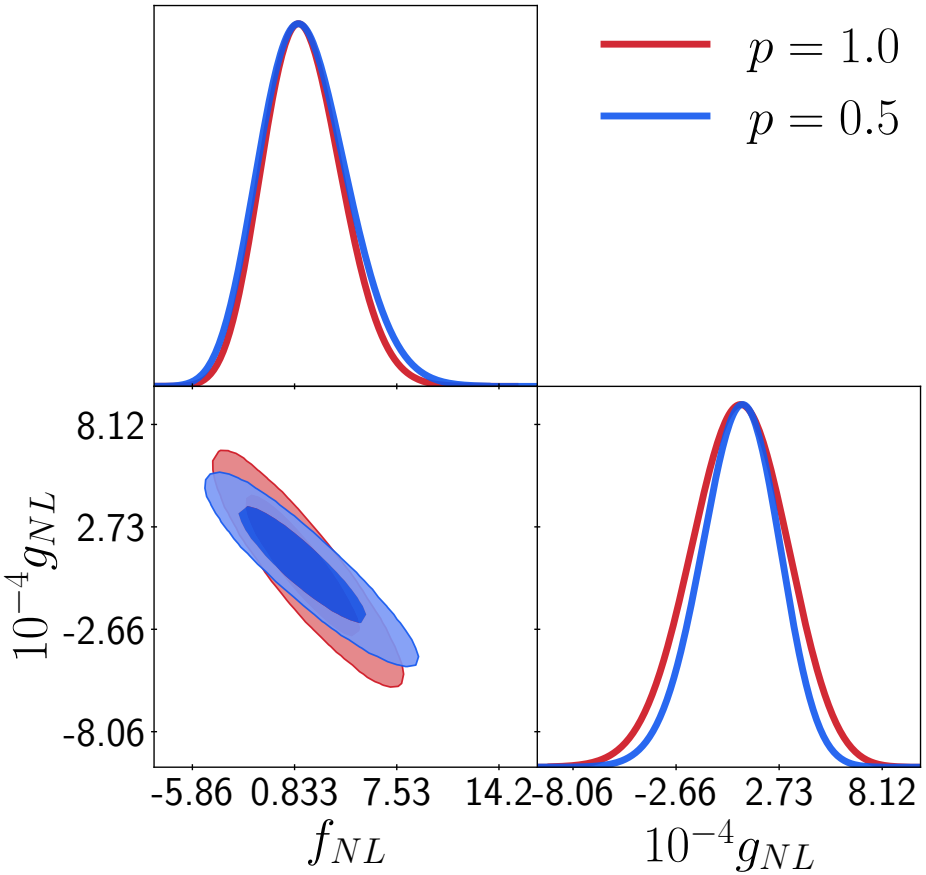
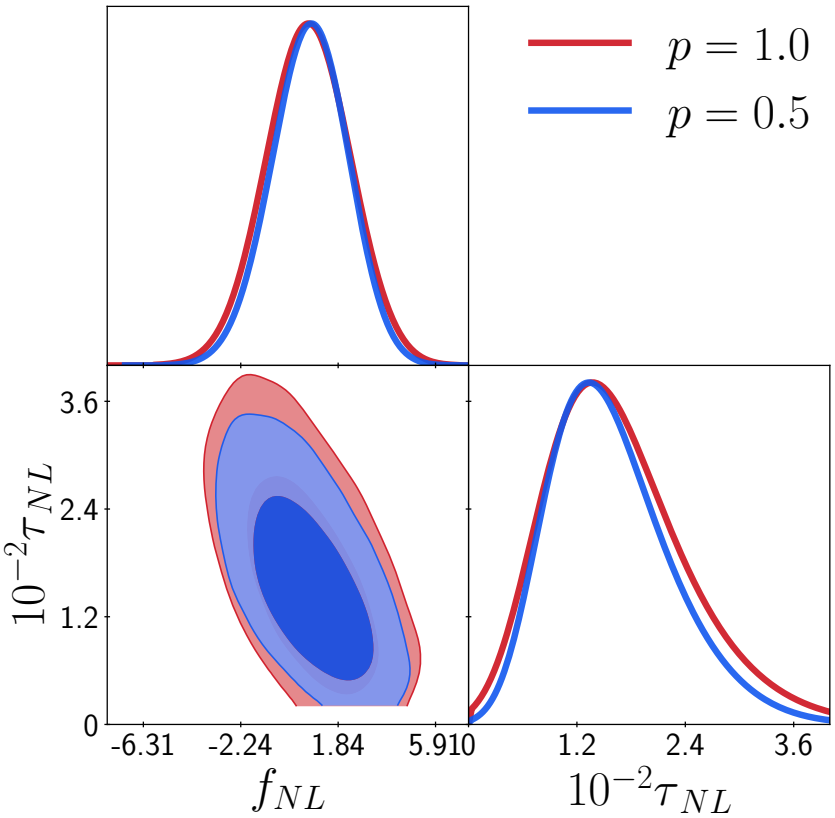
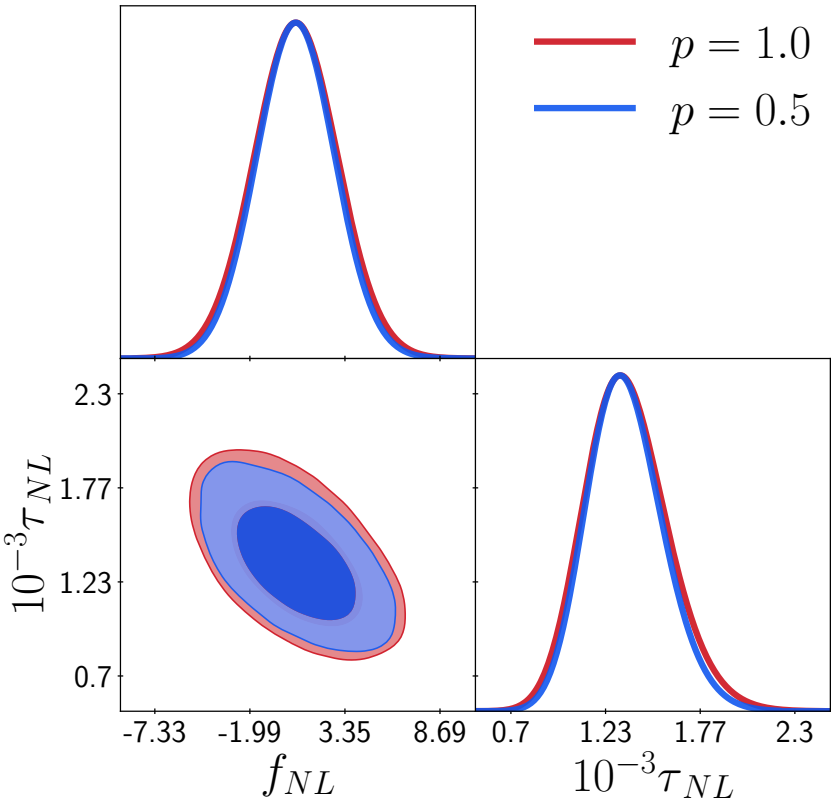


Figure: Joint SPHEREx power spectrum forecasts for two modelling choices $p = 1$ and $p = 0.5$.

Beyond f_{NL} : f_{NL} and τ_{NL}



(a) Fiducial $f_{NL} = 1.0$ and fiducial $\tau_{NL} = 1.3 \times 10^2$



(b) Fiducial $f_{NL} = 1.0$ and fiducial $\tau_{NL} = 1.3 \times 10^3$

p	$\sigma(f_{NL})$	$\sigma(\tau_{NL})$
1.0	1.79	0.78×10^2
0.5	1.64	0.67×10^2

(a) Fiducial $f_{NL} = 1.0$ and fiducial $\tau_{NL} = 1.3 \times 10^2$

p	$\sigma(f_{NL})$	$\sigma(\tau_{NL})$
1.0	2.42	0.24×10^3
0.5	2.22	0.21×10^3

(b) Fiducial $f_{NL} = 1.0$ and fiducial $\tau_{NL} = 1.3 \times 10^3$

Table: Joint MCMC forecast for f_{NL} and τ_{NL} obtained from the SPHEREx multitracer likelihood. For each fiducial value of τ_{NL}, we consider two example values of $p = 1$ and $p = 0.5$

Covariance between f_{NL} and τ_{NL} remains ~ -0.6 : less degenerate than f_{NL} and g_{NL}.

Can potentially constrain τ_{NL} tightly at the expense of f_{NL}.