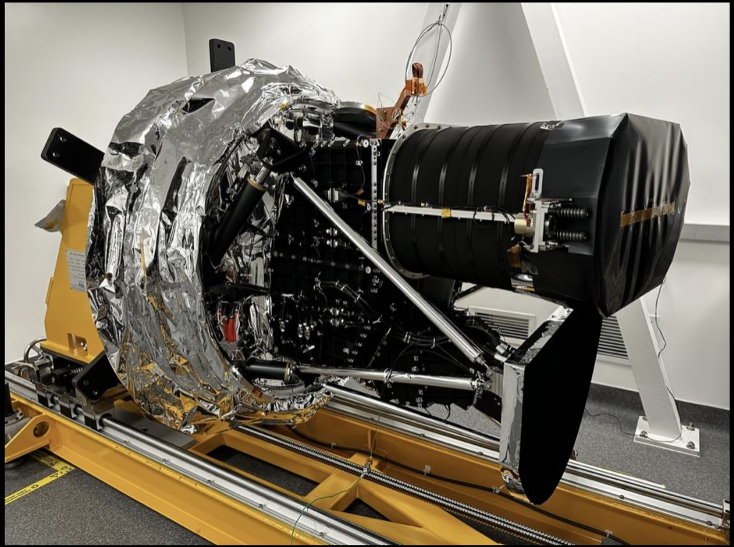
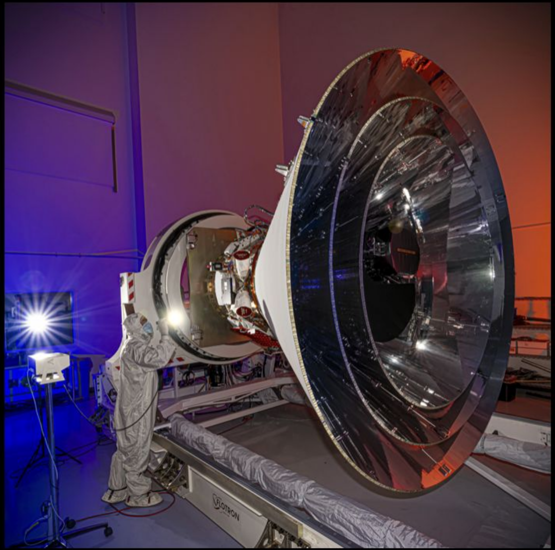
Non-Gaussianity Panel

SPHEREX STATUS



Telescope and instrument integration and testing finished at Caltech in Feb. 2024



Full observatory assembly (Apr. 2024) and testing on-going at BAE Systems in Boulder, CO

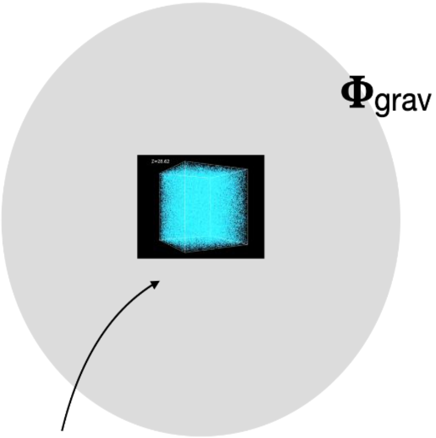
- Launch scheduled for Feb. 27 2025 from Vanderberg SFB
- Instrument performances as measured in the Caltech lab matches our proposed “optimistic” (CBE) values
- Check out https://spherex.caltech.edu for more info and cool pics
- Target is $\sigma(f_{NL}) < 1$ (95% CL) using PoS and BiS

PNG WITH LSS

- Most exciting aspects:
  - ➡ Measuring PNG is one of the very few observables we have to learn more about inflation. The main other observable being r
  - ➡ We are about to enter a new regime observationally
- Most worrisome aspects:
  - ➡ Can we handle the systematics effects on large scales that are present in all surveys (dust extinction, stellar contamination, spatially correlated photometric errors, calibration drifts, etc.). So far all measurements are systematics limited on large scales
  - ➡ Many of these systematics will be correlated across surveys so joint survey analysis won't be a panacea
  - ➡ Modeling on large scales needs to be careful and further developed, in particular for bispectrum (GR, WA, …). Some of these terms are degenerate with PNG
  - ➡ Can we actually measure f_{NL}, i.e. can we break the $b_\phi f_{NL}$ degeneracy and leverage the b_ϕ dimension in multi-tracer analysis?
  - ➡ We need practical answers to these questions in 2-3 years

Marilena Loverde

Scale-dependent bias and its generalizations



nonlinear structure
(galaxies, small-scales)

Only initial conditions (e.g. inflation) can physically correlate small scale structures w/ gravitational potential

⇒ local-type primordial non-Gaussianity correlates observable O ($n_{galaxies}$, P(k), . .) with large-scale Φ

$$\frac{\langle O(k)\delta_{cdm}(k')\rangle}{\langle O\rangle} \sim \frac{\delta \ln O}{\delta \Phi} \langle \Phi(k)\delta_{cdm}(k')\rangle$$

leads to scale-dependent bias, large squeezed-limit n-point functions, . . .

Don't particularly* need to have perfect model of O, only $\delta \ln O/\delta\Phi$ and separation of scales between scales of new physics, nonlinearity

fNL - Dalal, Dore, Huterer, Shirokov 2007; Slosar, Hirata, Seljak, Ho, Padmanabhan 2008; gNL - Smith, Ferraro, ML 2012

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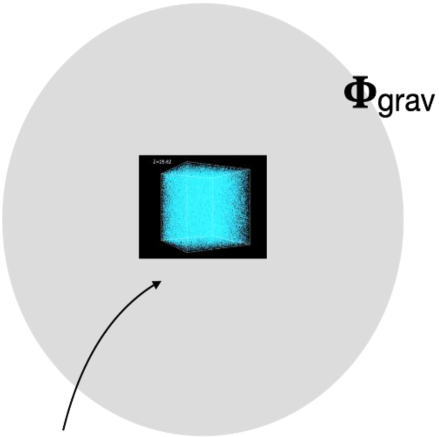

nonlinear structure
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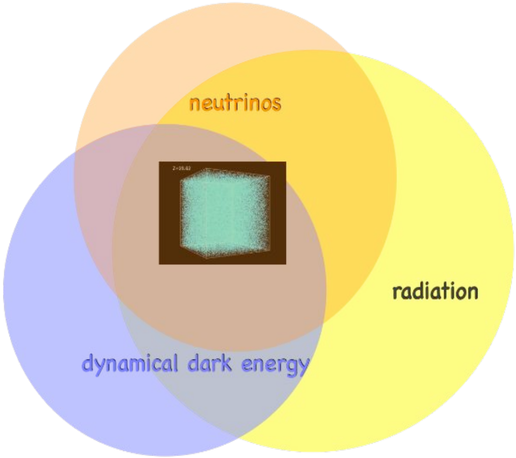
$$\frac{\langle O(k)\delta_{cdm}(k')\rangle}{\langle O\rangle} \sim \frac{\delta \ln O}{\delta \Phi} \langle \Phi(k)\delta_{cdm}(k')\rangle$$

many other sources can generate similar robust signatures



$$\frac{\langle O(k)\delta_{cdm}(k')\rangle}{\langle O\rangle} \sim \frac{\delta \ln O}{\delta \delta_X} \langle \delta_X(k)\delta_{cdm}(k')\rangle$$

Opportunity to test ΛCDM, isocurvature initial conditions, neutrinos, etc!

This is how we should be framing these tests of new physics

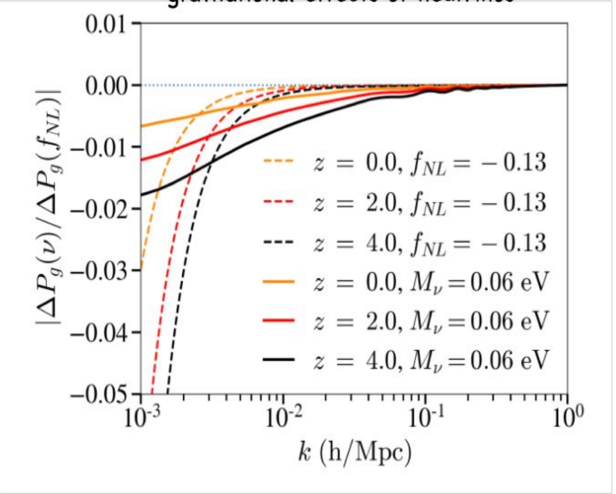
ML 2014; Chiang, Li, Hu, ML 2016-2018; Jamieson, ML 2018 + Shiveshwarkar 2020;

Scale-dependent bias and its generalizations

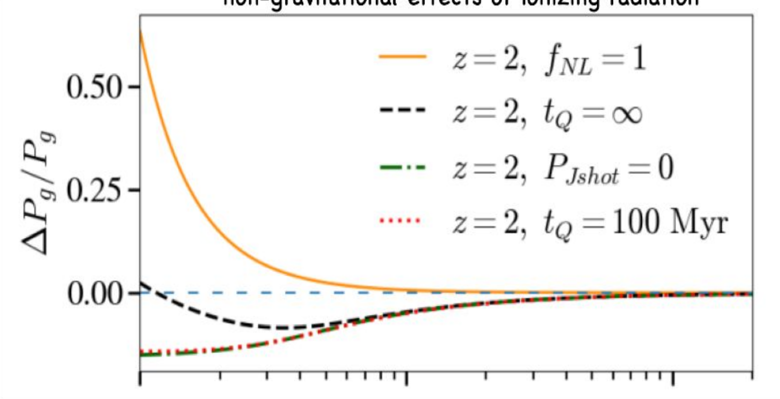
scale-dependent bias: $\frac{\langle O(k)\delta_{cdm}(k')\rangle}{\langle O\rangle \langle \delta_{cdm}\delta_{cdm}\rangle} \sim \frac{\delta \ln O}{\delta \Phi} \frac{\langle \Phi(k)\delta_{cdm}(k')\rangle}{\langle \delta_{cdm}(k)\delta_{cdm}(k')\rangle}$ w/O = $n_{galaxies}$

Opportunity to detect, also to confuse. With finite number k-modes at low-k, different signals can be confused

gravitational effects of neutrinos



non-gravitational effects of ionizing radiation



see talk by Charuhas Shiveshwarker tomorrow afternoon

Primordial NG from LSS

Benjamin D. Wandelt

How much information does 1 (Gpc/h)^3 of universe (DM, halos, galaxies) contain about primordial non-Gaussianity?

- Making progress with a growing list of summary statistics (e.g. Quijote PNG) P(k), B(k1,k2,k3), marked correlation functions, halo mass function, k-NN, wavelets, … (see references below)

- Not ready yet to forecast information from brute force applications of neural networks (e.g. Jung *et al.* arXiv:2403.00490, look for Bairagi, *et al.*, in prep.)

Jung, Coulton, *et al.* arXiv: 2206.15450, 2206.01619, 2206.01624, 2211.07565, 2305.10597, 2309.15151; Peron arXiv:2403.17657

AI discovers hints that b_ϕ degeneracy can be lifted

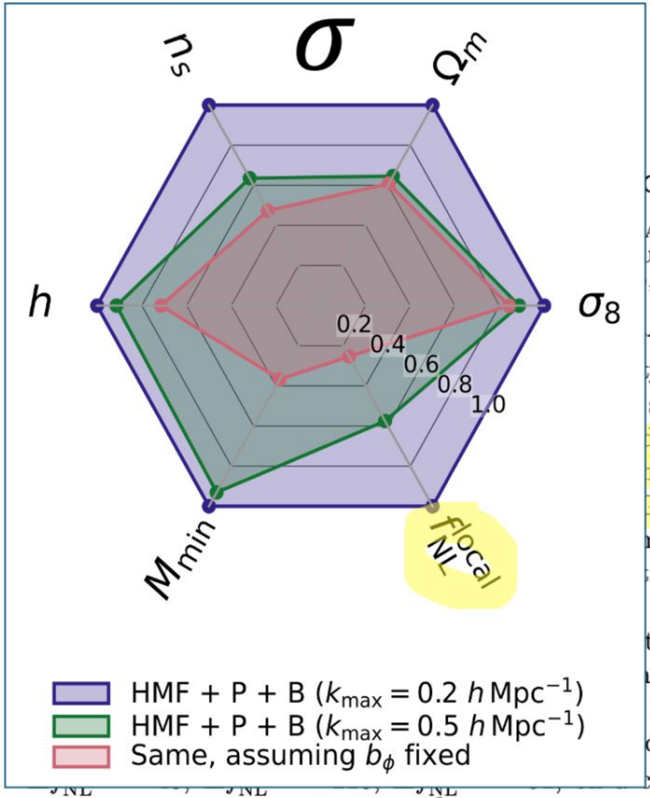
Quijote-PNG: The Information Content of the Halo Mass Function

Gabriel Jung,[1] Andrea Ravenni,[2,3] Marco Baldi,[4,5,6] William R Coulton,[7] Drew Jamieson,[8]
Dionysios Karagiannis,[9] Michele Liguori,[2,3,10] Helen Shao,[11] Licia Verde,[12,13]
Francisco Villaescusa-Navarro,[7,11] and Benjamin D. Wandelt[14,7]

ABSTRACT

We study signatures of primordial non-Gaussianity (PNG) in the redshift-space halo field on non-linear scales, using a combination of three summary statistics, namely the halo mass function (HMF), power spectrum, and bispectrum. The choice of adding the HMF to our previous joint analysis of power spectrum and bispectrum is driven by a preliminary field-level analysis, in which we train graph neural networks on halo catalogues to infer the PNG $f_{\rm NL}$ parameter. The covariance matrix and the responses of our summaries to changes in model parameters are extracted from a suite of halo catalogues constructed from the Quijote-png N-body simulations. We consider the three main types of PNG: local, equilateral and orthogonal. Adding the HMF to our previous joint analysis of power spectrum and bispectrum produces two main effects. First, it reduces the equilateral $f_{\rm NL}$ predicted errors by roughly a factor 2, while also producing notable, although smaller, improvements for orthogonal PNG. Second, it helps break the degeneracy between the local PNG amplitude, $f_{\rm NL}^{\rm local}$, and assembly bias, b_ϕ, without relying on any external prior assumption. Our final forecasts for PNG parameters are $\Delta f_{\rm NL}^{\rm local} = 40$, $\Delta f_{\rm NL}^{\rm equil} = 210$, $\Delta f_{\rm NL}^{\rm ortho} = 91$, on a cubic volume of $1\,({\rm Gpc}/h)^3$, with a halo number density of $\bar{n} \sim 5.1 \times 10^{-5}\ h^3{\rm Mpc}^{-3}$, at $z = 1$, and considering scales up to $k_{\rm max} = 0.5\ h\,{\rm Mpc}^{-1}$.

AI discovers hints that b_ϕ degeneracy can be lifted



Content of the Halo Mass Function

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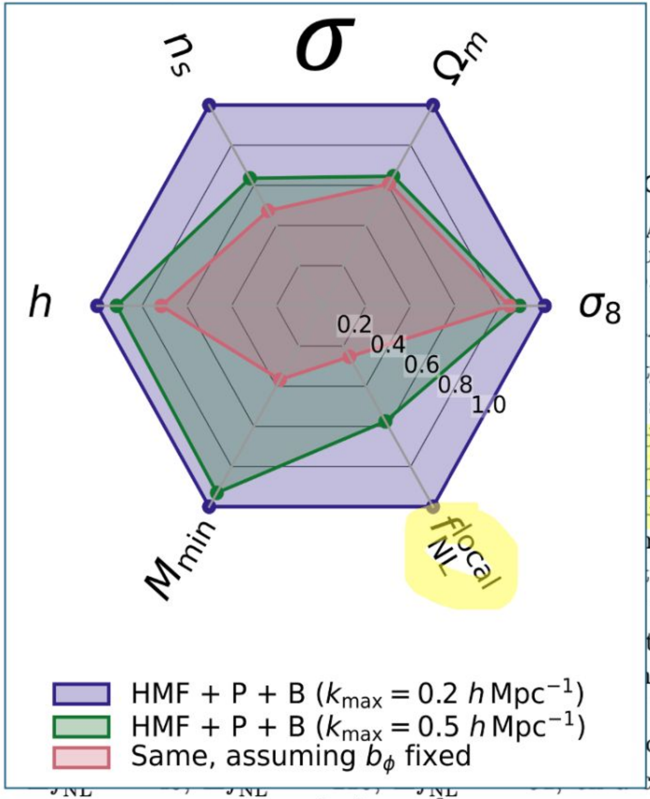

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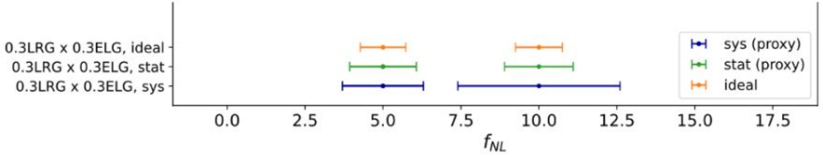
Seems like this generalizes to galaxies if we can extract information about the host halo formation redshift, e.g. from photometry



Fondi et al. arXiv: 2311.10088

20 $(\mathrm{Gpc/h})^2$