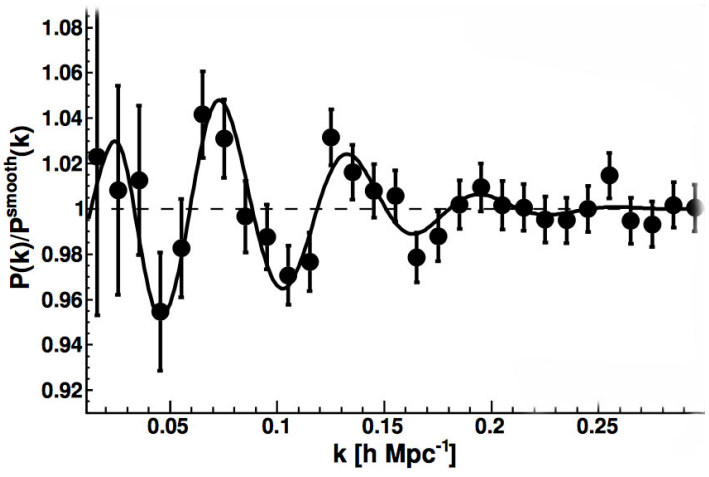
Primordial Features from Linear to Nonlinear Scales

Florian Beutler



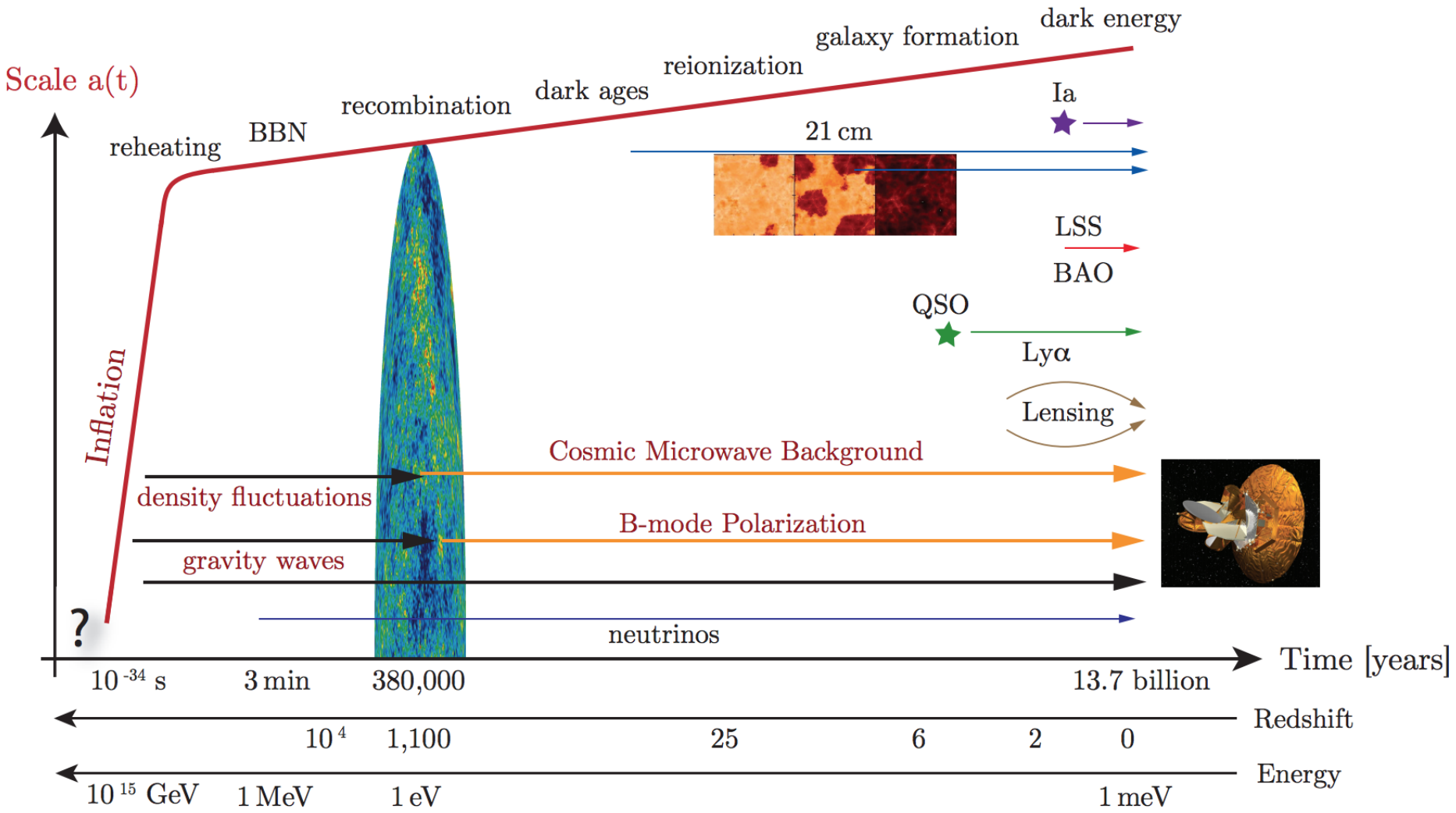
Royal Society University Research Fellow

Primordial Features from Linear to Nonlinear Scales

Florian Beutler, Matteo Biagetti, Daniel Green, Anze Slosar and Benjamin Wallisch

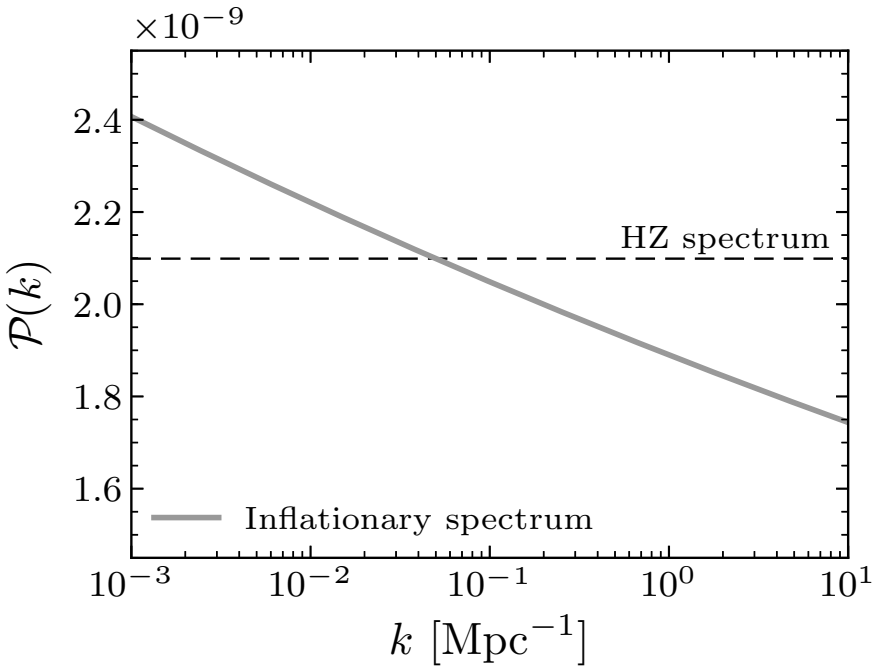
ArXiv: 1906.08758

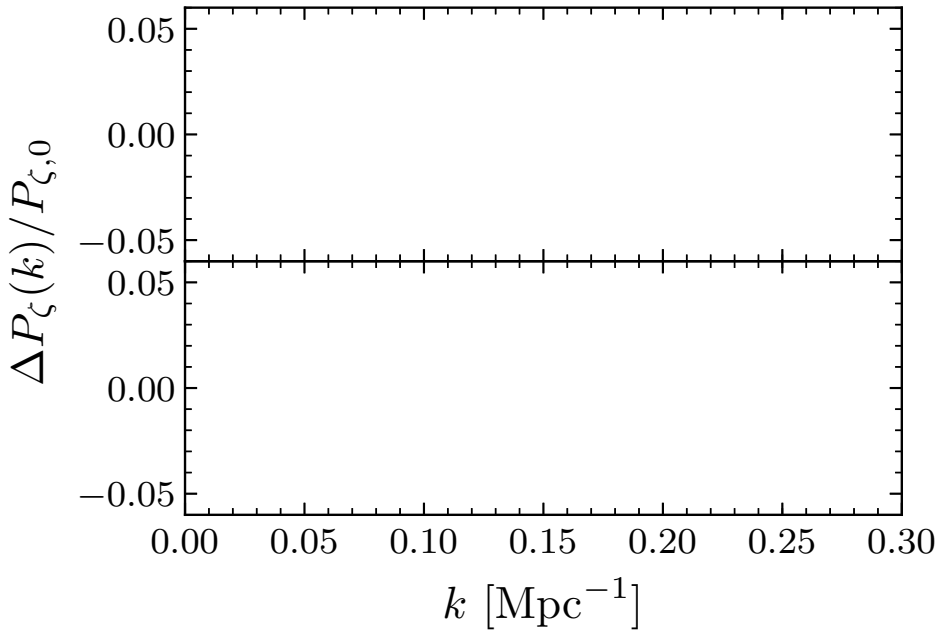
Inflation in one plot



Baumann (2009)

No features

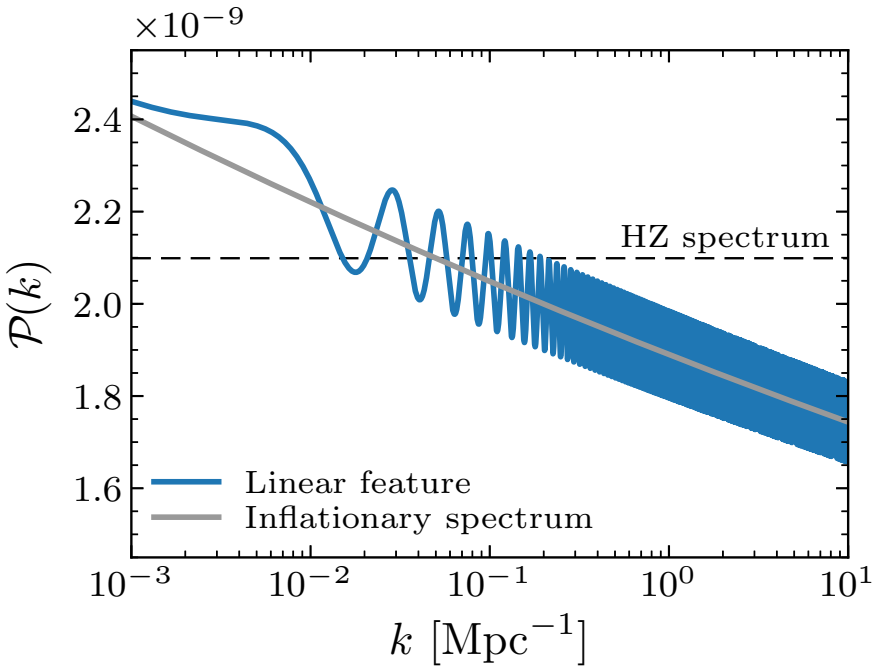


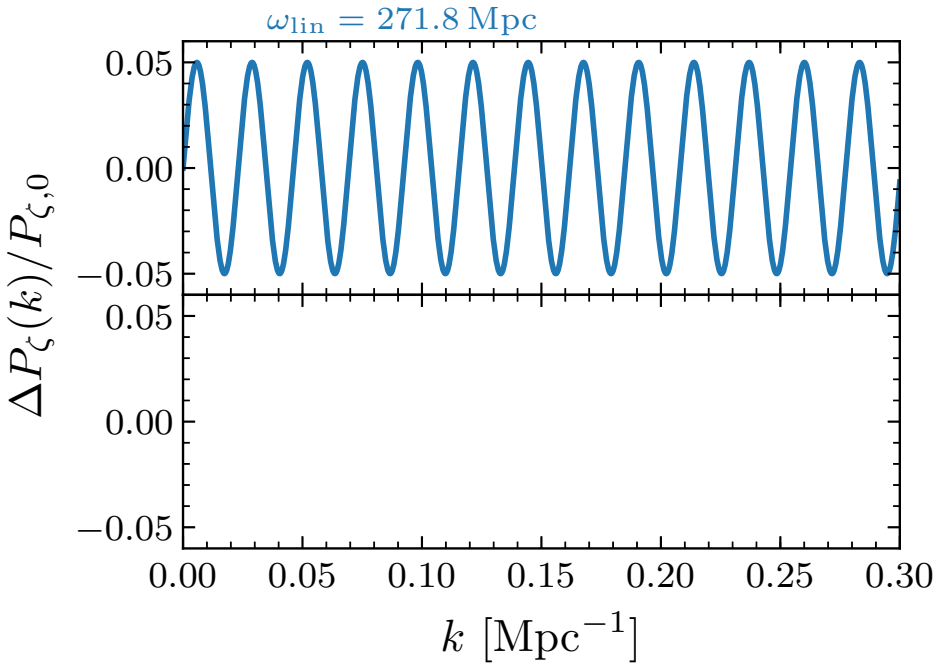


$$P_{\zeta,0}(k) = \frac{2\pi^2}{k^3}\mathcal{P}_{\zeta,0}(k) = \frac{2\pi^2 A_s}{k^3}\left(\frac{k}{k_*}\right)^{n_s-1}$$

Testing inflation through primordial features

Linear features



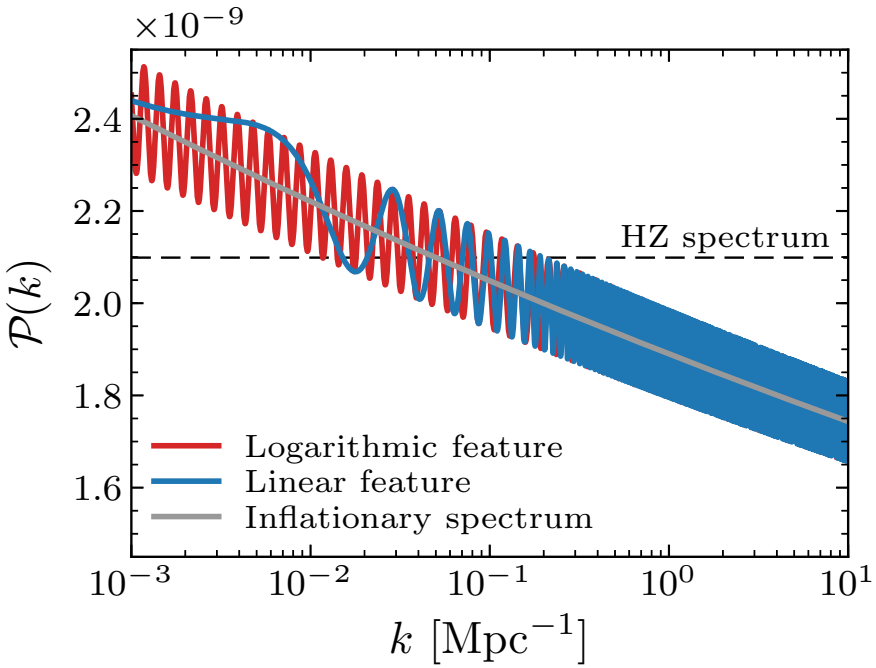


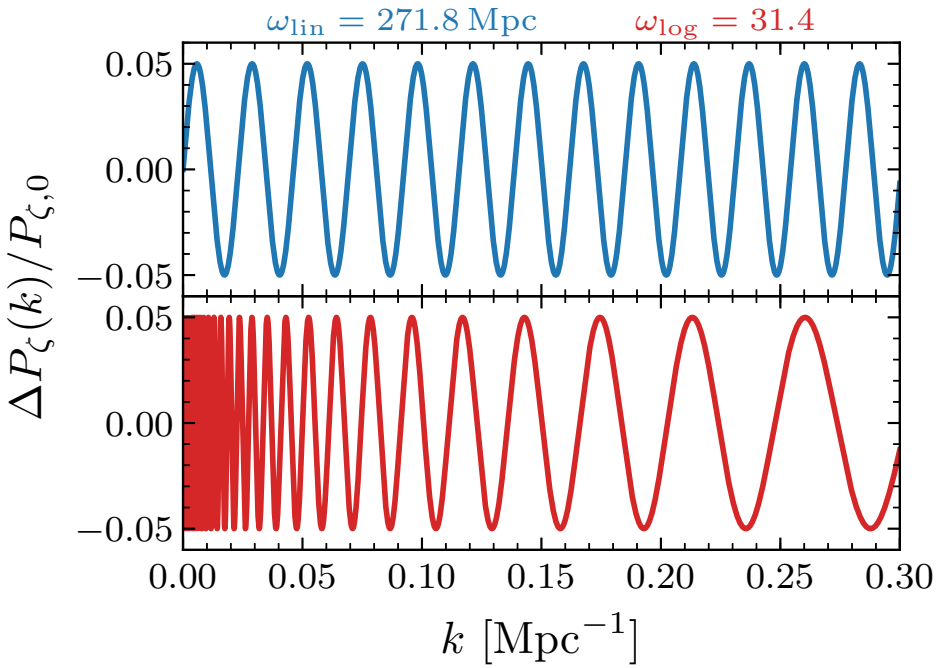
$$\frac{\Delta P_\zeta(k)}{P_{\zeta,0}(k)} = A_{\rm lin} \sin\left(\omega_{\rm lin} k + \phi_{\rm lin}\right)$$

[Sharp Features]
Starobinsky 1992
Adams, Cresswell & Easther 1997
...

Testing inflation through primordial features

Logarithmic features

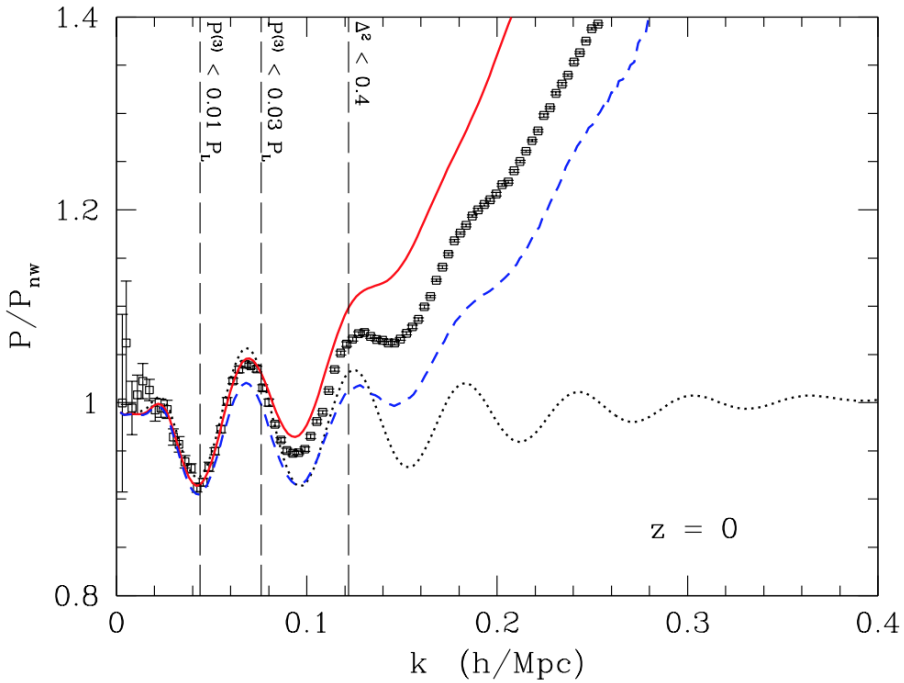


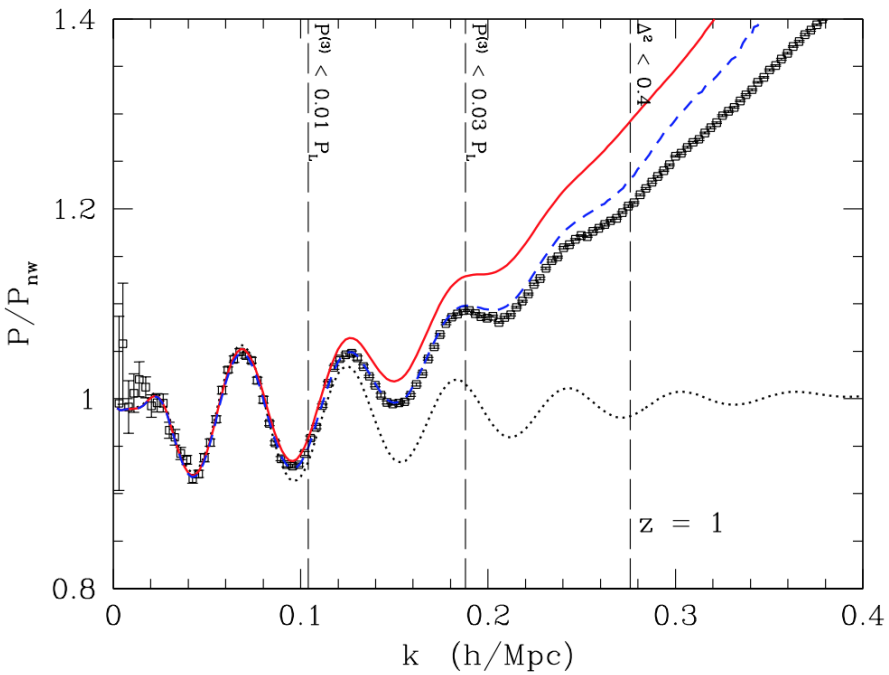


$$\frac{\Delta P_\zeta(k)}{P_{\zeta,0}(k)} = A_{\rm log} \sin\left(\omega_{\rm log} log(k/k_*) + \phi_{\rm log}\right)$$

[Resonant features]
Chen, Easther & Lim (2008)
Silverstein & Westphal (2008)
Flauger, McAllister, Pajer & Westphal (2010)
...

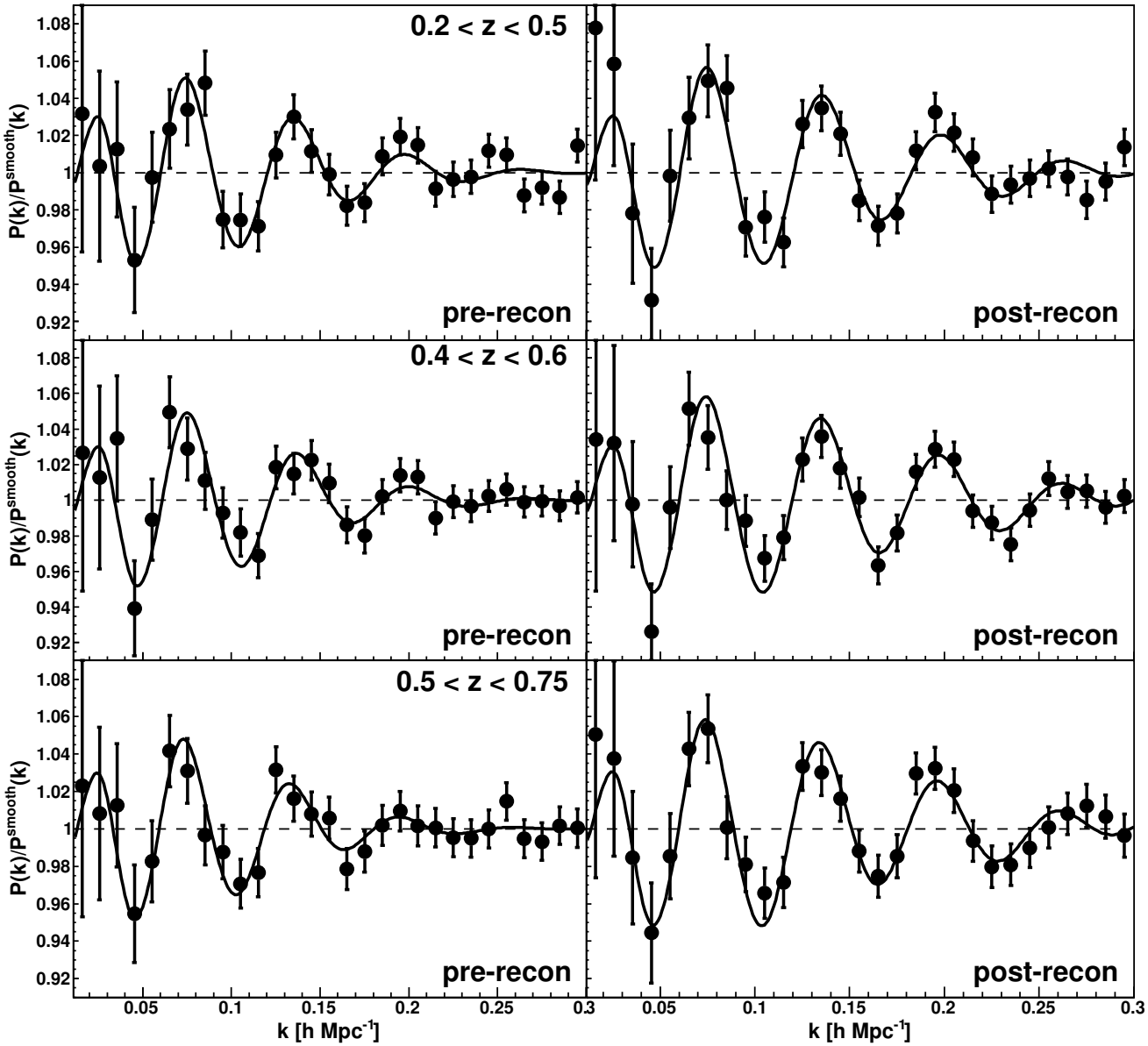
Non-linear gravitational evolution





Carlson et al. in (2009)

Baryon Acoustic Oscillations in BOSS DR12



Beutler et al. (2017)

Fitting the BAO

- Start with linear $P(k)$ and separate the broadband shape, $P^{\rm sm}(k)$, and the BAO feature $O^{\rm lin}(k)$. Include a damping of the BAO feature:

$$P^{\rm sm,lin}(k) = P^{\rm sm}(k)\left[1 + (O^{\rm lin}(k/\alpha) - 1)e^{-k^2\Sigma_{\rm nl}^2/2}\right]$$

- Add broadband nuisance terms

$$A(k) = a_1 k + a_2 + \frac{a_3}{k} + \frac{a_4}{k^2} + \frac{a_5}{k^3}$$
$$P^{\rm fit}(k) = B^2 P^{\rm sm,lin}(k/\alpha) + A(k)$$

- Marginalize to get $\mathcal{L}(\alpha)$.

Feature damping

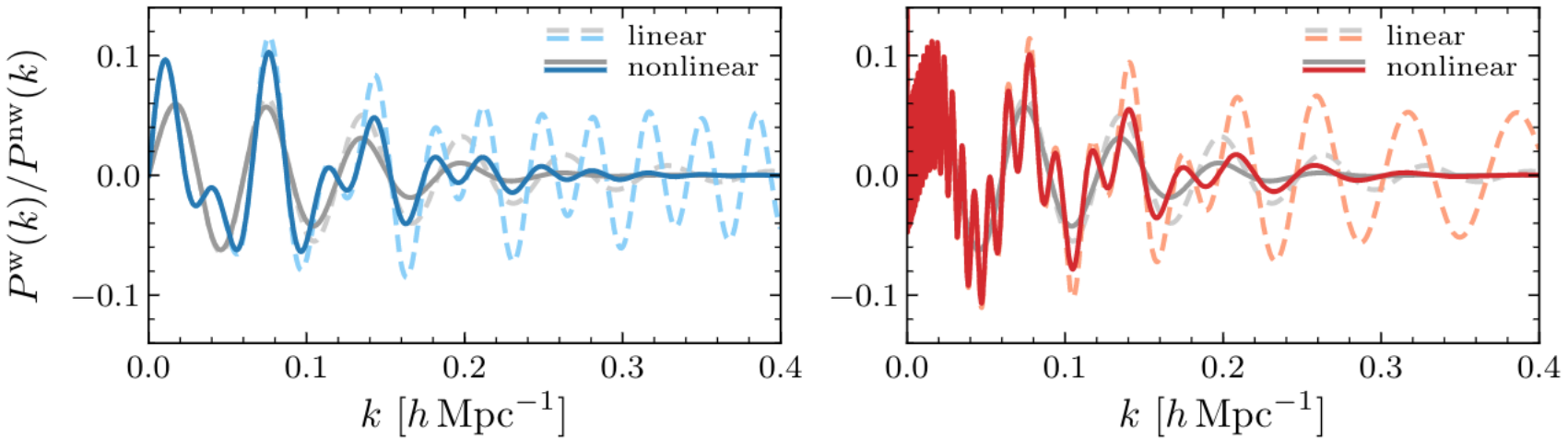
Linear Feature

- Damping factor of linear features equal to BAO damping for $\omega_{\rm lin} \lesssim 75\,{\rm Mpc}$

Logarithmic Feature

- Damping factor of log features approx. equal to BAO damping for $\omega_{\rm log} \lesssim 10$

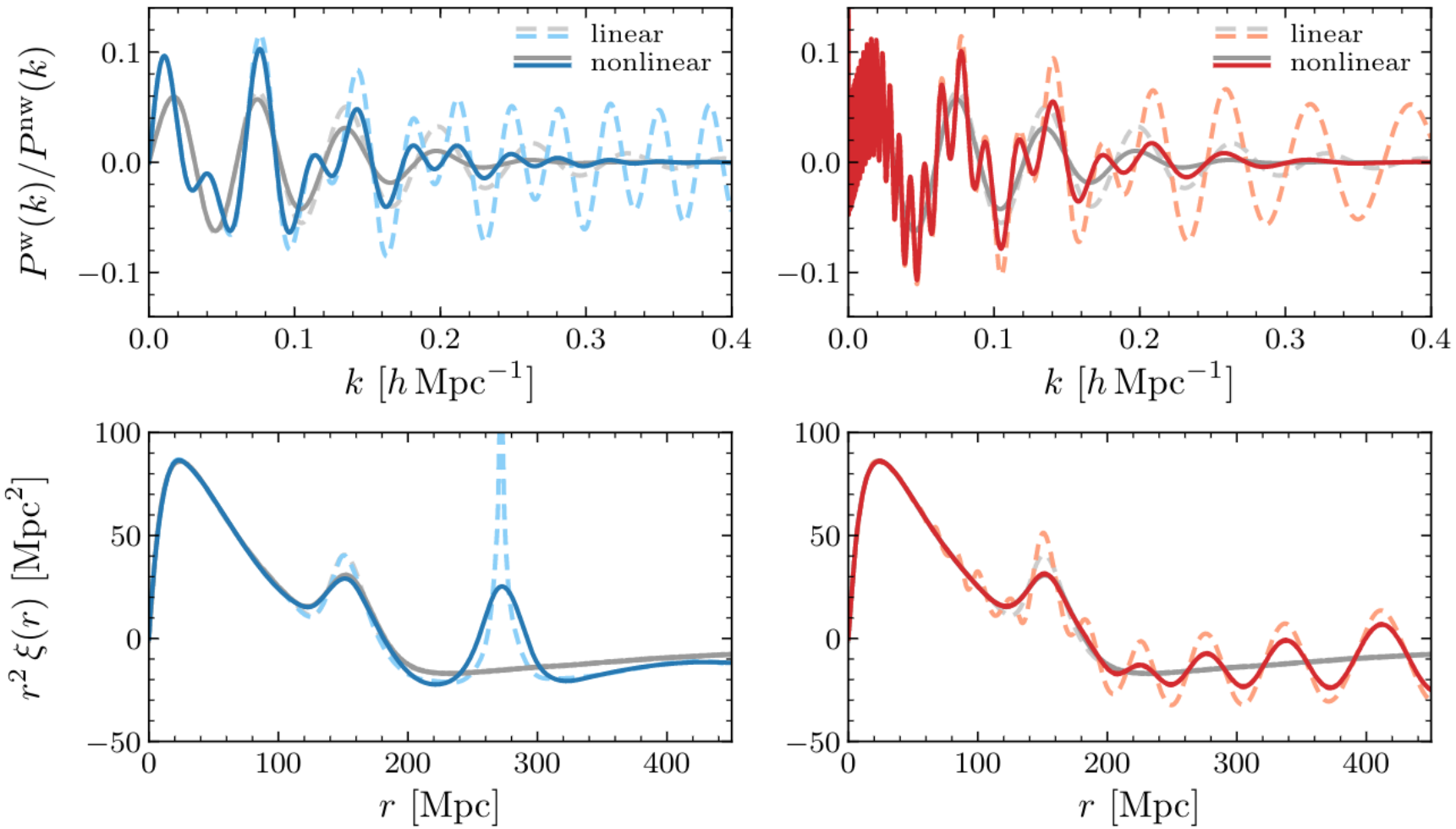
$$P(k) = P^{\rm nw}(k) + e^{-k^2\Sigma_{\rm nl}^2/2}\left[P^{w}_{\rm BAO}(k) + P^{w}_{\rm lin,log}(k) + P^{w}_{\rm BAO}(k)\delta P_{\zeta}^{\rm lin,log}(k)\right]$$



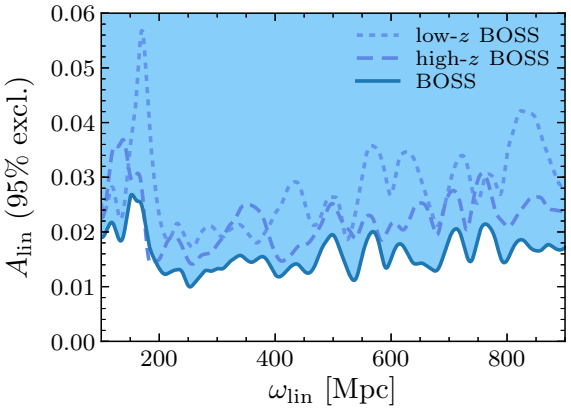
Fourier-space vs. configuration space

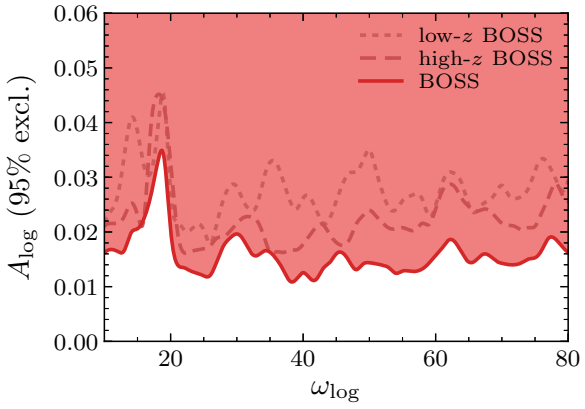
Linear Feature

Logarithmic Feature

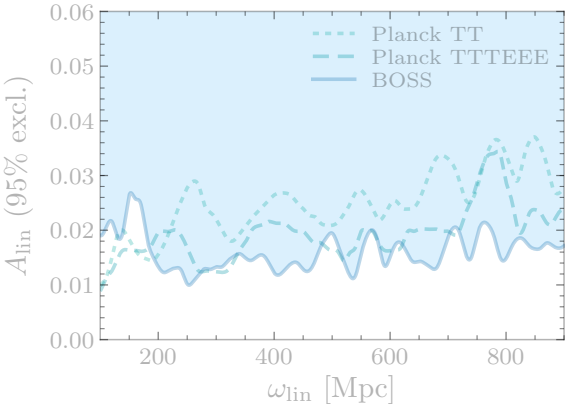


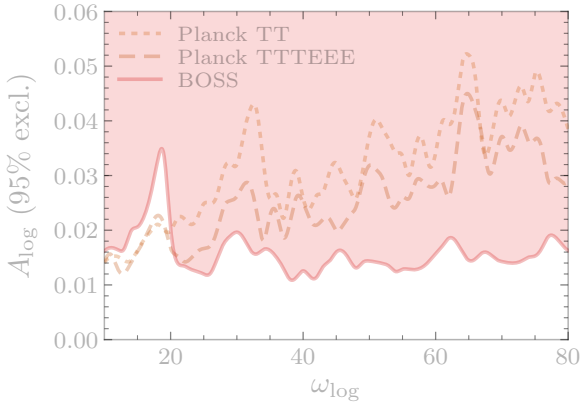
Feature constraints from BOSS DR12 and Planck



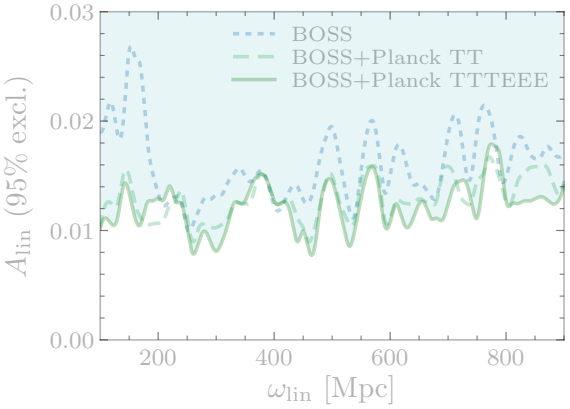


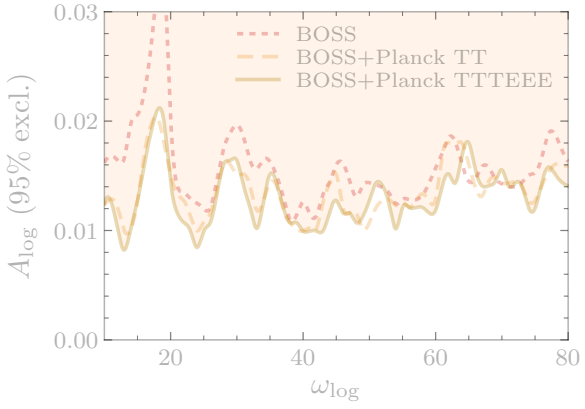
BOSS





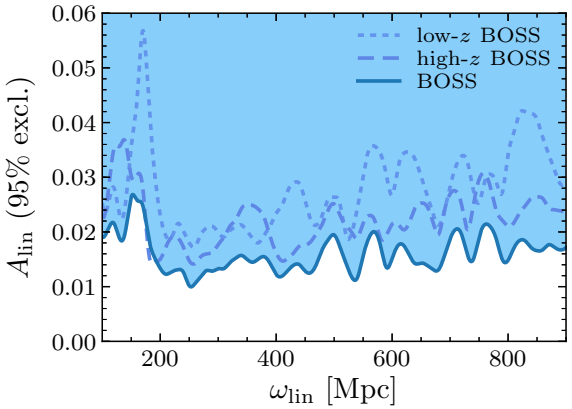
BOSS vs. Planck

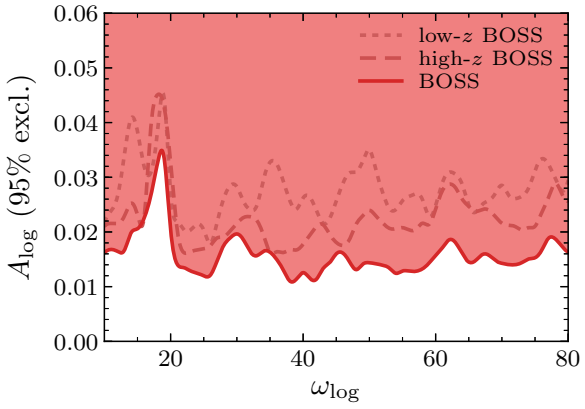




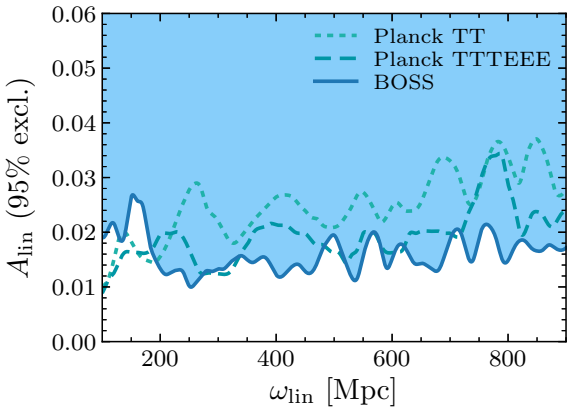
BOSS + Planck

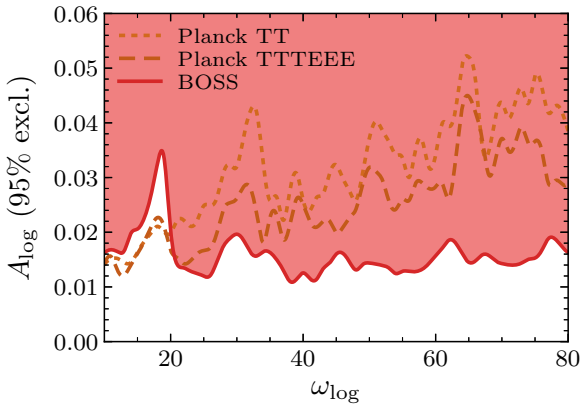
Feature constraints from BOSS DR12 and Planck





BOSS





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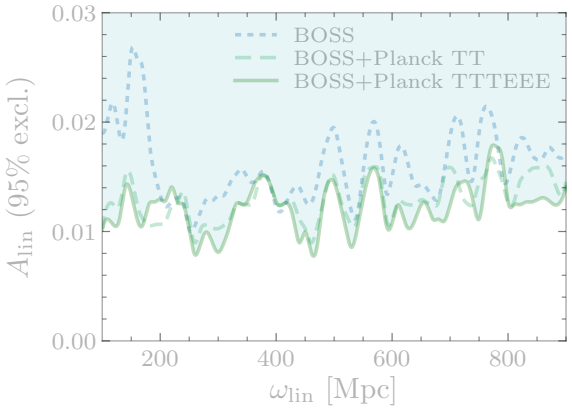

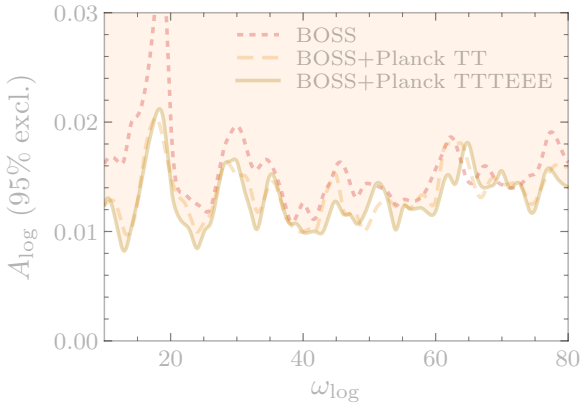

BOSS + Planck

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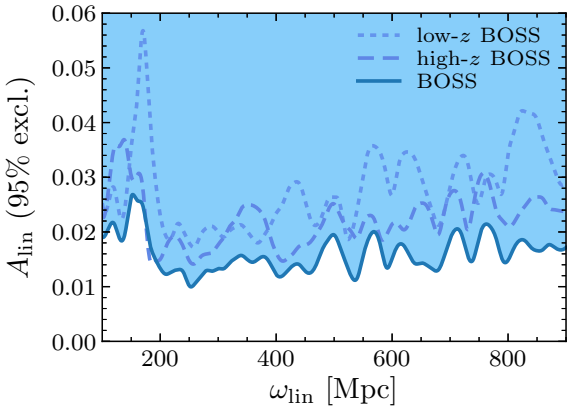

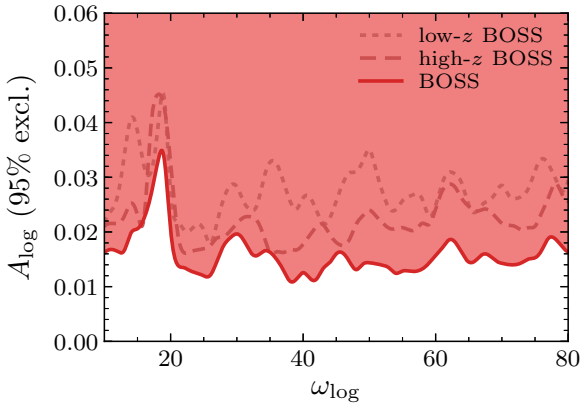

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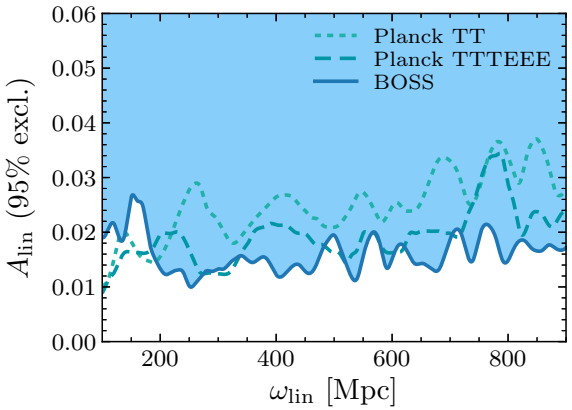

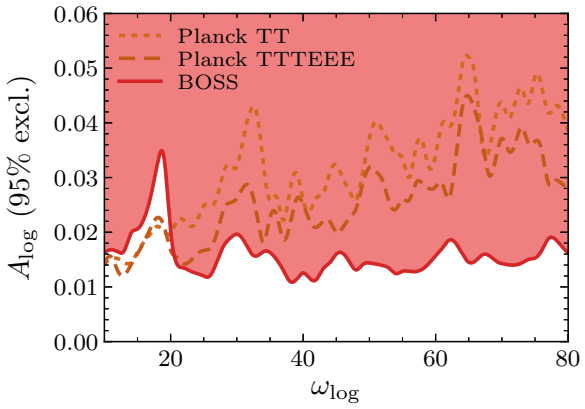

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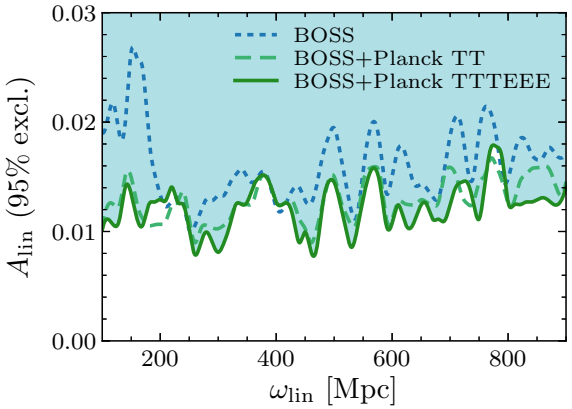
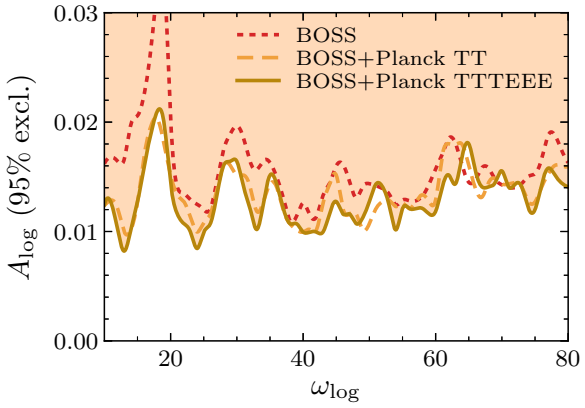
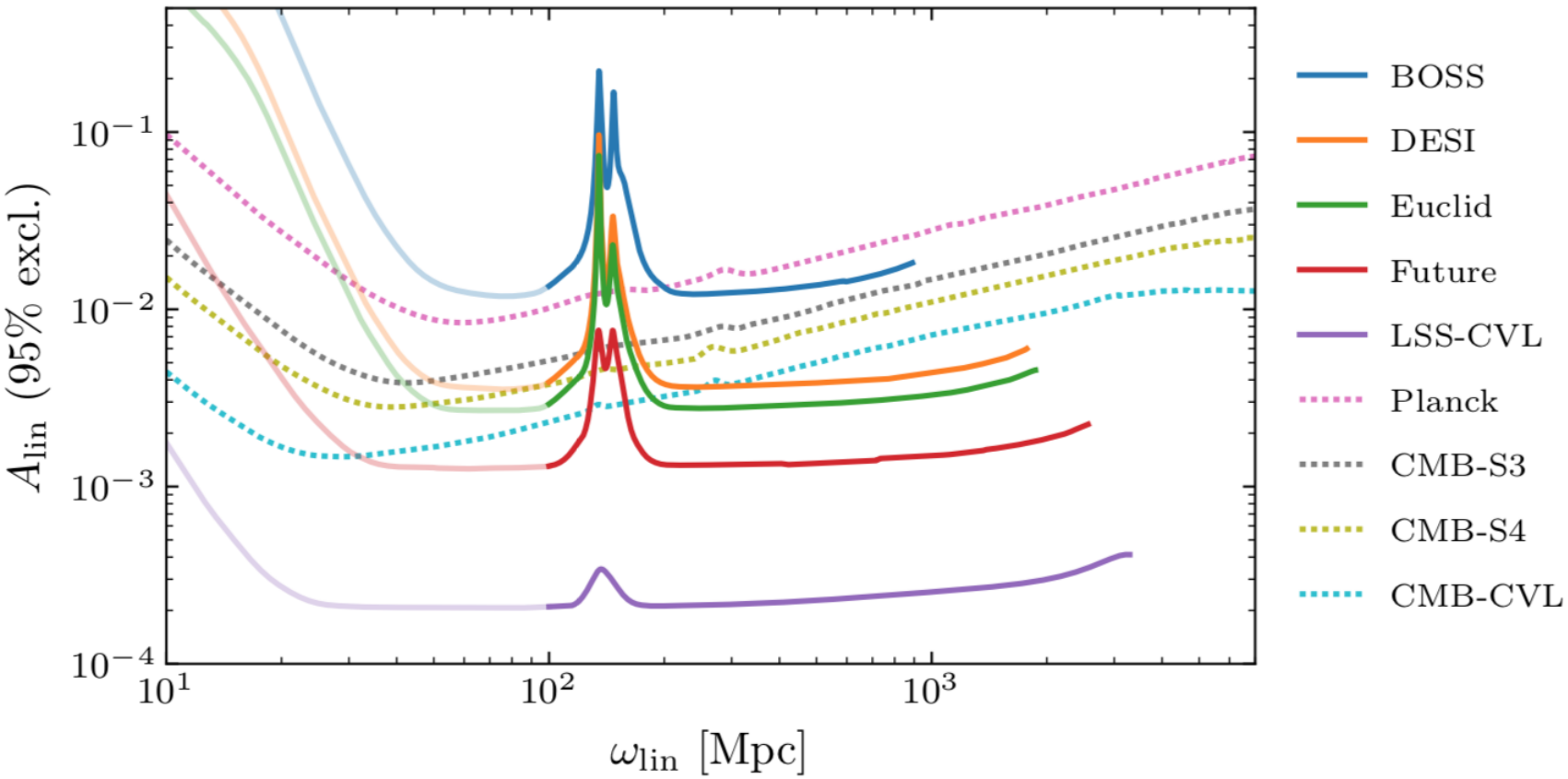




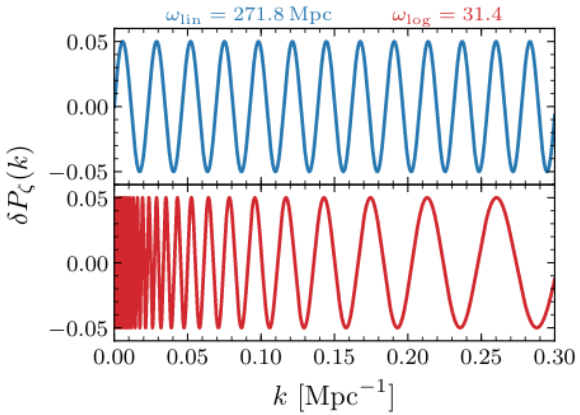
BOSS + Planck

Forecasts for primordial feature constraints



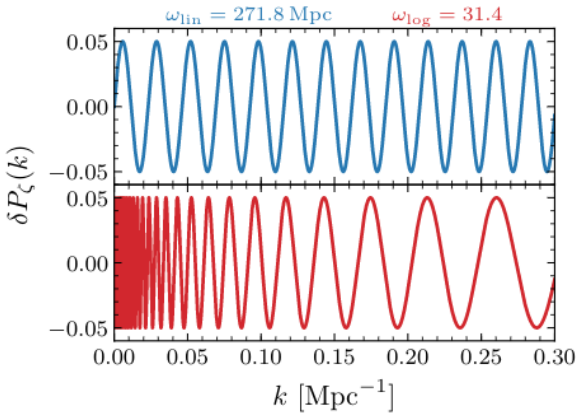
- LSS is more powerful than the CMB on small frequencies, while the CMB can access much higher frequencies
- DESI is going to provide constraints which cannot be accessed even by a CVL-CMB experiment

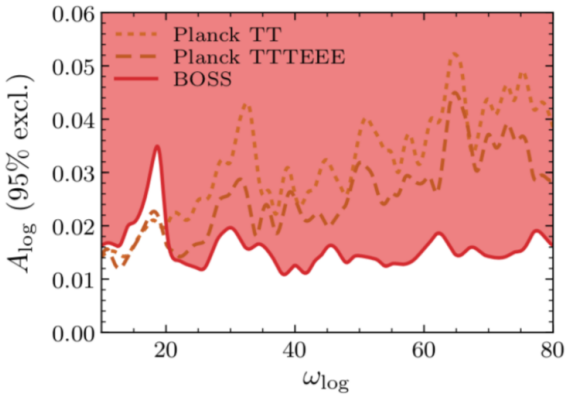
Summary



1. Many well motivated inflationary models introduce features in the primordial power spectrum
   And we know how to detect features → BAO
2. Constraints on primordial features from LSS are **already better than Planck** for a large frequency range
3. Future LSS constraints from DESI and Euclid will push into a parameter space, which is **even beyond a CVL-CMB experiment**

Summary





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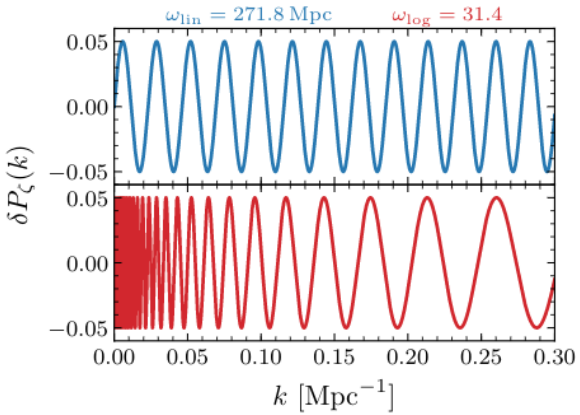

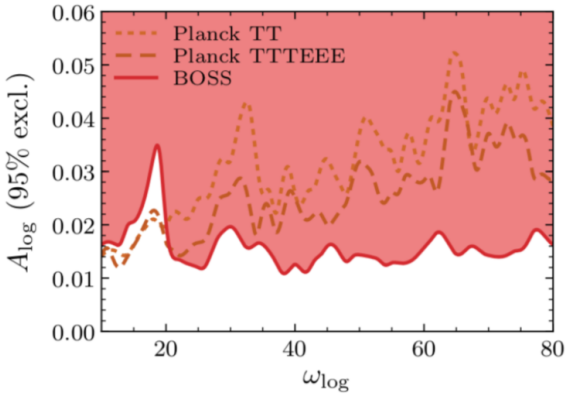

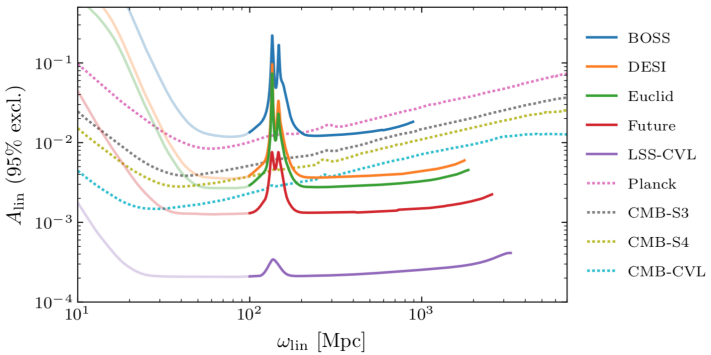

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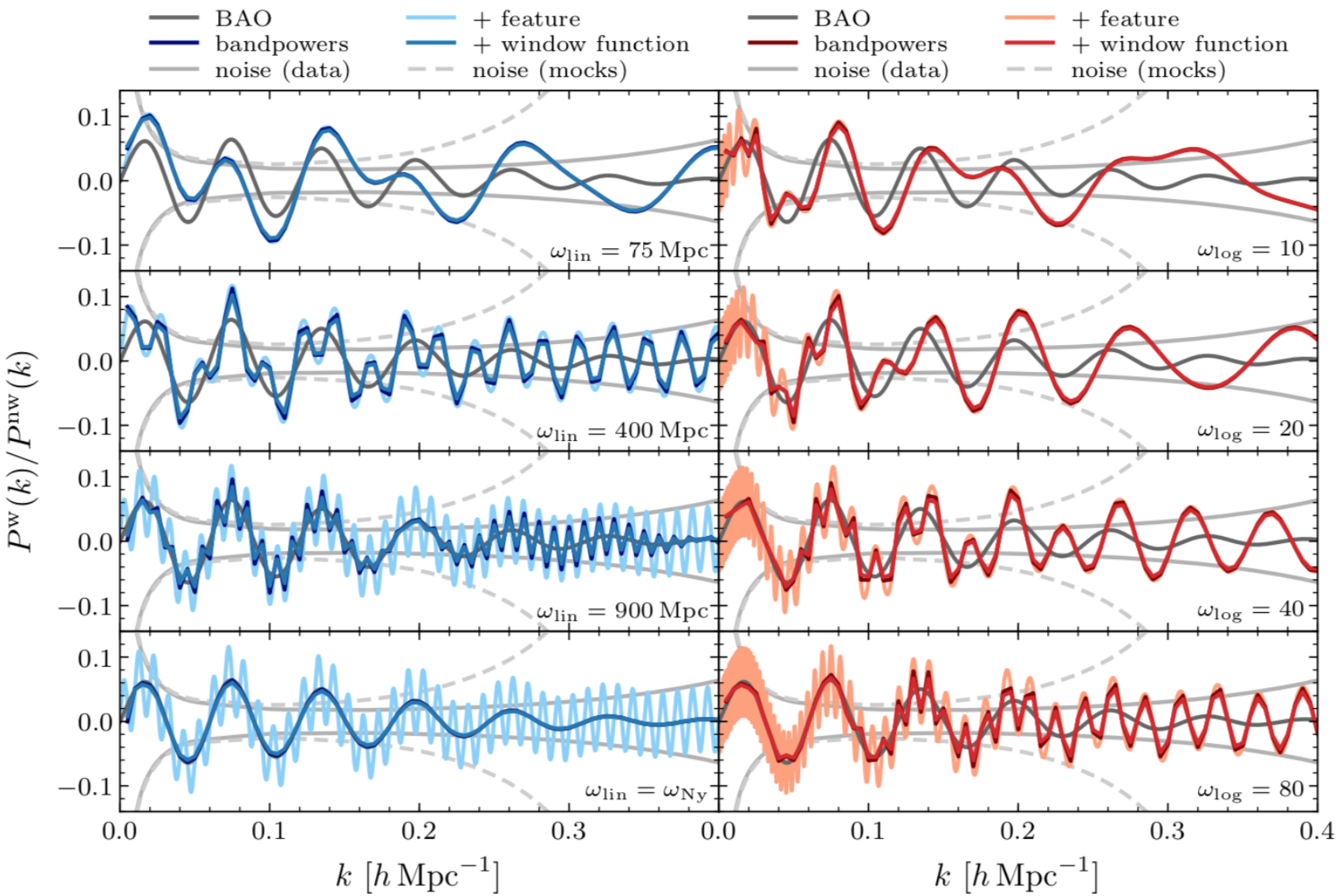
Impact of the window function for features search



Transfer of power