



Features in the Primordial Power Spectrum

(Snowmass Session)

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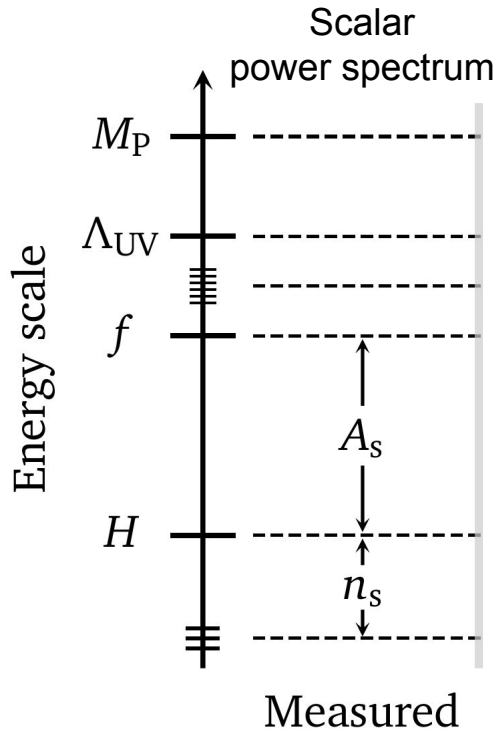
CMB-S4 Collaboration Meeting
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Initial Conditions and Inflation

Scalar scale

Hubble scale

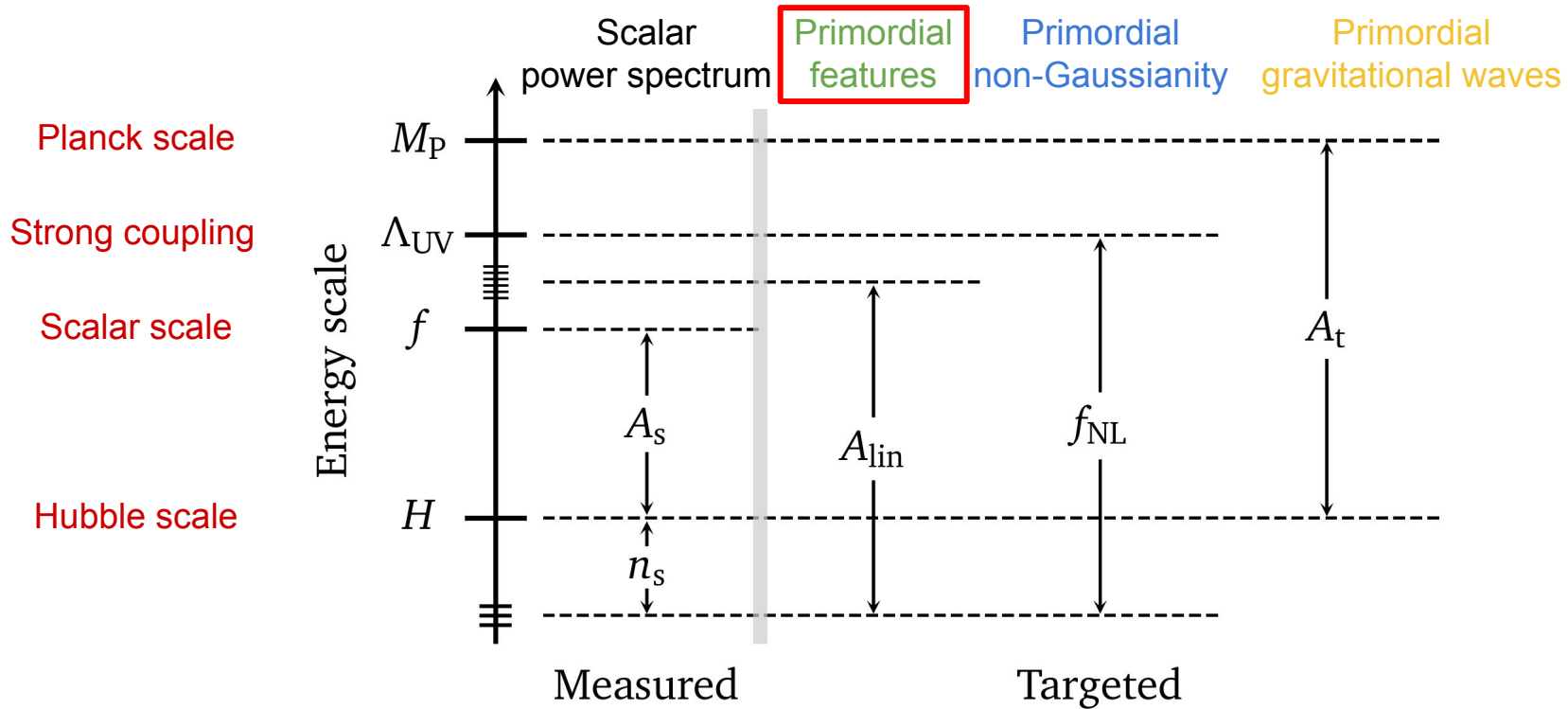


Primordial **density fluctuations** are inferred from observations as

Gaussian and **almost scale-invariant**.

→ Power-law power spectrum characterized by A_s and n_s .

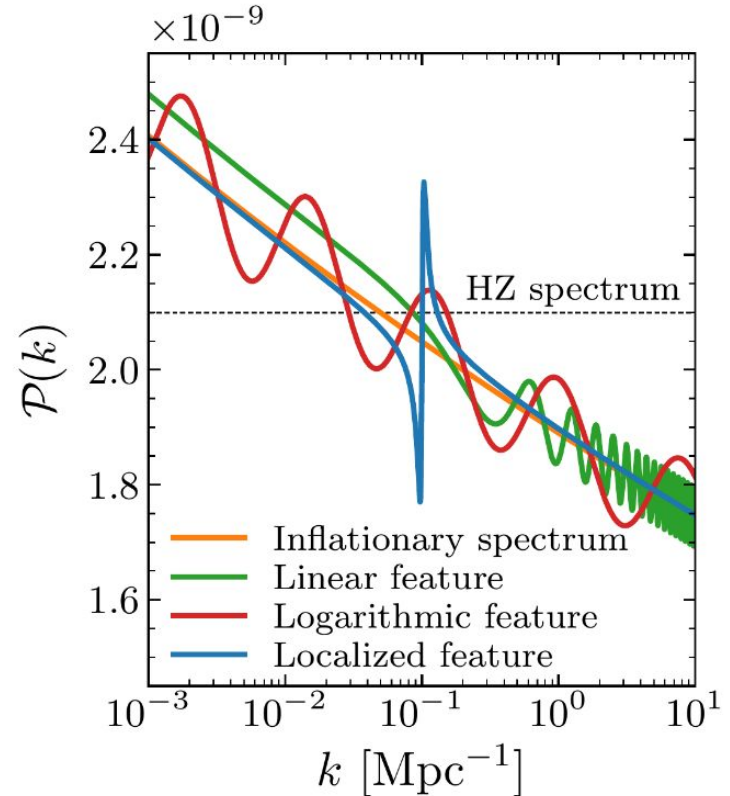
Simple Imprints of New Physics Predicted by Inflation



→ Access to new energy scales and detailed dynamics of inflation.

Theoretical Background for Primordial Features

- Primordial dynamics may exhibit a **significant departure from scale invariance**:
 - Generic in broad classes of models beyond simplest,
 - New energy scales during inflation.
- **Ubiquitous** when connecting inflationary modeling to fundamental physics.
- Strongly scale-dependent deviations from minimal power-law power spectrum:
 - **Oscillatory** and/or **localized imprints** in momentum space.



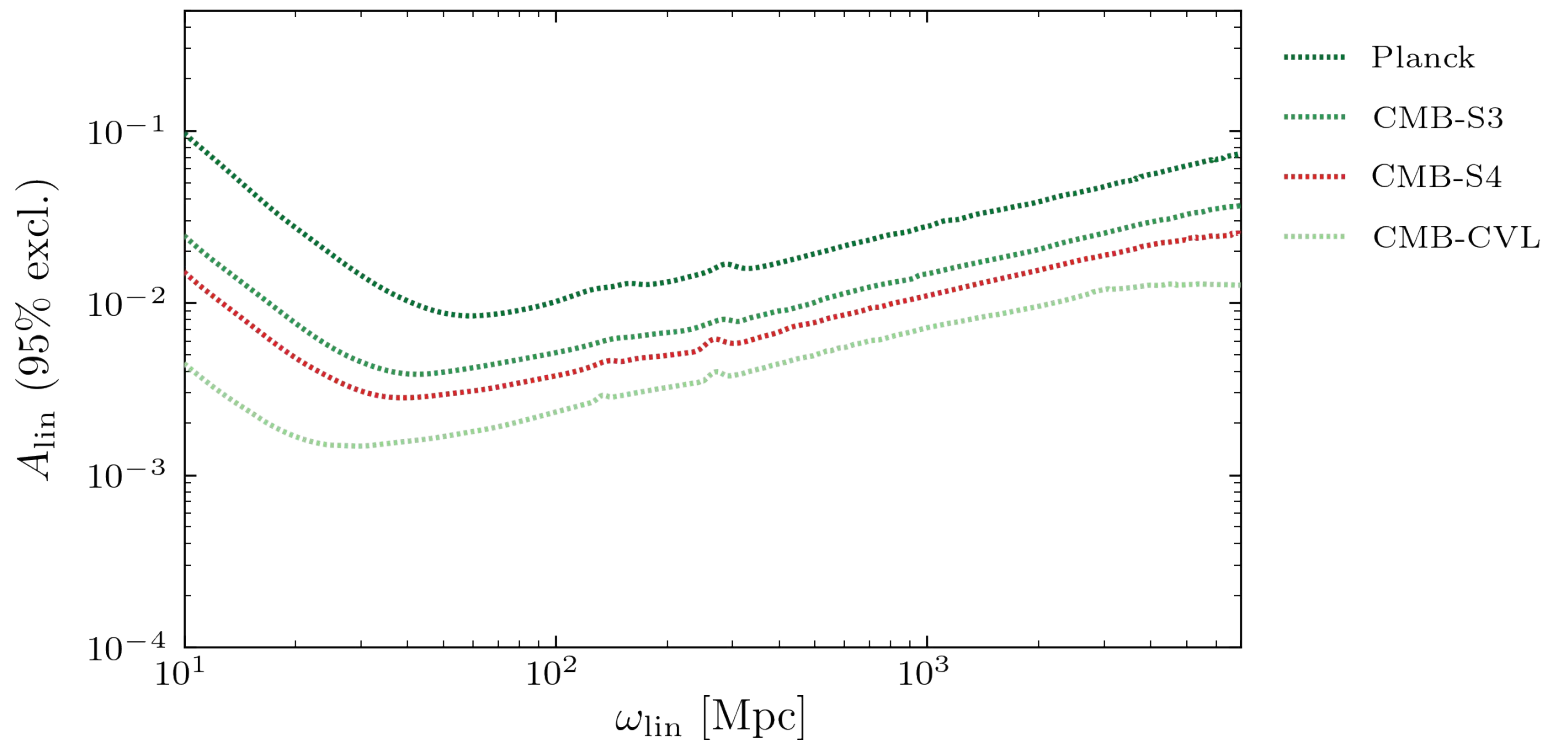
Theoretical Targets for Primordial Features

- Two main classes:
 - **Sharp features**: momentary departure of evolution from attractor,
 - **Resonant features**: periodic oscillation around attractor solution.
- **Correlated signals** in power spectrum and higher-point spectra.
- No useful theoretical priors on scale/amplitude of primordial features:
 - Origin: lack of our understanding of fundamental physics,
 - Cover as much of parameter and model space as possible.

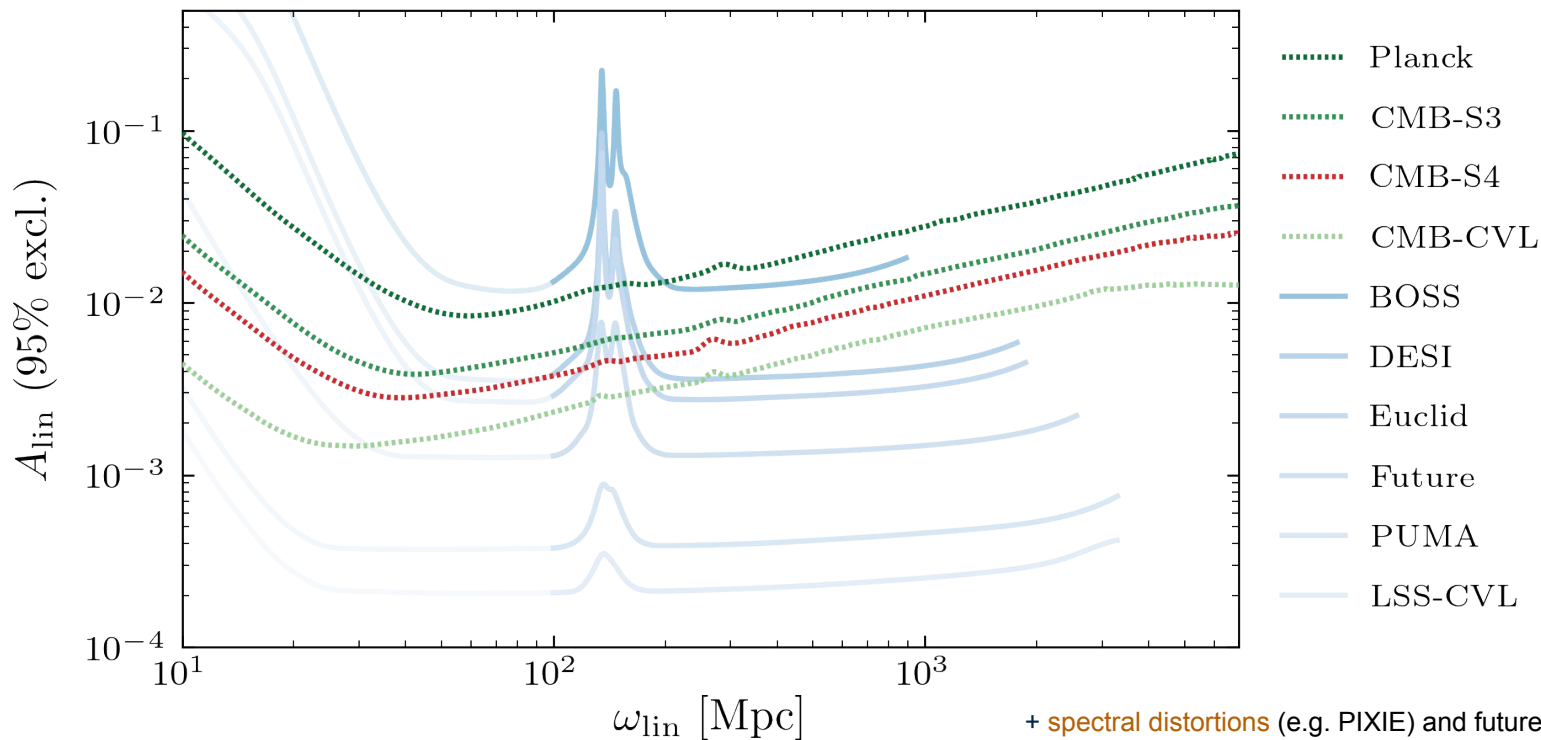
CMB Observations of Primordial Features

- **CMB anisotropies** have been leading the constraining power (Planck):
 - Template searches and non-parametric reconstruction,
 - Power spectrum and polyspectra searches,
 - No significant detections.
- **CMB-S4** science requirements for N_{eff} also cover those for primordial features:
 - Temperature and polarization spectra covering all, especially high multipoles.

CMB-S4 Will Improve Current and Stage-3 Bounds



LSS Surveys Are Complementary to the CMB



+ spectral distortions (e.g. PIXIE) and future gravitational wave background (e.g. LISA) on small scales

Conclusions

- Potential detection of primordial features could have profound implications for our understanding of fundamental physics.
- Upper limits can inform model building efforts and narrow the vast theoretical possibilities.
- **CMB-S4 will provide an important anchor for feature searches in the power spectrum and higher-point spectra** (via established and new analyses).
- See the white paper for further details.

[arXiv:2203.08128](https://arxiv.org/abs/2203.08128)

Inflation: Theory and Observations

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Comments and endorsements of the white paper are still welcome.