Simplifying the EFT of Inflation:

Generalized Disformal Transformations

and

Redundant Couplings

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Field Redefinitions

Inflationary observables: super-horizon correlation functions

\[ \langle \zeta(\tau, k) \zeta(\tau, -k) \rangle, \ \langle \gamma(\tau, k) \gamma(\tau, -k) \rangle \]

\[ \langle \zeta(\tau, k_1) \zeta(\tau, k_2) \zeta(\tau, k_3) \rangle, \ldots \]

\[ |k_i \tau| \ll 1 \]

Freedom to perform redefinitions of \( \zeta \) and \( \gamma \) that decay outside the horizon. (e.g.: \( \zeta \rightarrow \zeta + \lambda \frac{d\zeta}{dt} \))

\[ \downarrow \]

Used to simplify the action!
EFT of Inflation

- Single clock: $\phi(t)$  →  Time Diff.s

**Unitary Gauge**: perturbations are eaten by the metric.

- Focus on
  - Quadratic and cubic operators
  - Up to second order in derivatives.

\[
L = \frac{M_{\text{Pl}}^2}{2} \left[ R + 2\dot{H}g^{00} - 2(3H^2 + \dot{H}) \right] + \ldots
\]

Cheung et al., 07
Field redefinitions

Most generic transformation ...

\[ g_{\mu\nu} \rightarrow C(t, N, K, \ldots) g_{\mu\nu} + D(t, N, K, \ldots) n_\mu n_\nu + E(t, N, K, \ldots) K_{\mu\nu} + \ldots \]

... generates operators with too many derivatives!

\[ \delta S_{\text{EH}} = \frac{M_{\text{Pl}}^2}{2} \int d^4 x \sqrt{-g} \, G_{\mu\nu} \delta g^{\mu\nu} \]

To preserve the # of derivatives in the action:

\[ g_{\mu\nu} \rightarrow (f_1 + f_3 \delta N + f_5 \delta N^2) g_{\mu\nu} + (f_2 + f_4 \delta N + f_6 \delta N^2) n_\mu n_\nu \]

\[ (g^{00} \approx -1 + 2\delta N) \]
An example

\[ \mathcal{L}[g] = \mathcal{L}_{\text{EH+}\phi}[g] + c_R (3)R \delta N + c_K \delta N \delta K_{\mu\nu} \delta K^{\mu\nu} \]

Redefine \( g_{\mu\nu} \rightarrow \tilde{g}_{\mu\nu} = (1 + f_3 \delta N) g_{\mu\nu} + (1 + f_4 \delta N) n_\mu n_\nu \)

\[ \mathcal{L}[g] = \mathcal{L}_{\text{EH+}\phi}[g] + \left( c_R - \frac{f_3}{2} + \frac{f_4}{4} \right) (3)R \delta N + \left( c_K - \frac{f_3}{2} - \frac{f_4}{4} \right) \delta N \delta K_{\mu\nu} \delta K^{\mu\nu} \]

Use \( f_3 \) and \( f_4 \) to set to zero the couplings!

Observables do not depend on \( c_K \) and \( c_R \)!
EFTI up to cubic order in perturbations and 2 derivatives

- After integration by parts: 17 operators.

  6 field redefinitions \( (f_i) \) \rightarrow 6 redundant couplings!

  Minimal set: 11 operators!

- Predictions for \( \langle \gamma \gamma \rangle \) and \( \langle \gamma \gamma \gamma \rangle \) are the same as Einstein-Hilbert.

- All the couplings contributing to scalar-tensor-tensor action beyond EH can be removed.

  \( \langle \zeta \gamma \gamma \rangle \) is not fixed!

  Still affected by changes in the scalar sector.

Creminelli, Gleyzes, Noreña, Vernizzi, 14
Diff-like field redefinitions

Assume the action dominated by operators with no derivatives acting on the metric $P(X)$

$$L = L_{EH} + M_1^4 \delta N^2 + M_2^4 \delta N^3 + "small corrections"$$

$x = -\frac{1}{2} \partial_\mu \phi \partial^\mu \phi$

Additional transformations that mimic a time diff.:

$$\delta g_{\mu \nu} = \nabla_\mu \xi_\nu \quad \xi_\mu = F(t, \delta N, K) \eta_\mu$$

We remain at 2-derivative order!

- 6 transformations.
- Only three higher-derivative corrections.
Higher order in derivatives

Focus on tensor modes (assume \( \mathcal{P} \))

- 3-derivative level

\[ \langle \gamma \gamma \rangle \text{ does not change.} \]

Just 1 operator contributes to \( \langle \gamma \gamma \gamma \rangle : \delta K_{\mu \nu}^3 \)

- 4-derivative level

Only 1 operator affects \( \langle \gamma \gamma \rangle : \text{^{(3)}R}_{\mu \nu}^2 \)

Due to the coupling with \( \phi \)!

Corresponding \( \langle \zeta \gamma \gamma \rangle \) can be sizable!