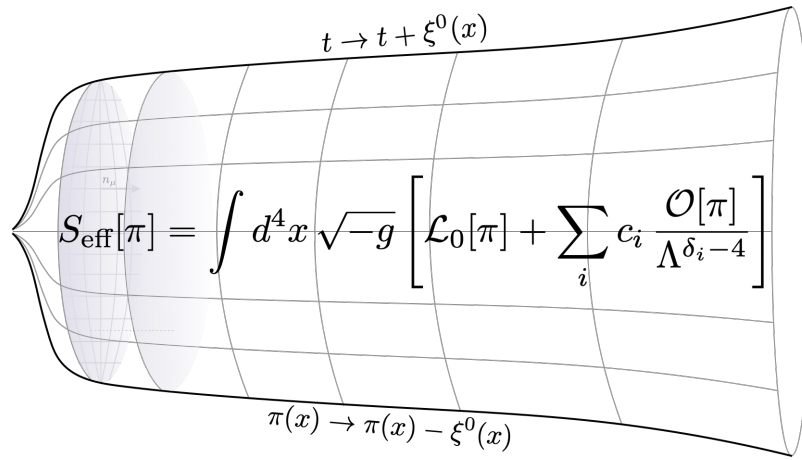


# Lecture Notes on Effective Field Theories in Cosmology

Rafael Bravo Guerraty

*Instituto de Física, Pontificia Universidad Católica de Chile,  
Avenida Vicuña Mackenna 4860, Santiago, Chile*



Winter School *Topics in Classical and Quantum Gravity* — Pontificia Universidad Católica de Chile, July 2026

---

## Abstract

In these notes I review the construction of the effective field theory (EFT) of cosmological perturbations around a FLRW background. I mainly focus on the geometric construction of the EFT of inflation, but the same logic and structure is straightforwardly extended to the EFT of dark energy. The construction is based on the fact that cosmological perturbations are nothing but Goldstone bosons of the *spontaneously* broken time diffeomorphism invariance of FLRW backgrounds. By writing the action in unitary gauge we capture the gravitational dynamics along a preferred spacetime foliation, by applying the Stückelberg mechanism we restore the full diffeomorphism invariance of the theory and the Goldstone appears explicit in the action, then by taking the decoupling limit we end up with the effective action describing fluctuations around FLRW.

---

---

## Contents

|                                                                         |           |
|-------------------------------------------------------------------------|-----------|
| <b>Why Effective Field Theory in Cosmology?</b>                         | <b>3</b>  |
| The Principles of EFT . . . . .                                         | 3         |
| <b>1 Spontaneous Symmetry Breaking in Flat Space</b>                    | <b>4</b>  |
| 1.1 Counting degrees of freedom . . . . .                               | 4         |
| 1.1.1 Massless spin $-1$ . . . . .                                      | 4         |
| 1.1.2 Massive spin $-1$ . . . . .                                       | 4         |
| 1.2 Stückelberg mechanism and the decoupling limit . . . . .            | 5         |
| 1.3 The origin of the mass . . . . .                                    | 6         |
| 1.4 Why EFT in cosmology . . . . .                                      | 6         |
| 1.5 Toy model I — global $U(1)$ . . . . .                               | 6         |
| 1.6 Toy model II — gauge $U(1)$ , Stückelberg, decoupling . . . . .     | 7         |
| 1.7 Breaking time diffeomorphisms . . . . .                             | 7         |
| 1.8 ADM as the language of the foliation, the building blocks . . . . . | 7         |
| <b>2 Cosmology as Spontaneous Symmetry Breaking</b>                     | <b>8</b>  |
| 2.1 When is a spacetime symmetry broken? . . . . .                      | 9         |
| 2.2 The most general action and tadpole cancellation . . . . .          | 11        |
| 2.3 The universal part is slow-roll in disguise . . . . .               | 11        |
| 2.4 Stückelberg in gravity . . . . .                                    | 11        |
| 2.5 Decoupling limit, sound speed, dispersion . . . . .                 | 11        |
| <b>3 Stückelberg Action in the decoupling limit</b>                     | <b>12</b> |
| <b>4 Model Space, Observables, and Dark Energy</b>                      | <b>14</b> |
| 4.1 The model map: corners of $\{M_n^4\}$ . . . . .                     | 14        |
| 4.2 Observables . . . . .                                               | 14        |
| 4.3 Extension to dark energy . . . . .                                  | 14        |

---

*Disclaimer: These notes are still under construction!*