Effective Field Theory and Inflation

Outline

Motivation

Cosmology has entered a precision era in which a simple consistent paradigm (the ΛCDM — or 'standard' — model of cosmology) captures all observations and is presently being redundantly tested with unprecedented precision. For particle physicists the great precision of this testing provides three of the separate lines of evidence for the failure of the Standard Model of particle physics: evidence for Dark Matter, Dark Energy and unusual initial conditions (including especially the properties of primordial fluctuations).

Inflation is the best-developed theory of initial conditions, in which primordial fluctuations are identified as arising from quantum vacuum fluctuations stretched by accelerated universal expansion. If the picture to which such theories point is correct then primordial fluctuations provide the first known prediction of an observable (and indeed observed) quantum gravity effect.

Effective field theories (EFTs) enter this story in two crucial ways. First EFTs justify why both gravity and quantum fluctuations can be understood with controlled theoretical error, despite the well-known absence of a definitive theory of quantum gravity. Second, just like in particle physics EFTs provide an efficient and relatively model-independent parameterization of the kinds of observable consequences quantum fluctuations can have.

Contents

These lectures organize these lines of thought into the following three lectures:

1. *Introduction to Big-Bang cosmology*
    - FRW expansion and history of the universe
    - Fluctuations and the formation of structure
2. *Inflationary cosmology*
    - Simple inflationary models
    - New EFT issues: quantum gravity and time-dependent backgrounds
3. *Quantum origin of primordial fluctuations*
    - Fluctuations in simple models
    - Parameterizing single-field fluctuations

Background readings

Some reviews that might provide useful background information are:

- *TASI Lectures on Inflation*
  D. Baumann
  (arxiv.org/abs/0907.5424)
- *Lectures on Cosmic Inflation and its Potential Stringy Realizations*
  C.P. Burgess
  (arxiv.org/abs/0708.2865)
- *Quantum Gravity as a low energy effective field theory*
  J. Donoghue
  (http://dx.doi.org/10.4249/scholarpedia.32997)
- *Quantum Gravity in Everyday Life: General Relativity as an Effective Field Theory*
  C.P. Burgess
  (arxiv.org/abs/gr-qc/0311082)
- *The Effective Field Theory of Inflation*
  C. Cheung, P. Creminelli, A.L. Fitzpatrick, J. Kaplan and L. Senatore
  (arxiv.org/abs/0709.0293)