

Course Syllabus

3e cycle CUSO lectures

Semi-classical and functional methods on curved spacetimes and applications to cosmology

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Week 1

- What is the effective action?
 - What it can (and can't) do for you.
 - How to extract observable quantities from it.
 - Classical vs quantum degrees of freedom.
- The equivalence (field redefinition) theorem.
- Linear and non-linear realizations of symmetries.
- How to compute the effective action formally; generating functions and derivative expansions.
- Introduction to the heat kernel formalism (pt I).

Week 2

- Introduction to the heat kernel formalism (pt II).
- Regularization and renormalization:
 - Dimensional regularization– why it's more than just good manners.
 - Interpretation of, and physical significance of UV vs. IR divergences.
 - Renormalization on backgrounds with curvature (nothing special about gravity).
 - Comparison with flat space diagrammatic techniques.
- Applications:
 - The Coleman-Weinberg potential in two lines.
 - Real and imaginary parts of the effective action.
 - Particle production during inflation; Schwinger pair production.
 - The scale of strong gravity at large N .

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Week 3

- Particle physics vs cosmology:
 - Decoupling on time dependent backgrounds.
 - In-out (S-) matrix elements vs. in-in matrix elements.
- Introduction to the Schwinger-Keldysh formalism:
 - Dealing with non-trivial initial density matrices.
 - Diagrammatic expansion (conceptually nice, but lots of redundancy).
 - Operator expansion.
- Spacetime generalization of Goldstone's theorem.

Week 4

- The EFT of the adiabatic mode:
 - \mathcal{R} as a Goldstone boson.
 - Picking an operator basis.
- Applications– explicitly integrating out fields:
 - Massive fields and reduced speeds of sound.
 - Physically interpreting the generated operators.
- Finite time correlation functions.
- Consistency relations as "Ward" identities.

Time/ interest/ weather permitting?

- Possibility of brief overviews of:
 - Quantum corrections to gravitational processes.
 - Non-local contributions to the effective action.
 - Dealing with out of equilibrium dynamics.
 - ... open to suggestions!