



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## COURSE SYLLABUS

### Quantum Field Theory I

2324-1-F1701Q135

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#### Aims

Become familiar with some of the main tools for the study of Quantum Field Theories (QFT): the functional approach, the perturbative expansion, regularization and renormalization of UV divergences, renormalization group.

#### Contents

Functional approach to QFT. The self-interacting scalar theory with quartic potential. Perturbative renormalization. Renormalization group. UV and IR fixed points. Renormalization group flows.

#### Detailed program

Path integral in Quantum Mechanics. The LSZ reduction formula, correlators, scattering amplitudes and cross-sections.

Path integral in QFT, functional calculus. The path integral for the free scalar theory. Generating functional of Green functions. The perturbative expansion for the scalar theory  $\phi^4$ . Feynman rules. Kallen-Lehmann formula.

Analogy between Statistical Mechanics and QFT. The effective action. One-particle irreducible diagrams and effective action via background field method. Coleman-Weinberg potential.

Superficial degree of divergence. Various regularization methods, cutoff and dimensional regularizations. BPHZ-renormalization: the  $\phi^4$  case at two loops.

Introduction to the renormalization group. The renormalization group equations. Beta functions. Qualitative study of the running of the coupling constants: Landau poles, UV and IR fixed points. General RG flows. Relevant, Irrelevant and marginal operators. RG flows and the Wilson Fisher point. Wilson Fisher expansion and critical exponents.

Introduction to the Wilsonian renormalization.

## **Prerequisites**

General Relativity, Theoretical Physics I and II.

## **Teaching form**

Frontal lectures

## **Textbook and teaching resource**

M.E. Peskin, D.V. Schroeder, An introduction to Quantum Field Theory

P. Ramond, Field Theory : A Modern Primer, 2nd Edition

M. Srednicki, Quantum Field Theory

T-P. Cheng and L-F. Li, Gauge Theory of Elementary Particle Physics

D. Anselmi, Renormalization

S. Weinberg, The Quantum Theory of Fields I, II

## **Semester**

Second semester

## **Assessment method**

Oral exam preceded by a short exercise to be solved in presence. The oral exam will include a discussion of the exercise plus a set of open questions on the topics presented in the lectures.

The final evaluation will take into account the level of comprehension of all the topics introduced in the course, the level of computational skills in QFT acquired, as well as scientific language skills and clarity of the answers.

## **Office hours**

By appointment, sending an e-mail to [silvia.penati@unimib.it](mailto:silvia.penati@unimib.it)

## **Sustainable Development Goals**

QUALITY EDUCATION

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