UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Quantum Field Theory I

2526-1-F1703Q040

Aims

Knowledge and understanding: The student will learn the fundamental concepts of Relativistic Quantum Field Theory. The student will become familiar with some of the main tools for the study of Quantum Field Theories, the functional approach, the perturbative expansion, regularization and renormalization of UV divergences, renormalization group.

Applying knowledge and understanding: The student will learn to apply Relativistic Quantum Field Theories to the study of Fundamental Interactions. The student will learn how to apply perturbative techniques to the evaluation of generating functionals and correlates for scalar theories.

Making judgments: The student will develop critical thinking and judgment skills in selecting the most appropriate tool, among those provided during the course, to solve a specific problem.

Communication skills: The student will be expected to acquire a correct and appropriate scientific language suited to the topics covered in the course.

Learning skills: The student will be able to deepen their understanding of specific concepts not covered during the course and to independently pursue advanced study using specialized scientific texts.

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 and class tutorials. There will be no remote teaching.

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, Renormalizazion
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 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

Sustainable Development Goals

QUALITY EDUCATION