Universitat Autònoma de Barcelona

Advanced Quantum Field Theory 2016/2017

Code: 42867
ECTS Credits: 9

Degree	Type	Year	Semester
4313861 High Energy Physics, Astrophysics and Cosmology	OT	0	2

Contact

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Use of languages

Principal working language: english (eng)

External teachers

Matthias Jamin

Prerequisites

It is recommended to have followed the Introductory course of Quantum Field Theory to have the basic notions necessary to follow this course. Naturally all prerequisites of the Introductory Quantum Field Theory course also apply here, namely, Classical Mechanics, Classical Electrodynamics and Quantum Mechanics (introductory and advanced).

Objectives and Contextualisation

The main purpose of this course is twofold. On the first part, the goal is to present a different formulation of Quantum Mechanics not based on operators in Hilbert space but on the Path Integral formalism and then extend this formulation from Quantum Mechanics to Quantum Field Theory. The main objects (Generating functionals and Green functions) will be introduced and computed first in a discretized form and then in a continuous form. The formalism will be applied to scalars, fermions and gauge fields. In the second part the appearance of infinities in the computation of interacting field theories will be presented and the regularization and renormalization theory will be detailed. Renormalization group theory and aspects of non-abelian gauge theories like QCD will be discussed. Finally at the end of the course some more advanced topics will be presented, namely, anomalies, hadronic tau decays and chiral perturbation theory.

Skills

- Formulate and tackle problems, both open and more defined, identifying the most relevant principles and using approaches where necessary to reach a solution, which should be presented with an explanation of the suppositions and approaches.
- Understand the bases of advanced topics selected at the frontier of high energy physics, astrophysics and cosmology and apply them consistently.

Learning outcomes

1. Apply the mechanisms of renormalisation systematically.
2. Calculate transition widths using lagrangians of effective theories.
3. Understand the foundations of functional formalism in quantum field theory.

Content

1. Functional Methods

1.1 Path Integrals in Quantum Mechanics

1.2 Functional Quantization

2. Symmetries in the functional formalism

3. Theory of renormalization

3.1 Ultraviolet divergences and dimensional regularization

3.2 Renormalized perturbation theory

3.3 Aspects of beyond leading order

4. Renormalization and symmetry

5. Aspects of non-abelian gauge theories: QCD and SU(N) gauge theories

6. Renormalization Group: equations and solutions

6.1 One-loop renormalization of quark mass and QCD coupling

6.2 Running of QCD coupling and quark massses

6.3 Renormalization of composite operators.

7. Other topics: Anomalies, Hadronic tau decays, chiral perturbation theory

Methodology

Theory Lectures and Exercises proposed along the course.

Activities

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Theory Lectures	52	2.08	1, 2, 3
Type: Supervised			
Discussion and Questions	11	0.44	1, 2, 3
Type: Autonomous			
Exercises	20	0.8	1, 2, 3
Study of Theoretical Foundations	90	3.6	1, 2, 3

Evaluation

The evaluation will be implemented via the proposed exercises to the students during the course of the two main parts of the course. Part I: From Functional Methods to Renormalization and Symmetry and Part II: From Aspects of non-abelian gauge theories to chiral perturbation theory.

Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
Homework Exercise part I	60%	30	1.2	1, 3
Homework Exercise part II	40%	22	0.88	1, 2

Bibliography

1) M. E. Peskin and D. V. Schroeder, An introduction to Quantum Field Theory, Westview Press.

2) R. J. Rivers, Path Integral Methods in Quantum Field Theory, Cambridge University Press.

3) S. Pokorski, Gauge Field Theories, Cambridge Monographs on Mathematical Physics.