PHYS-431 **Quantum field theory I**

Rattazzi Riccardo

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	6
Session	Winter
Semester	Fall
Exam	Oral
Workload	180h
Weeks	14
Hours	**5 weekly**
Courses	3 weekly
Exercises	2 weekly
Number of positions	

Summary

The goal of the course is to introduce relativistic quantum field theory as the conceptual and mathematical framework describing fundamental interactions.

Content

1. Introduction. Fundamental motivations for quantum field theory, Natural units of measure, Overview of the Standard Model of particle physics.
2. Classical Field Theory. Lagrangian and Hamiltonian formulation.
3. Symmetry Principles. Elements of group theory, Lie groups, Lie Algebras, group representations, Lorentz and Poincaré groups.
4. Symmetries and Conservation laws. Noether Theorem. Conserved currents and conserved charges. The conserved charges of the Poincarè group and their interpretation.
4. Canonical quantization of real and complex scalar fields. Creation and annihilation operators. Fock space. Bose-Einstein statistics. Heisenberg picture field. Realization of symmetries in the quantum theory.
5. Spinorial representations of the Lorentz group. Weyl, Majorana and Dirac spinors and their wave equations. Quantization of the Dirac field. Anticommutation relations and Fermi-Dirac statistics.
6. Quantized Electromagnetic field. Gauge Invariance, Gauss Law and physical degrees of freedom. Quantization in the Coulomb and Lorenz gauges.
7. Causality with classical and with quantum fields.

Learning Prerequisites

Required courses

Classical Electrodynamics, Quantum Mechanics I and II, Analytical Mechanics, Mathematical Methods

Recommended courses

General Relativity warmly recommmended

Learning Outcomes

By the end of the course, the student must be able to:

- Expound the theory and its phenomenological consequences
- Formalize and solve the problems

Transversal skills

- Use a work methodology appropriate to the task.

Teaching methods

Ex cathedra and exercises in class

Assessment methods

Exam: oral, consisting of one theoretical question and one exercise, picked randomly and for which the candidate is allowed a 60 minute preparation

Resources

Bibliography

- "An introduction to quantum field theory / Michael E. Peskin, Daniel V. Schroeder". Année:1995. ISBN:0-201-50397-2
- "The quantum theory of fields / Steven Weinberg". Année:2005. ISBN:978-0-521-67053-1
- "Quantum field theory / Claude Itzykson, Jean-Bernard Zuber". Année:1980. ISBN:0-07-032071-3
- "Relativistic quantum mechanics / James D. Bjorken, Sidney D. Drell". Année:1964
- "A modern introduction to quantum field theory / Michele Maggiore". Année:2010. ISBN:978-0-19-852074-0
- "Théorie quantique des champs / Jean-Pierre Derendinger". Année:2001. ISBN:2-88074-491-1

Ressources en bibliothèque

-
- An Introduction to Quantum Field Theory / Peskin
- The Quantum Theory of Fields / Weinberg
- Théorie quantique des champs / Derendinger
- Relativistic Quantum Mechanics / Drell
- A Modern Introduction to Quantum Field Theory / Maggiore
- Quantum Field Theory / Itzykson

Websites

- https://www.epfl.ch/labs/lptp/wp-content/uploads/2018/07/Quantum-Field-Theory

Moodle Link

- https://moodle.epfl.ch/course/view.php?id=14811

Prerequisite for

Recommended for Theoretical Physics and for Particle Physics