PHYS-431 **Quantum field theory I**

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

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|---|---|
| Language of teaching | English |
| Credits | 6 |
| Session | Winter |
| Semester | Fall |
| Exam | Written |
| 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 on 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. The Lorentz and Poincaré groups with their representations on fields. Noether theorem: conserved currents, conserved charges and their role as generators of the group. The conserved charges of the Poincarè group.
4. Canonical quantization of real and complex scalar fields. Creation and annihilation operators. Fock space. Bose statistics. Heisenberg picture field. Realization of symmetries in the quantum theory.
5. Spinorial representations of the Lorentz group. Covariant wave equations and the resulting Weyl, Majorana and Dirac spinors. Plane wave solutions of the Dirac equation. Chirality and helicity. Quantization of the Dirac field. Anticommutation relations and Fermi statistics.
6. Unitary representations of the Poincaré group: Casimir invariants, massive and massless representations.

## Learning Prerequisites

### Required courses

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

### Recommended courses

General Relativity and Quantum Mechanics III warmly recommended.

## 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

3 hours ex-cathedra
2 hours exercises

## Assessment methods

Oral exam, based on one theoretical question and one exercise picked through a random choice. The candidate is allowed 1 hour  to prepare and 20 minutes to present and discuss the handwritten results.

## 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

### Ressources en bibliothèque

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

### Notes/Handbook

Lecture Notes for QFT-I and QFT-II

### Websites

- https://www.epfl.ch/labs/lptp/

### Moodle Link

- https://go.epfl.ch/PHYS-431

## Prerequisite for

Recommended  for Theoretical Physics and for Particle Physics