UCLouvain

lphys2234

2025

Quantum field theory 2

The version you're consulting is not final. This course description may change. The final version will be published on 1st June.

5.00 credits	30.0 h	Q2

This biannual learning is being organized in 2025-2026

Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	This course relies on the basics of quantum field theory as discussed in the course LPHYS2132
Main themes	- S matrix and correlation functions : asymptotic theory, Källen-Lehmann representation, LSZ reduction, time-ordered n point functions and perturbation theory. - Renormalized perturbation theory to all orders, and renormalization schemes ; i) Feynman diagrams approach ; ii) Functional integral and methods approach. - Perturbative and non-perturbative functional methods in quantum field theory ; effective quantum action and potential. - Selected topics in advanced quantum field theory, depending on the interests of each year's target audience, one of which being the topic of a personal project.
Learning outcomes	**At the end of this learning unit, the student is able to :** **a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2M and PHYS2M1)** AA1 : A1.1, A1.2, A1.6 AA2 : A2.1, A2.5 AA3 : A3.1, A3.2, A3.3, A3.4 AA4 : A4.1, A4.2 AA5 : A5.1, A5.2, A5.3, A5.4 AA6 : A6.1, A6.2 AA7 : A7.1, A7.3, A7.4 AA8 : A8.1 1 **b. Specific learning outcomes of the teaching unit** By the end of this teaching unit, the student will be able to : 1. implement renormalised perturbation theory of theories with quantum scalar and spinorial fields, possibly even vector and gauge fields ; 2. understand the roles of regularization and of renormalization points in a perturbative renormalization scheme ; 3. explain the occurrence of masses and interaction coupling constants which are running functions of renormalization scales ; 4. further the study of a specific topic of advanced quantum field theory ; 5. relate the contents of the course to current developments in quantum field theory at the interface of the fundamental quantum interactions and of the gravitational interaction.
Evaluation methods	The exam will consist of a small presentation about the personal project, followed by an oral examination about the project and the entire course content.
Teaching methods	The course will mostly be taught as lectures in class. In addition, each student will choose one personal project that they pursue over the quadrimester.
Content	The course will cover the following topics: - LSZ formula and the relation between the S-matrix and correlation functions - The path integral and functional methods in quantum mechanics and quantum field theory - Renormalisation of non-Abelian gauge theories

	- QFT in a medium: Introduction to the real- and imaginary time formalisms at finite temperature and density, applications in cosmology and astroparticle physics - Non-equilibrium phenomena in QFT and the Schwinger-Keldysh formalism The content can to some degree be adapted to the interests of the audience.
Bibliography	- M. E. Peskin and Daniel S. Schroeder, *An Introduction to Quantum Field Theory* (Westview Press, Perseus Books, 1995). - M. Schwartz, Quantum Field Theory and the Standard Model, Cambridge University Press, 2014 - M. Le Bellac, Thermal Field Theory, Cambridge University Press, 2011 - J. Berges, Introduction to Nonequilibrium Quantum Field Theory, https://arxiv.org/abs/hep-ph/0409233
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [60] in Physics	PHYS2M1	5		
Master [120] in Physics	PHYS2M	5		