UCLouvain

lphys2215

2019

Statistical field theory

In view of the health context linked to the spread of the coronavirus, the methods of organisation and evaluation of the learning units could be adapted in different situations; these possible new methods have been - or will be - communicated by the teachers to the students.

5 credits	30.0 h	Q2

This biannual learning unit is not being organized in 2019-2020 !

Teacher(s)	Hagendorf Christian ;
Language :	English
Place of the course	Louvain-la-Neuve
Main themes	This teaching unit provides an introduction to field-theoretic methods in statistical mechanics. In particular, it deals with path integrals and functional integrals, perturbative expansions and Feynman diagrams, renormalisation theory and Wilson's renormalisation group. The theoretical concepts are illustrated via their applications to statistical mechanics and condensed matter physics.
Aims	**a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2M and PHYS2M1)** 1.1, 1.2, 2.1, 3.1, 3.2, 3.3, 3.4, 4.1, 5.4 **b. Specific learning outcomes of the teaching unit** At the end of this course, the student will be able to : 1 ' apply path-integral methods to solve problems in statistical mechanics and quantum mechanics ; ' derive Feynman rules and the perturbation theory of a quantum field theory from quantisation via functional integration ; ' use methods of perturbative renormalisation in order to compute critical exponents ; ' apply the ideas of Wilson's renormalisation group to systems of statistical mechanics. - - - - *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled “Programmes/courses offering this Teaching Unit”.*
Evaluation methods	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** The evaluation is based on an oral exam. The students are asked to present their personal work on a physical or mathematical problem that is related to the teaching unit’s topics. The evaluation tests the student’s knowledge and his/her understanding of the notions seen in the theoretical course, his/her ability to apply them to new problems and his/her oral presentation skills.
Teaching methods	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** The learning activities consist of lectures. The lectures introduce fundamental concepts of the theory of nonlinear systems and their motivation through concrete examples from various scientific disciplines.
Content	The main goal of statistical field theory is to describe a system of statistical mechanics at the vicinity of a critical point by methods of (Euclidian) quantum field theory. The purpose of this teaching unit is to provide the student with an introduction to this field-theoretical approach and to treat the theory of renormalisation in statistical mechanics. The teaching unit’s approach to these problems is based on quantisation via functional integration. The following topics are covered by the teaching unit : 1. **Path integrals and functional integrals :** the path integral for a quantum particle in one dimension — derivation, generalisation higher dimensions, observables and correlation functions, finite-temperature systems — Euclidean theory, Euclidean quantum mechanics and statistical physics, boson and fermion systems. 2. **Quantisation of the free field via functional integration :** free fields and the scaling limit of the Gaussian model, correlation functions and propagators, Wick’s theorem. 3. **Critical phenomena — a reminder :** phase transitions and universality, critical exponents, mean-field theory and Landau theory, critical dimension, critical phenomena and Euclidian field theory, magnetic systems.

	1. **The** '4 **model — perturbation theory :** functional integral for the '4 theory, perturbation series and Feynman rules, combinatorics of Feynman diagrams, connected and irreducible graphs, correlation functions and connected diagrams, effective action. 2. **The** '4 **model : renormalisation:** ultraviolet divergences and their regularisation, renormalisation in d = 4 dimensions, substraction scales, scaling dimensions, beta function, renormalisation in d < 4 dimensions: '-expansion, renormalisation group flow. 3. **Le groupe de renormalisation de Wilson :** basic principles, renormalisation group flow in the space of Hamiltonians, examples from statistical mechanics (gaussian model, Ising model, decimation procedure of Migdal-Kadanoff), fixed points and critical manifolds, linearisation and critical exponents.
Inline resources	The MoodleUCL website of this teaching unit contains a detailed plan of the covered topics, a complete bibliography, exercise sheets and a collection of exam subjects from past years.
Bibliography	• E. Brézin, Introduction to statistical field theory. Camebridge University Press (2006). • J. Cardy, Scaling and renormalisation in statistical physics. Camebridge lecture notes in statistical physics (1996). • C. Itzykson, J.M. Drouffe, Théorie statistique des champs. EDP Sciences (1989). • M. Kardar, Statistical Physics of fields. Camebridge University Press (2007). • G. Parisi, Statistical field theory. Addison-Wesley (1988). • J. Zinn-Justin, Intégrale de chemin en mécanique quantique : introduction. EDP Sciences (2003). • J. Zinn-Justin, Quantum field theory and critical phenomena. Oxford Science Publications (1996).
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Aims
Master [60] in Physics	PHYS2M1	5		
Master [120] in Physics	PHYS2M	5		