UCLouvain

lphys2316

2019

Advanced mathematical physics

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	Q1

Teacher(s)	Hagendorf Christian ;Ruelle Philippe ;
Language :	English
Place of the course	Louvain-la-Neuve
Main themes	The teaching unitwill attempt to answer the following general question: why and how is a statistical model near a critical point described by a quantum field theory? The first part will examine the Ising model in details: duality; spectrum of the transfer matrix and relationswith a theory of free fermions; the free fermionas a conformal theory; identification of its operator contentfrom lattice observables via a scaling limit. The second part will generalise these concepts and introduce the minimal conformal theories. The following topics will be addressed: the conformal Ward identity, primary operators and descendants, the Virasoro Algebra andits representations, the Kac determinant and the operator content of minimal models, correlation functions and fusion rules.
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. 1 **b. Specific learning outcomes of the teaching unit** At the end of this teaching unit, the student will have : ' acquired a basic working knowledge of conformal field theories in two dimensions. - - - - *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 course's topics. The evaluation tests the student's knowledge and his understanding of the notions seen in the theoretical course, his ability to apply them to new problems and his 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	• **Introduction :** classical statistical mechanics in d dimensions and quantum systems in d-1 dimensions, transfer matrices: spectrum and correlation functions, a renormalisation group reminder, scaling relations; • **The two-dimensional Ising model :** duality and the critical point, disorder operators, lattice fermions, transfer matrix, Hamiltonian limit, spectrum of the quantum Hamiltonian : the Jordan-Wigner transformation, diagonalisation, scaling limit: the free fermion, conformal Hamiltonians; • **The conformal Ward identity :** conformal invariance in d > 2 dimensions, the energy-momentum tensor, conformal invariance in d = 2 dimensions, the Ward identity, the Virasoro algebra, central charge, quasi-primary and primary fields, conformal families, the operator product expansion; • **Free-field theories in two dimensions :** the massless Gaussian free field in two dimensions, propagators, correlations functions and the Wick theorem, vertex operators; the massless free fermion in two dimensions, the fermionic Wick theorem; • **Minimal models — an introduction :** the operator formalism, representations of the Virasoro algebra, unitarity, the Kac determinant, reducibility and singular vectors, differential equations for correlation functions, fusion rules, minimal models: examples and related models in statistical mechanics, the critical Ising model : correlation functions in the scaling limit.
Bibliography	• J. Cardy, Scaling and renormalisation in statistical physics. Cambridge lecture notes in statistical physics (1996). • Ph. Di Francesco, P. Mathieu, D. Sénéchal, Conformal field theory. Springer (1997). • P. Ginsparg, Applied conformal field theory. arXiv:hep-th/9108028 (1991). • C. Itzykson, J.M. Drouffe, Théorie statistique des champs. EDP Sciences (1989). • G. Mussardo, Statistical field theory. Oxford University Press (2010).

Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)

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