UCLouvain

lphys2316
2022

Advanced mathematical physics

5.00 credits	30.0 h	Q1

Teacher(s)	Ruelle Philippe ;Walmsley Hagendorf Christian ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	LPHYS2113. Having followed LPHYS2132et LPHYS2215 is an asset.
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.

Learning outcomes	**At the end of this learning unit, the student is able to :**
	
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	    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 teaching unit, the student will have :
	    ' acquired a basic working knowledge of conformal field theories in two dimensions.

Evaluation methods	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	The learning activity consists of lectures. They aim at introducing the fundamental concepts and, by establishing results, at showing their reciprocal links and relations with other courses of the Master of Physical Sciences programme. The activity is given in class.
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	Learning outcomes
Master [120] in Physics	PHYS2M	5		🔍