UCLouvain

lphys2113

2021

Critical phenomena

5.00 credits	22.5 h + 7.5 h	Q1

Teacher(s)	Ruelle Philippe ;
Language :	English
Place of the course	Louvain-la-Neuve
Prerequisites	Having followed LPHYS 1343 is an asset.
Main themes	Introduction to phase transitions and the specific phenomena appearing in the neighbourhood of transition points (critical phenomena) ; modelization of the ferromagnetic transition and description of the singularities of thermodynamic functions; homogeneous Landau theories ; conceptual understanding of critical phenomena from the group renormalization analysis.
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)** 1.1, 1.5, 2.1, 2.3, 3.1, 3.2, 3.3, 3.4, 7.2, 8.1. **b. Specific learning outcomes of the teaching unit** At the end of the teaching unit, the student will be able to : 1 1. investigate a simple model to show the existence or the absence of phase transition ; 2. solve an homogeneous Landau problem ; 3. evaluate the quality of approximation schemes like mean field theories ; 4. define renormalization transformations in simple models ; 5. identify the type of a given phase transition ; 6. explain the importance of fixed points of the renormalization group and their relation to universality classes.
Evaluation methods	Two evaluation methods may be considered : a written exam or an oral presentation on a subject chosen by the student and validated by the teacher. In case compulsory take-home projects are submitted during the semester, these will contribute to the final mark. This contribution will be used in every exam session.
Teaching methods	The teaching consists of lectures and tutorial sessions during which the students have the opportunity to think together about concrete problems. These sessions can be devoted to problem solving, numerical simulations, collective discussions or individual oral presentations.
Content	• Introduction to the phenomenology of phase transitions (liquid-gas transition and ferromagnetic transition) ; experimental scaling laws and critical exponents. • Introduction of the Ising model as an effective description of the ferromagnetic transition; qualitative discussion ; resolution of the 1d model by transfer matrix ; Peierls argument for the Ising model. • Low and high temperature expansions in the Ising model ; duality. • Mean field theory for the Ising model and computation of the critical exponents ; general Landau theory and application to the ferromagnetic transition. • Resolution of the 1d Ising model by decimation ; basic ideas of the renormalization group. • General discussion of the renormalization group : renormalization transformations, associated flow, fixed points, critical surfaces, relevant and irrelevant directions. • Linearization of renormalization transformations and consequences : scaling laws, singularities of thermodynamical functions and calculation of critical exponents.
Bibliography	Julia M. Yeomans, Statistical Mechanics of Phase Transitions, Oxford University Press, 1992, 153 pages.
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		🔍
Master [60] in Physics	PHYS2M1	5		🔍