UCLouvain

lphys1343

2024

Statistical physics

6.00 credits	45.0 h + 30.0 h	Q2

Teacher(s)	Walmsley Hagendorf Christian ;
Language :	French > English-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	It is recommended that students master the notions of Hamiltonian mechanics as developed in course LMAT1261, of thermodynamics as developed in course LPHYS1114 and the basics of quantum mechanics as developed in course LPHYS1241.
Main themes	This teaching unit is an introduction to the concepts and methods of statistical physics at equilibrium and out of equilibrium.
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** 1.1, 1.3, 1.4, 2.1, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 **b. Specific learning outcomes of the teaching unit** At the end of this teaching unit, the student will be able to : 1 1. describe macroscopic systems by the probabilistic methods of statistical physics within the framework of microcanonical, canonical and grandcanonic ensembles, and derivetheir macroscopic / thermodynamic laws; 2. treat interacting particle systems by the mean field approximation; 3. understand the effect of quantum statistics on the physics of fermion and boson systems; 4. analyse the evolution of a system towards equilibrium by the master equation; describe elementary transport phenomena.
Evaluation methods	The evaluation is based on a written exam. It deals with the fundamental concepts of statistical physics and their applications to problems of atomic physics, solid-state and condensed matter physics etc. It tests the student's knowledge and the understanding of theoretical concepts, the student's ability to analyse the physics of a macroscopic system via the formalism of the statistical physics as well as the coherent presentation of this analysis.
Teaching methods	The learning activities consist of lectures and exercise sessions. The lectures are intended to introduce the fundamental concepts of statistical physics and, by establishing results, to show their reciprocal links and their relations with other teaching unitsof the Bachelor's programme in physics. The exercise sessions present the wide range of applications of statistical physics, allow the student to become acquainted with the formalism of statistical physics and interpret its predictions.
Content	The objective of statistical physics is to determine the laws of physics of macroscopic systems from the fundamental laws oftheir microscopic constituents by probabilistic methods. This teaching unitprovidesan introduction to this approach for systems at equilibrium and out of equilibrium. The course will cover a selection of the following topics : **1. Reminder of thermodynamics:** thermodynamic description of macroscopic systems, first and second law, thermodynamic potentials, equations of state. **2. The f oundations of statistical physics:** probability reminders, micro- and macro-states, counting states and density of states, statistical entropy, fundamental postulate and the microcanonical, relaxation of constraintsand thermodynamic quantities. **3. The canonical ensemble:** coupling to a heat reservoir and the Gibbs law, the equivalence of ensembles, applications (kinetic theory, perfect polyatomic and molecular gases, the thermodynamics of oscillators and the Debye model, black-body radiation). **4. S ystems of interacting particles :** liquid-gas transition (Mayer and cumulative expansion, the van der Waals equation, Maxwell's construction), paramagnetic-ferromagnetic transition (microscopic origin of magnetism, Heisenberg and Ising model, transfer matrices), mean field theory. **5. The g randcanonic al ensemble and quantum statistics:** coupling to a particle reservoir, Fermi-Dirac and Bose-Einstein statistics, the degenerate Fermi gas, Bose-Einstein condensation, applications (semiconductors, neutron star, helium-3 and helium-4). **6. The e volution towards equilibrium:** the evolution postulate and the master equation, Boltzmann's H theorem, the Boltzmann equation and transport phenomena in fluids.

Inline resources	The MoodleUCL website of this teaching unit contains a detailed plan of the covered content, a complete bibliography, exercise sheets and a collection of exam subjects from past years.
Bibliography	• B. Diu, C. Guthmann, D. Lederer, B. Roulet , *Éléments de physique statistique.* Hermann (2001). • M. Kardar, *Statistical physics of particles.* Camebridge University Press (2007). • H. Krivine, J. Treiner, *La physique statistique en exercices*. Vuibert (2008). • F. Reif, *Fundamentals of thermal and statistical physics.* Waveland Inc (2008). • C. Texier, G. Roux, *Physique statistique. Des processus élémentaires aux phénomènes collectifs.* Dunod (2017).
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Minor in Physics	MINPHYS	6		
Bachelor in Physics	PHYS1BA	6		