UCLouvain

# lphys1343

*2021*

# Statistical physics

| 6.00 credits | 45.0 h + 30.0 h | Q2 |
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| Teacher(s) | Hagendorf Christian ; |
| Language : | French |
| Place of the course | Louvain-la-Neuve |
| Prerequisites | LPHYS1112 or equivalent teaching unitfromanother programme. Having followed LPHYS1342 and having followed and passed LPHYS1241 are assets.<br>*The prerequisite(s) for this Teaching Unit (Unité d'enseignement – UE) for the programmes/courses that offer this Teaching Unit are specified at the end of this sheet.* |
| Main themes | This teaching unit is an introduction to the concepts and methods of statistical physics at equilibrium and out of equilibrium. |
| Aims | **a. Contribution of the teaching unit to the learning outcomes of the programme**<br>1.1, 1.3, 1.4, 2.1, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6<br>**b. Specific learning outcomes of the teaching unit**<br>At the end of this teaching unit, the student will be able to:<br>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;<br>' treat interacting particle systems by the mean field approximation;<br>' understand the effect of quantum statistics on the physics of fermion and boson systems;<br>' analyse the evolution of a system towards equilibrium by the master equation; describe elementary transport phenomena.<br>- - - -<br>*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.**<br>The evaluation is based on a written exam and a continuous assessment during the semester.<br>The written exam 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.<br>The result of the continuous assessment will be used for each session and cannot be represented.<br>The evaluation methods may be adapted and modified according to the evolution of the Covid-19 pandemic. |
| Teaching methods | **Due to the COVID-19 crisis, the information in this section is particularly likely to change.**<br>The learning activities consist of lectures and exercisesessions. 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.<br>The exercisesessions presentthe 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.<br>The following contents are covered:<br>1. **T hermodynamics reminder :**thermodynamic description of macroscopic systems, first and second law, thermodynamic potentials, equations of state.<br>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.<br>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).<br>4. **S ystems of interacting particles :**liquid-gas transition (Mayer and cumulative expansion, the van der Waals equation, Maxwell'sconstruction), paramagnetic-ferromagnetic transition (microscopic origin of magnetism, Heisenberg and Ising model, transfer matrices), meanfield theory. |

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| | 5. **The g randcanonic al ensemble and quantum statistics:**coupling to a particle reservoir, Fermi-Dirac and Bose-Einstein statistics, degenerate Fermi gas, Bose-Einstein condensation, applications (semiconductors, neutron star, helium-3 and helium-4).<br>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).<br>• M. Kardar, Statistical physics of particles. Camebridge University Press (2007).<br>• H. Krivine, J. Treiner, La physique statistique en exercices. Vuibert (2008).<br>• F. Reif, Fundamentals of thermal and statistical physics. Waveland Inc (2008).<br>• 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) | | | | |
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| Program title | Acronym | Credits | Prerequisite | Aims |
| Bachelor in Physics | PHYS1BA | 6 | LPHYS1112 | 🔍 |
| Minor in Physics | MINPHYS | 6 | LPHYS1112 | 🔍 |