UNIVERSITY OF GOTHENBURG

PHYSICS

FIM786 Nonequilibrium processes in physics, chemistry and biology, 7.5 higher education credits

Icke-jämviktsprocesser inom fysik, kemi och biologi, 7,5 högskolepoäng

Second Cycle

Confirmation

This course syllabus was confirmed by Department of Physics on 2012-03-06 and was last revised on 2017-06-13 to be valid from 2017-06-13, spring semester of 2017.

Field of education: Science 100%
Department: Physics

Position in the educational system

The course is given within the Masters Programme 'Complex Adaptive Systems'. It can also be given as a freestanding advanced course in physics at the University of Gothenburg.

The course can be part of the following programmes: 1) Complex Adaptive Systems, Master's Programme (N2CAS), 2) Physics of Materials and Biological Systems, Master's Programme (N2PMB) and 3) Physics, Master's Programme (N2PHY)

Main field of studies	*Specialization*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Entry requirements

The student should have knowledge in Mathematical analysis and Algebra, Thermodynamics and Statistical Physics, Classical and Quantum Mechanics corresponding to the first three years at the Bachelor level.

Applicants must prove knowledge of English: IELTS 6.5, no band below 5.5 or TOEFL paper-based 575 TWE 4.5 or above, computer-based: 213 Essay writing 4, internet-based: 90 TWE score 20 or Oxford/Cambridge: Certificate in Advanced English, Certificate of Proficiency, Diploma of English Studies. This requirement does not apply to students with a Bachelor degree from an English speaking university, or to students having passed English level B at Swedish/Nordic Upper Secondary School.

Learning outcomes

In this course the student should acquire a general knowledge of stochastic processes and their use to describe the time evolution of systems in nature; the student will learn basic concepts and practical methods of the kinetic theory for classical and quantum many body systems. The following topics are covered: Statistical description of a dissipative macroscopic system and origin of irreversible evolution. Stochastic processes and basic distributions. Boltzmann equation and transport theory. Langevin theory of classical and quantum Brownian motion. Fluctuation and noise. Applications to physical, chemical and biological systems.

After having taken the course the student should have acquired:

- knowledge of basic concepts and practical methods of the kinetic theory for classical and quantum many particle systems,
- understanding the origin of irreversible evolution of physical, chemical, and biological systems, and hierarchy of relaxation processes,
- practical skills in solving transport problems, analyzing dissipative and fluctuation phenomena, and effects of environment,
- a general knowledge of stochastic processes and their use to describe the time evolution of systems in nature.

Course content

The great majority of physical, chemical, and biological processes occur outside the thermodynamic equilibrium. How do we describe many-particle systems driven away from equilibrium, or evolving towards the equilibrium due to an interaction with an environment? In contrast to the universality of the thermodynamics, the non-equilibrium evolution is system specific and requires individual approach. The purpose of the course is to introduce basic concepts of kinetic theory and stochastic processes, and to study practical tools to investigate non-equilibrium states. We will discuss the origin of irreversible evolution and dissipation, hierarchy of relaxation processes, transport phenomena and noise, Brownian motion. The course includes a selection of applications to quantum solid state systems, chemical reaction kinetics, and soft matter like colloidal dispersions, polymers, gels, glasses and biological systems.

The first half of the course deals with general concepts of non-equilibrium statistical physics and methods to describe dissipative and transport processes in many-body systems. Starting with a simple example of a random walk the basic concepts in probability theory and stochastic processes are introduced. More complex systems are studied via the Boltzmann equation and by considering Markov processes. The latter introduces the study of Master-, Fokker-Planck- and Langevin equations. The student can choose two different directions for the second part of the course:

1. Quantum non-equilibrium systems
Here we consider applications in modern solid state physics, quantum electronics and optics. We study methods to describe the state and evolution of quantum non-equilibrium systems, linear response theory, problem of quantum noise, relation between fluctuations and dissipation, behavior of quantum particle in an environment.

2. Transport in soft matter and biological systems
Here we study applications in complex systems. We study methods to describe transport processes in various systems like polymers, colloids, soft matter. Description of chemical reactions and Brownian motors. Applications to systems in physics, chemistry and biology.

The course is based on a series of lectures and exercises. The second half of the course can be organized as a project work.

Form of teaching
Home assignmnets and written examination.

Language of instruction: English

Assessment
The final grade for the course is obtained when all compulsory parts of the course have been approved. Students that have failed the course twice has the possibility of asking for another examiner. Such a request must be registered to the relevant department.

Grades
The grading scale comprises: Pass with Distinction (VG), Pass (G) and Fail (U).
If there are established criteria for G and VG, they have to be made available to the student.

Course evaluation
The evaluation of the course is done by the teacher and students together during and after the course.

Additional information

The Masters Programme in "Complex Adaptive Systems" is given in collaboration with Departments at Chalmers University. The course is identical to and given together with the courses MCC011 and TIF106 "Nonequilibrium processes in physics, chemistry and biology" in Masters Programmes at Chalmers.

This course replaces an earlier course "Stochastic processes in physics, chemistry and biology" FIM785, and both courses cannot simultaneously be included in a masters exam.