Jnr: 2015/1652-3.1.2

Course syllabus

Faculty of Technology
Department of Physics and Electrical Engineering

4FY521 Kvanttransport i nanostrukturer, 7,5 högskolepoäng
Quantum transport in nanostructures, 7.5 credits

Main field of study
Physics

Subject Group
Physics

Level of classification
Second Level

Progression
A1F

Date of Ratification
Approved by Faculty of Technology 2015-05-22
The course syllabus is valid from spring semester 2016

Prerequisites
Physics 90 credits, mathematics 45 credits or equivalent. An introduction course in Solid State Physics 7,5 credits or equivalent.

Objectives

At the end of the course the students:

- should be able to account for the different regimes of transport theory.
- should have acquired a basic knowledge in deriving and solving the Boltzmann equation.
- should have acquired familiarity with the physics of Coulomb blockade and its analysis in terms of rate equations in the sequential tunneling approximation.
- should have acquired a basic knowledge of phase coherent transport in mesoscopic systems and some of its remarkable physical effects such as conductance quantization.
- should have learnt to use the non-equilibrium Green's function formalism in quantum transport and its application to inelastic scattering
- should be knowledgeable about linearized transport equations
- should have become familiar with important effects in quantum transport where the electron spin plays a crucial role.

Content

Boltzmann transport equation

- Derivation
- Relaxation time approximation
- Linearized approximation
- Numerical solutions by discretization and Monte-Carlo simulations
- Quantum corrections to semiclassical transport, weak localization.

Transport in Coulomb blockade (CB) systems

- Rate equations
- Sequential tunneling, 2D stability diagram; CB oscillations, and CB staircase
- Electrical-, thermal-conductance, Seebeck-, Peltier-coefficients from linearized theory
- Numerical solution
- Elastic and inelastic cotunneling
- Magnetic SET with nanoparticles and molecules

Phase coherent quantum transport

- Landauer formulation
- Linearization, conductance, thermal conductance, Seebeck and Peltier effect
- Formulation in terms of one-particle Green's functions
- Partitioning
- Self-energies
- Current calculation
- Non-equilibrium density matrix
- Inelastic effects
- Spin polarized transport

Magnetoelectronics

- Theory of charge and spin transport
- Spin current and spin accumulations
- Magneto-electronic circuit theory
- Spin-transfer magnetization torque

Examples

- Inelastic scattering in nanotubes
- Coulomb blockade in 2-D electron gas
- 1-D Datta-Das spin transistor
- Coherent transport in atomic wires
- Spin-Hall effect

Type of Instruction

The teaching consists of lectures and tutorials.

Students can also register for the "distance" version of the course and follow the course via the internet. IT support and technical information: Email and web connection. Real-time and recorded lectures on course homepage.

Examination

The course is assessed with the grades A, B, C, D, E, Fx or F.
The grade A constitutes the highest grade on the scale and the remaining grades follow in descending order where the grade E is the lowest grade on the scale that will result in a pass. The grade F means that the student's performance is assessed as fail (i.e.

a pass. The grade F means that the student's performance is assessed as fail (i.e. received the grade F).

Assessment of student performance is made through written test and/or oral examinations and/or presentation of mandatory assignments. Reexamination will be offered within six weeks under the regular semester periods. The numbers of examinations are limited to five times.

Course Evaluation

During the course or in close connection to the course, a course evaluation is to be carried out. The result and analysis of the course evaluation are to be communicated to the students who have taken the course and to the students who are to participate in the course the next time it is offered. The course evaluation is carried out anonymously. The compiled report will be filed at the Faculty.

Credit Overlap

The course cannot be included in a degree along with the following course/courses of which the content fully, or partly, corresponds to the content of this course:4FY821 Quantum transport in nanostructures, 7.5 credits

Other

Grade criteria for the A–F scale are communicated to the student through a special document. The student is to be informed about the grade criteria for the course by the start of the course at the latest.

Required Reading and Additional Study Material

Reference Literature

1.Quantum Transport, atom to transistor, S. Datta, Cambridge, 2006.
2.Electronic Transport in Mesoscopic systems. S. Datta, Cambridge University Press, 2005.
3.Quantum Kinetics in Transport and Optics of Semiconductors, H. Haug, A.-P. Jauho, Springer, 2007
4.Many-Body Quantum Theory in Condensed Matter Physics: An Introduction, H. Bruus, K. Flensberg, Springer.
5.Quantum Transport: Introduction to Nanoscience, Yuli V. Nazarov, Cambridge University Press; 1 edition (28 May 2009).
6.Selected review papers