

# Quantum Structures: Photonics and Transport

Programme course

6 credits

Kvantstrukturer: fotonik och transport

TFYA91

Valid from: 2020 Spring semester

**Determined by**

Board of Studies for Electrical  
Engineering, Physics and Mathematics

**Date determined**

2019-09-23

## Main field of study

Applied Physics, Physics

## Course level

Second cycle

## Advancement level

A1X

## Course offered for

- Master's Programme in Physics and Nanoscience
- Master's Programme in Materials Science and Nanotechnology
- Applied Physics and Electrical Engineering - International, M Sc in Engineering
- Applied Physics and Electrical Engineering, M Sc in Engineering

## Specific information

The course is cancelled 2020.

The course is partly replaced by TFYMO3 from 2021.

## Entry requirements

Note: Admission requirements for non-programme students usually also include admission requirements for the programme and threshold requirements for progression within the programme, or corresponding.

## Prerequisites

Physics of Condensed Matter (part 1), Quantum Mechanics.

## Intended learning outcomes

The course will provide deeper understanding of semiconductor properties such as crystal structures, band structure, doping, absorption, transport, and how they are affected by the reduced dimensionality of quantum structures. The students are expected to attain a solid understanding of these properties and the principles of quantum devices and to become well prepared for further studies in the field.

After the course the students should be able to

- explain the effects of reduced dimensionality on optical, electronic and transport related properties of quantum structures
- explain fundamental principles for quantum devices
- choose and utilize appropriate strategies to compute (analytically and/or computer-based) relevant parameters, such as carrier density, Fermi-level, doping etc., in quantum structures
- use optical characterization techniques at cryo-temperatures, perform analysis of the obtained information and write a lab report in English

## Course content

The objective of the course is to transfer a basic understanding of fundamental properties and characteristics of quantum structures, and how these properties can be exploited for applications in photonics, electronics, and future quantum technologies. Within the frame of the course, a description of the important methods to fabricate, characterize and model epitaxial quantum structures. The course aims at an improved understanding of the effects caused by a reduction of the dimensionality of a semiconductor; from the 3-dimensional bulk, via 2- and 1-dimensional quantum wells and -wires, to 0-dimensional quantum dots.

- Methods for fabrication of epitaxial quantum heterostructures
- Defects in semiconductors, the effective mass model
- Models for energy bands and quantized energy levels in defects, quantum wells, wires and dots
- Internal strain and electric fields in heterostructures
- Distribution functions for electrons and holes, density of states and doping
- Transport properties and scattering processes in low-dimensional systems, including resonant tunneling, quantized conductance, and the quantized Hall effect
- Optical properties, absorption, and low-dimensional excitons
- Recombination processes, the Purcell effect and quantum electrodynamics
- Concepts for manipulation and measurement of individual electrons and photons
- Applications and potential applications of quantum structures

Laboratory Exercises involves:

- Polarization-resolved, low-temperature, high-frequency optical process measurements in low dimensional quantum structures by optical Hall effect spectroscopy
- Analysis of measurement data using numerical methods

## Teaching and working methods

Lectures, tutorial sessions and laboratory exercises. The tutorial sessions are mainly focused on problem solving, but can to some extent also include demonstration of research facilities. The laboratory exercises includes modern approaches for characterization and modeling of quantum structures.

## Examination

LAB1	Laboratory Work	2 credits	U, G
TEN1	Written Examination	4 credits	U, 3, 4, 5

## Grades

Four-grade scale, LiU, U, 3, 4, 5

## Other information

### About teaching and examination language

The teaching language is presented in the Overview tab for each course. The examination language relates to the teaching language as follows:

- If teaching language is Swedish, the course as a whole or in large parts, is taught in Swedish. Please note that although teaching language is Swedish, parts of the course could be given in English. Examination language is Swedish.
- If teaching language is Swedish/English, the course as a whole will be taught in English if students without prior knowledge of the Swedish language participate. Examination language is Swedish or English (depending on teaching language).
- If teaching language is English, the course as a whole is taught in English. Examination language is English.

### Other

The course is conducted in a manner where both men's and women's experience and knowledge are made visible and developed.

The planning and implementation of a course should correspond to the course syllabus. The course evaluation should therefore be conducted with the course syllabus as a starting point.

## Department

Institutionen för fysik, kemi och biologi

## Director of Studies or equivalent

Magnus Boman

## Examiner

Vanya Darakchieva

## Course website and other links

<http://www.ifm.liu.se/undergrad/fysikgtu/coursepage.html?selection=all&sort=kk>

## Education components

Preliminary scheduled hours: 54 h

Recommended self-study hours: 106 h

## Course literature

### Books

Davies, John H, Davies, John H, (2009) *The physics of low-dimensional semiconductors : an introduction*  
ISBN: 9780521481489, 9780521484916

### Articles

H. L. Stormer, The quantized Hall effect *Science* 220/1983/1241

### Other

*Utdelat material, forskningsartiklar*