# Quantum Structures: Photonics and Transport

Programme course

6 credits

Kvantstrukturer: fotonik och transport

TFYA91

Valid from: 2018 Spring semester

**Determined by**
Board of Studies for Electrical Engineering, Physics and Mathematics

**Date determined**

# Main field of study

Applied Physics, Physics

# Course level

Second cycle

# Advancement level

A1X

# Course offered for

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

# Specific information

The course is not offered during 2018.

# 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 Condenced Matter (part 1), Quantum Mechanics.

# Intended learning outcomes

After the course, the student should be able to

- explain optical, electronic och transport related properties of quantum structures
- explain and exemplify crystal structures, band models, doping and the effect of

doping on the properties of quantum structures

- explain the effects of reduced dimensionality of a quantum structure
- explain the principles for quantum devices, for control and measurements of individual electrons and photons
- compute parameters such as carrier density, Fermi-level, doping and quantum states from given experimental data
- demonstrate an ability to choose and use relevant computational approaches for computing doping properties and quantization effects in quantum structures.
- use optical characterization techniques at cryo-temperatures
- write a report in English with analysis of experimental data and estimation of errors
- independently acquire essential information, interpret the results and perform analysis on information obtained from scientific articles

# 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

- Absorption and recombination in quantum structures with luminescence based spectroscopy
- Numerical approaches for modeling of quantized states and band structure

# 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 moderna approaches for characterization and modeling of quantum structures.

## Examination

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

## Grades

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

## Department

Institutionen för fysik, kemi och biologi

## Director of Studies or equivalent

Magnus Boman

## Examiner

Fredrik Karlsson

## Course website and other links

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

## Education components

Preliminär schemalagd tid: 54 h
Rekommenderad självstudietid: 106 h

## Course literature

**Böcker**

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

**Artiklar**

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

**Övrigt**

*Utdelat material, forskningsartiklar*