



LUND
UNIVERSITY

Faculty of Science

FYST65, Physics: Spectroscopy and the Quantum Description of Matter, 7.5 credits

Fysik: Spektroskopi och materiens kvantmekaniska struktur, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2022-06-09 to be valid from 2022-06-09, spring semester 2023.

General Information

The course is an elective course for second cycle studies for a scientific candidate - or Master's degree (120 credits) in physics. The course is developed for students at master's level in physics and related engineering programmes (engineering physics) and for doctoral students in related subjects. The course is open to students from other programmes, provided that they have sufficient prior knowledge.

Language of instruction: English

Main field of studies

Physics

Depth of study relative to the degree requirements

A1N, Second cycle, has only first-cycle course/s as entry requirements

Learning outcomes

The overarching aim of the course is that the students should obtain a deeper understanding of the quantum mechanical description of matter and the connection to spectroscopic methods. Such an understanding is of fundamental importance for many fields in both basic and applied research in atomic, molecular and solid state physics, and in materials science and chemistry. The course provides the students knowledge by means of a unique set of methods that are valuable for an understanding of the quantum mechanical properties of matter.

Knowledge and understanding

On completion of the course, the students shall be able to:

- describe several basic phenomena that arise on interaction between light and matter,
- describe concepts that are relevant for spectroscopic measurements and data analysis,
- explain the fundamentals of the quantum mechanical description of atoms, molecules and solid materials,
- reproduce the principles of the different spectroscopic methods treated in the course, and which examine the electronic structure of matter, particularly electron spectroscopy.

Competence and skills

On completion of the course, the students shall be able to:

- discuss and analyse the results of the spectroscopic methods,
- search for and analyse information in the field of the course in addition to the course material, e.g. in scientific articles and advanced literature,
- report and present results of spectroscopic measurements during laboratory work,
- write a scientific paper including summary, analysis and discussion of the results,
- write collegial feedback to fellow students on written reports,
- hold a short oral presentation on a scientific subject within the scope of the course.

Judgement and approach

On completion of the course, the students shall be able to:

- relate the quantum mechanical description of matter to the results of spectroscopic experiments,
- evaluate the capabilities and limitations of spectroscopic methods,
- interpret and assess information within the subject of the course from sources in addition to the course material, e.g. scientific articles and advanced literature.

Course content

The course gives an introduction to physical phenomena that arise upon the interaction between light and matter with a focus on X-ray absorption, and introduces methods for characterisation of the properties of matter. By understanding the interaction of light with matter, the students will be able to choose appropriate methods to obtain information about electronic and chemical properties or structural properties. The course gives a review of the principles of the most important spectroscopic methods using X-ray radiation. In the course, the following subject matter is treated:

- Interaction between light and matter, primarily atoms,
- Chemical bonds in molecules and condensed matter and their relation to the quantum mechanical description,
- Spectroscopies to examine the electronic structure of matter, in particular electron spectroscopy, as well as band structure, chemical and structural properties.

The course consists of 2 modules:

Module 1, Continuous evaluation, 3.5 credits

The module contains lectures to describe the relation between quantum mechanics and spectroscopic methods, with increasing complexity. The module also contains exercises and laboratory sessions, including experimental work and data analysis that

connects to the methods that are treated in the lectures. In the module, study visits at laboratories at Lund University are carried out, including MAX IV, in connection with laboratory activities.

Module 2, Research project, 4 credits

In the course, special emphasis is placed on the final scientific projects in module 2 where the students work individually with a theme in order to deepen their knowledge of experimental methods, physical phenomena or the properties of matter. The module includes an exercise in writing a scientific summary, a project draft, feedback to fellow students, the written thesis, and oral presentation and critical review.

Course design

The course is mainly problem-based, and the students work with different assignments that are related to experiments. The course concludes with a scientific project that is presented both in a written report and in an oral presentation. The teaching consists of lectures, seminars, group work, written assignments, laboratory sessions and scientific projects with seminars for presentation. Participation in laboratory sessions, written assignments and the scientific project and other connected teaching is compulsory. Written assignments, laboratory sessions and scientific projects are graded.

Assessment

Examination takes place during the course in the form of a continuous evaluation with written assignments (module 1). Written examination is also arranged at the end of the course in the form of a scientific project and through a seminar with oral presentation of the scientific project (module 2).

For students who have not passed the regular examination, an additional examination during scheduled retake period is offered.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Subcourses that are part of this course can be found in an appendix at the end of this document.

Grades

Marking scale: Fail, Pass, Pass with distinction.

To pass the entire course, a passing grade on written assignments and project report, are required, as well as participation in all compulsory parts.

The final grade is by equal weight of the grade on written assignments during module 1 (50 %) and the grade on module 2 (50 %). For the grade on module 2, the written scientific project and the oral presentation have equally strong emphasis, 50 % each.

Entry requirements

Admission to the course requires 120 credits scientific studies in which 75 credits in

physics and 45 credits in mathematics are included, or a Degree of Bachelor in physics - in both cases including knowledge equivalent to FYSB22 Basic quantum mechanics, 7.5 credits, FYSB24 Atomic and Molecular Physics, 7.5 credits and FYSC23, Solid State Physics, 7.5 credits, and English 6/B.

Further information

This course replaces FYST20, Spectroscopy and the quantum mechanical structure of matter, 7.5 credits, and cannot be included in a degree together with this course.

The courses FYTB13 Electromagnetism, 7.5 credits, and FYST37 Advanced quantum mechanics, 7.5 credits, are recommended but are not compulsory.

The course is offered at the Department of Physics, Lund University.

Subcourses in FYST65, Physics: Spectroscopy and the Quantum Description of Matter

Applies from V23

- 2301 Research project, 4,0 hp
Grading scale: Fail, Pass, Pass with distinction
- 2302 Continuous evaluation, 3,5 hp
Grading scale: Fail, Pass, Pass with distinction