Synchrotron Radiation Course, 7.5 credits

Synkrotronstrålning, 7.5 hp

Third-cycle education course

6FIFM81

Department of Physics, Chemistry and Biology

Valid from: First half-year 2024

Approved by **Approved**

Registration number

Entry requirements

PhD students in Physics, Materials Chemistry, Chemistry, Biology, Materials Science, Engineering and related fields.

Specific information

This course provides an in-depth knowledge in key areas of Synchrotron Radiation for materials science applications (generation of synchrotron radiation and how to use it at an experiment)

Learning outcomes

By the end of the course the students will be able to:

- Describe and explain how synchrotron radiation is generated including relativistic phenomena
- Derive and apply basic theories/models of bending magnets/undulators/wigglers to solve problems in the key areas
- Understand and analyze some experimental data that relate to the atomistic and electronic structure of solids and/or surfaces
- Communicate theories and/or experimental findings using synchrotron radiation through a comprehensible, rigorous, oral presentation

Contents

This course prepares for practical use of, and gives theoretical fundamental knowledge about modern synchrotron radiation sources and free-electron lasers that emit electromagnetic radiation from electrons with a velocity near the speed of light. The properties of the x-ray radiation such as angular and energy distribution, brilliance, polarization, time structure and coherence from so-called insertion devices in storage rings; undulators and wigglers and their fundamental properties are covered. Optical constants in absorption, reflection and transmission are estimated and calculated in connection with x-ray optical components (gratings and mirrors) in monochromators and beamlines. The basic physics of free-electron lasers are treated in connection with different applications of femto-second short x-ray pulses. Experimental methods for detecting photons and electrons as response to the x-ray radiation are discussed in connection to different research areas. After the course, the participant should be able to make estimates and simple calculations of the x-ray properties from insertion devices for synchrotron radiation experiments. The participant should be able to describe different experimental methods and measurement techniques for electronic structure measurements and crystallography. To check the understanding, a number of hand-in problems during the lectures are given and laboratory work at MAX-lab in Lund is made. Synchrotron radiation science is interdisciplinary and concerns physics, chemistry, biology, nano- and materials science.

Educational methods

Lectures including:

- Radiation from accelerated electrons at relativistic energies: energy spectra, power distribution, angular dependence
- The construction of a synchrotron storage ring
- The properties of x-rays: emittance and brilliance, radiated power, time structure, polarization
- Undulators and wigglers.
- Undulator spectrum and the polarization dependence of synchrotron radiation
- Optics for VUV and x-rays
- Monochromators
- The function of free-electron lasers and their significance
- Applications of synchrotron radiation in physics, chemistry, biology, materials science and nanoscience

Practical work: Laboratory day or remote demonstrations from the MAX IV Laboratory in Lund

Examination

Written report and oral presentation of individual projects groups.

Grading

Two-grade scale

Course literature

David Attwood: Soft X-Rays and Extreme Ultraviolet Radiation: Principles and Applications, Cambridge University Press 1999.
https://doi.org/10.1017/CBO9781139164429
https://people.eecs.berkeley.edu/\~attwood/srms/

General information

The course is planned and carried out according to what is stated in this syllabus.