KTH Engineering Sciences

Course pm 2017
SK2550 (for Master students)/SK3550 (for PhD students), X-ray physics and applications, 6 hp (ECTS)

Course responsible/examiner

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General course information

The course language is English. KTH course web is used as electronic course platform.

Course goals

After the course you should be able to:

- Describe the x-ray optical properties of materials for different x-ray energies on the basis of the general laws of x-ray radiation interaction with matter
- Explain different possibilities to generate x-ray radiation
- Explain the working principle of different x-ray optics on the basis of their material x-ray optical properties
- Apply the knowledge on x-ray sources and optics to explain experimental arrangements in the field of modern x-ray physics
- Apply the knowledge on x-ray interaction with matter to explain different types of analytical methods that use x-ray radiation as a probe
- give an oral presentation about a scientific topic and explain the physical background in a small discussion (SK2550 only)
- present your own research topic and its relation to modern x-ray science (SK3550 only)

Course organization

The course contains 12 x 2h meetings and a 3h laboratory on basic x-ray properties.

The first six lectures presented by the examiner deal with the most important issues of x-ray physics which are essential for all further understanding of modern x-ray physics research. Homework problems are given for the first 5 lectures. Lecture six will give an introduction into modern experimental methods in x-ray physics, basically an introduction on the more detailed student presentations.
In the remaining 6 meetings students have to give a presentation on a special method's topic.
A third part of the course is a student x-ray lab, done in small groups of three students. Note that the schedule contains 6 time slots for the lab, but you have to attend only once.

Part 1: Basics (Lectures with homework problems)

1. Introduction
2. X-ray interaction with matter
3. X-ray sources
4. X-ray optics
5. Coherence and x-rays, x-ray detectors
6. Overview of modern experimental methods

Part 2: Application examples (Student seminar with presentations)

- X-ray Free electron laser
- High-harmonic x-ray source
- Laser-produced plasma x-ray source
- X-ray microscopy
- X-ray diffraction
- X-ray crystallography
- X-ray medical imaging
- X-ray tomography
- X-ray coherent diffraction imaging
- X-ray lithography
- X-ray fluorescence spectroscopy
- X-ray absorption spectroscopy
- …

Students will work individually or in groups of two (depending on the number of participants) on this task. You can make wishes for a certain topic, but in the end the topics are distributed by the examiner. **Please make sure to come to the first meeting at the 20th January!** As an introduction to your topic you will get some reference material. This could be a paper, a PhD thesis or the link to a webpage. The material should serve as a starting point for your own literature search. You will also get some starting questions to help you identifying important considerations. You will also receive a presentation template in Powerpoint that you can use for your talk. All documents are available on KTH course web.
Few days before your presentation you should book a meeting with me and we will discuss your presentation material. This is the first opportunity to get feedback from me and improve your presentation.
The time for each presentation is 45 min. That means that your talk should be **30 min**, not much longer or shorter. After that there is some time for questions and finally feedback. Your fellow students will have 10 min to give you feedback on the content and quality of the presentation. For this they will in small groups fill out a questionnaire and answer some predefined questions. After this you will directly get all the feedback forms. At the same time you will receive a final feedback from me.
For all talks a total of 6 meetings are foreseen, i.e., there is time for maximum 12 students/groups. Depending on the number of students/groups this schedule can be adjusted.

Part 3: X-ray Lab: Basic properties of x-rays

This lab uses state-of-the-art research equipment including a microfocus x-ray source, a single photon counting diode and a scintillator x-ray camera. A detailed description of the lab can be found in a separate document on KTH course web, and you are supposed to read this document before you take the lab. There are 6 3h slots available, but you have to attend only once. Sign up for your preferred time. The lab starts directly at the stated time without an academic quarter and takes the full 3 hours. The gathering point is Albanova on level 2 at the lower end of the building in front of the entrance to the BIOX offices to the right. Here you will be picked up by your lab assistant.

Examination

The examination consists of two parts:

Part 1: homework problems and lab report (INLA 3 hp), grading pass/fail.

Homework problems: You have a certain time for the solution of each problem sheet (found on KTH SOCIAL), and every student has to hand in his/her own set of solutions in KTH SOCIAL as pdf document. Note: There is an automatic check for plagiarism, including other submitted work! Deadlines can be found in KTH SOCIAL and on each problem set. Problems handed in too late will not be considered for grading. You can earn a total of 56 points, and you need at least 34 points (= 60%) to pass. Additionally you need at least 10% of the points on each of the 5 problem sets to pass.

Lab report: Each lab group (not each student!) has to write a **small** report about the results. A lab report template can be found on KTH course web. **The latest date for handing in the report is 31st March 2017**. Grading for the report is pass/fail. Without the report you cannot pass the course.

Part 2: Presentation and oral examination (REDA 3 hp), grading A-F.

This examination moment consists of two parts. The first part is the presentation given by the students. (PhD students SK3550: individual presentation about own research topic and its connection to modern x-ray science). **Due to the risk of low student attendance participation in part 2 is compulsory, you have to be present at least 70% of the time.** Remember that the presentation in front of an audience is an important learning outcome of the course and it is a question of fairness to listen to the talks of your colleagues.

The second part is a short (15 min) extra oral examination about your presentation topic and its connection to the main course content. The individual times and dates for this examination will be defined separately, but normal days lie within the exam week after period 3. The grading for both parts together is A-E and will determine your

overall final grade for the course. PhD students (SK3550) can just get a pass/fail grade on the course and therefore participation in the oral exam is not necessary.

Course literature

The course is not based on a specific book, but most of the course content can be found in:
D. Attwood and A. Sakdinawat, X-Rays and Extreme Ultraviolet Radiation: Principles and Applications (Cambridge University Press, October 2016)
This is the best book in the field of x-ray physics. The release date for this new edition is December 2016, so hopefully it will be available until the course starts. The old edition is not available any more.
Most figures and important parts including all formulas can be found in the lecture slides of David Attwood's lecture on the same topic given at the University of California, Berkeley. They can be found on his web-side:
http://www.coe.berkeley.edu/AST/sxreuv/

Course evaluation

You are strongly encouraged to participate in the anonymous course evaluation (LEQ) at the end of the course done in KTH course web. The goal of the evaluation is to continuously improve the students' learning experience.