PHYS-640

Neutron and X-ray Scattering of Quantum Materials

Fogh Ellen, Rønnow Henrik M., Schmitt Thorsten

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Nuclear engineering	MA1	Opt.
Physicien	MA1, MA3	Opt.
Physics		Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Frequency

Every year

Remark

Next time: Fall

Summary

Neutron and X-ray scattering are some of the most powerful and versatile experimental methods to study the structure and dynamics of materials on the atomic scale. This course covers basic theory, instrumentation and scientific applications of these experimental methods.

Content

The application of neutron and X-ray scattering spans from crystalline matter to bio-materials and engineering, including fields like magnetism and superconductivity. Similar to the vast possibilities with X-rays at synchrotron facilities like the Swiss Light Source at the Paul Scherrer Institute (PSI) in Switzerland, the European Synchrotron Radiation Facility in Grenoble, neutron scattering is a large-scale-facility technique with neutron sources among others at PSI in Switzerland, the Institute Laue-Langevin in Grenoble and a new joint European Spallation Source under construction in Sweden. The course provides an introduction to the dynamic experimental techniques of neutron and X-ray scattering and covers the following aspects:

1) Theory of the neutron scattering cross section
2) Neutron sources and neutron instrumentation
3) Neutron imaging, neutron reflectivity and neutron small angle scattering
4) Neutron diffraction, crystal structures
5) Inelastic neutron scattering, phonons
6) Magnetic neutron scattering, magnetic structures
7) Inelastic magnetic neutron scattering, magnetic dynamics
8) Theory of the interaction between X-rays and matter
9) X-ray sources and X-ray instrumentation
10) X-ray absorption spectroscopy
11) X-ray emission spectroscopy and Resonant Inelastic X-ray Scattering (RIXS)
12) Resonant Elastic X-ray Scattering (REXS)
13) Inelastic X-ray Scattering
14) Time resolved pump-probe X-ray spectrosocpy

The course contains lectures and exercise sessions. Exercise sessions will contain derivation of relevant formulas, Monte-Carlo simulation of neutron scattering experiments, and discussions of representative scientific articles using X-ray and neutron scattering techniques. The course includes performing a real neutron or X-ray experiment and a tour of the large-scale experimental research facilities at the PSI.

Keywords

Neutron Scattering, X-ray scattering, X-ray spectroscopy, diffraction, crystal structures, lattice vibrations, phonons, magnetism, spin waves, magnons, neutron imaging

Learning Prerequisites

Required courses

Solid State Physics 1 and 2, basic quantum mechanics and basic atomic physics.

Learning Outcomes

By the end of the course, the student must be able to:

- predict and interpret neutron and X-ray scattering experiments.
- Read and evaluate articles containing neutron and X-ray scattering results

Assessment methods

Oral

Resources

Bibliography

"Elements of Modern X-ray Physics" by Des McMorrow and Jens Als-Nielsen (2nd edition)
"Neutron scattering â## Theory, Instrumentation and Simulation"##, lecture notes by Kim Lefmann
Relevant scientific articles

Ressources en bibliothèque

- Neutron scattering : Theory, Instrumentation and Simulation / Lefmann
- Elements of Modern X-ray Physics / McMorrow

Websites

- http://Lab web page: lqm.epfl.ch