MSE-670

Advanced Microscopy for Magnetic Materials

Carbone Fabrizio, Grundler Dirk, Invited lecturers (see below), La Grange Thomas, Tengdin Phoebe Marie

Cursus	Sem.	Type
Materials Science and Engineering		Opt.

Language of teaching	English
Credits	1
Session	
Exam	During the semester
Workload	30h
Hours	**19**
Courses	16
Exercises	3
Number of positions	**24**

Frequency

Only this year

Remark

The teaching activities include lectures given by world-leading experts combined with an interactive exercise class including demonstrations.

Summary

Theoretical and practical expertise is gained about the microscopy of spin structures and magnetic configuiations down to the sub-nm length and sub-ns time scales such as transmission electron microscopy, x-ray and light scattering, magnetic dichroism, and scanning probe technlques.

Content

Course Description:

Recent advances in X-ray, optical, scanning probe, and electron microscopy techniques allow one to characterize and image the static and dynamic magnetic configurations of nanostructures and non-collinear spin systems down to the nanoscale. These pump-probe techniques can explore spin dynamics with high spatial resolution down to sub-ns timescales. The techniques are based on principles such as transmission electron microscopy, x-ray scattering, x-ray, and electron magnetic dichroism, scanning probe microscopy, and inelastic light scattering. They probe different physical quantities and provide complementary information for fundamental research on magnetic materials and their functional properties, e.g., magnetic storage, spintronics, and magnonics. Swiss research groups have contributed to recent technological advancements, and the magnetism research community is continuously growing. Hence, this course provides an overview and specific insight into advanced optical, x-ray, and electron microscopy techniques for the characterization of magnetic properties of materials. The planned course allows Ph.D. students to acquire theoretical knowledge through lectures and get practical insight via live demonstrations performed in different labs on the EPFL campus.

Plan: 3-day block course for Ph.D. students held on Nov. 16th-18th, 2022

(A) 2.5 days - 90 min (including examples and Q&A sessions) lectures from 8 invited experts, 4 external and 4 internal. Online recordings will be provided and accessible in a Moodle, as well as slide handouts and literature references

(B) 0.5-day demonstrations- LTEM (CIME Titan Facility, EPFL), BLS (LMGN, EPFL), and MOKE (LUMES, EPFL)

Agenda

Day 1: (Lectures are 2x45 min plus a 15 min break)

9h30-10h15
Welcome coffee

10h15-12h
Dirk Grundler, Professor, EPFL "Introduction-Materials science of magnetic materials".

12h15-13h15

Lunch served in the meeting room

13h30-15h15
Victor Ukleev, Staff Scientist, BESSY II, Berlin, German "Static and dynamic magnetic imaging using x-ray based techniques".

15h30-17h15
Thomas La Grange, Senior Scientist, EPFL "Lorentz Transmission Electron Microscopy: Theory, Practice, Simulations, and Quantitative Phase reconstruction".

Day 2
8h30-10h15
Fabrizio Carbone, Professor, EPFL "In-situ and Ultrafast Lorentz Transmission Electron Microscopy (LTEM)".

10h30-12h15h
Martino Poggio, Professor Department of Physics, University of Basel "Nanomagnetic studies using scanning probe microscopy techniques".

12h30-13h30
Lunch served in the meeting room

13h45h-15h30
Rafal Dunin-Borkowski: Director of Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Juelich, Germany, "Electron Holography: Theory, Practical Examples from Medium to Atomic resolution".

15h45-18h LTEM demonstration and free discussion
Students are separated into 3 groups for LTEM Demonstration (45 min) at CIME Titan Facility, EPFL (MXC 014). Groups of 7-8 people are formed due to limited space in the microscope room. The remaining time is for free discussion/preparation for the course exam.

Day 3:

10h15-12h
Ping Che, Scientist, Université Paris-Saclay (UMR-137), France "Characterizing magnetic materials using inelastic Brillouin light scattering (BLS) technique".

12h15-13h15
Free lunch

13h30-15h15
Phoebe Tengdin, Scientist, EPFL "Ultrafast Optical Spectroscopy and Imaging Techniques: Magnetic Optical Kerr Effect (MOKE)".

15h30-17h30
Demonstrations 45 min each on BLS (LMGN, EPFL) and MOKE (LUMES, CH H0 604 EPFL)

17h45-18h15 Written Test for Ph.D. students aiming at credits

Note

Invited lecturers :
Dr. Victor Ukleev, Prof. Martino Poggio, Prof. Rafal Dunin-Borkowski, Dr. Ping Che

Keywords

LTEM, BLS, Electron Holography, Magnetic Materials, Scanning Probe Microscopy, XMCD, X+ay Microscopy, UTEM,

Learning Prerequisites

Required courses

Courses on electromagnelism and on solid matter such as solid state physics, materials science, anorganic chemistry

Assessment methods

Reg. assessment

Resources

Bibliography

Biblography and Reference materials will be available on a course Moodle (Moodle link TBD)

Moodle Link

- https://go.epfl.ch/MSE-670