Adam Mickiewicz University in Poznan

Doctoral School of Exact Sciences AMU

Studying matter with neutron beams

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Field of science	Physics / Materials Science / Chemistry / Life Sciences
Teaching method	Lectures
Language	English
Number of hours	15
Aims of the course	The course aims to familiarise students with the methods of studying matter with a suite of neutron scattering methods. Nondestructive and powerful, they reach where neither laboratory techniques nor synchrotron methods can, at the same time being fully complementary. The lectures will provide the participants with the basics of neutron scattering, both nuclear and magnetic, spectroscopy, diffraction and reflection methods, as well as research instruments used in the study of atomic structures, soft matter, and large-scale structures (polymers, micelles, etc.). Students will be presented with specific examples of the mentioned research. Polish researchers have access to the world's No. 1 neutron scattering infrastructure at the Institute Laue-Langevin, and will soon be able to apply for beam time at the European Spallation Source, once it becomes commissioned.
Course contents	• Fundamental introductory matter (neutron properties, neutron sources, neutron–X-ray complementarity, etc.). Neutron scattering for physics, chemistry, materials sciences (incl. functional materials), life sciences, biology. • Neutron scattering on a single nucleus and the assembly of nuclei. • Neutron scattering lengths and cross-sections, the concepts of coherent/incoherent and elastic/inelastic scattering. • Neutron imaging (neutron tomography). • Elements of neutron optics (needed to understand neutron transport, wavelength selection, etc.). • Studying atomic structures with neutrons: Neutron diffraction. • Studying large-scale structures: Small-angle neutron scattering, neutron reflectometry. • Studying dynamics with neutrons: Neutron spectroscopy. • Neutron spin and magnetic moment as a measuring probe: Studying magnetic structures and dynamics, experiments with polarised neutrons.
Prerequisites and co-requisites	Basic knowledge of mathematics and condensed matter physics, basic concepts of quantum mechanics (will be needed to understand the interaction of the neutron with an atomic nucleus; spinors and the Pauli matrices formalism will help to understand the lecture on polarised neutrons, but this is not essential).

Learning outcomes	
On completion of the course PhD candidates will be able to:	**Assessment mode**
On completion of the course, the students will be able to understand and apply neutron scattering methods in condensed matter research, ranging from fundamental physical problems, through materials sciences, large-scale structures (polymers, bio-structures, drug carriers, etc.), and to pose a real-life research problem suitable for treating with neutron scattering. With the help of experts (experienced users, instrument scientists, etc.), they will be able to write and submit an experimental proposal for a particular instrument. E_W01, E_W02, E_U01	written assessment

Literature	References pertaining to specific subjects will be provided during lectures. Here are some recommended general texts: 1. G.L. Squires, *Introduction to the Theory of Thermal Neutron Scattering,* Cambridge University Press, 2012 2. A.T. Boothroyd. *Principles of Neutron Scattering from Condensed Matter,* Oxford University Press 2020, ISBN 9780198862314, ebook available. **Highly recommended!** 3. H. Schober, *An introduction to the theory of nuclear neutron scattering in condensed matter.* Journal of Neutron Research. 2014;**17**(3-4):109-357. doi:10.3233/JNR-140016, available free from the web 4. R. Pynn: *"Neutron Scattering: A Primer", "An Introduction to Neutron Scattering" and "Neutron Scattering for Biomolecular Science"* (lecture notes, available on the web) 5. Editors: I.S. Anderson, A.J. Hurd, R.L. McGreevy. Springer Book Series *Neutron Scattering Applications and Techniques* (6 books), Electronic ISSN: 1868-0380, print ISSN: 1868-0372
Additional information	The content may be subject to slight modification, should specific student needs arise.