Adam Mickiewicz University in Poznan

Doctoral School of Exact Sciences AMU

Science with X-ray Free Electron Lasers

The course will be conducted by several lecturers - specialists in selected fields related to the application of free-electron laser radiation - representing various academic and research institutions from across Poland

prof. dr hab. Jacek Kubicki; dr Wojciech Gawełda

Field of science	Physics
Teaching method	Lecture with multimedia presentation (on-line)
Language	English
Numbers of hours	• 20 lectures (including virtual laboratory) • 5 hours student project
Aims of the course	Introduction to working principles and applications of X-ray free electron lasers.
Course contents	1 XFEL vs. lasers and synchrotron radiation – similarities and differences. 2. XFEL radiation sources and parameters. 3. X-ray – matter interactions. 4. Basic X-ray techniques: wide- and small-angle X-ray scattering, crystallography and spectroscopy. 5. XFEL optics and diagnostics. 6. XFEL-based research: biology, chemistry, atomic structure of materials, matter in extreme temperature and pressure conditions, magnetism, electronic structure of solids, non-linear X-ray optics. 7.Preparation of an XFEL research proposal.
Prerequisites and co-requisites	

Learning outcomes	
On completion of the course PhD candidates will be able to:	**Assessment mode**
1. Differentiate between X-ray free-electron lasers (XFELs), conventional lasers, and synchrotron radiation in terms of generation mechanisms, key parameters, and applications. E_W01, E_W02 2. Characterize XFEL radiation sources, including their fundamental properties and operational principles. E_W01, E_W02 3. Explain X-ray–matter interactions relevant to experimental and theoretical studies. E_W01, E_W02 4. Identify and describe basic X-ray techniques such as wide-angle and small-angle X-ray scattering (WAXS/SAXS), X-ray crystallography, and spectroscopy. E_W01, E_W02 5. Understand the principles and functions of XFEL optics and	The final note is a combination of two partial notes of: • colloquium in a form of a test from the course lectures • student project – preparation of an XFEL beamtime proposal

diagnostic systems. E_W01, E_W02 6. Assess the applicability of XFEL-based methods in various research domains, including structural biology, chemistry, materials science, high-energy-density physics, magnetism, and ultrafast electronic processes. E_W01, E_W02 7. Conceptually design XFEL beamtime proposals, demonstrating familiarity with relevant experimental techniques and scientific objectives. E_U01, E_U02, E_U09, E_K01	
Literature	**1. P. Willmot, "Introduction to synchrotron radiation", Wiley 2011** **2. Bergmann, U., Yachandra, V. & Yano, J. "X-Ray Free Electron Lasers", The Royal Society of Chemistry, 2017** **3. Attwood, D., & Sakdinawat, A. (2017). X-Rays and Extreme Ultraviolet Radiation: Principles and Applications (2nd ed.). Cambridge: Cambridge University Press.** **4. Jens Als-Nielsen, Des McMorrow (2011) Elements of Modern X-ray Physics. John Wiley & Sons, Ltd.**
Additional information	The course will be conducted by several lecturers - specialists in selected fields related to the application of free electron laser radiation: dr hab. Eng. Ryszard Sobierajski, prof. IF PAN (Institute of Physics Polish Academy of Sciences), prof. Wojciech Gawełda (Universidad Autónoma de Madrid, Adam Mickiewicz University, Poznań), dr hab. Eng. Marcin Sikora, prof. AGH (AGH University of Science and Technology), and dr hab. Eng. Jerzy Antonowicz, prof. PW (Warsaw University of Technology), dr Wojciech Błachucki (Institute of Nuclear Physics Polish Academy of Sciences), dr hab. Katarzyna Jarzembska, prof. UW (Warsaw University) The course will be run remotely, for students and doctoral students from several institutions in Poland at the same time. All lectures will be made available to participants (as slides in pdf format) via a specially prepared internet platform. Each participant will have the possibility of interactive consultation with the teachers, also outside the class hours. After passing the lecture part, participants will have the opportunity to prepare a small project in the form of an application for beamtime at an XFEL facility. The work will be carried out under the guidance of lecturers according to the topic selected by the student. **Students interested to participate are asked to contact at the email address: cd-xfel@ifpan.edu.pl.** Further information will be available at the webpage: https://www.ifpan.edu.pl/cd-xfel/dzialania/kurs-dla-studentow-i-doktorantow/