Applications of Synchrotron Radiation

Course description sheet

Basic information

Field of study AGH UST International Courses **Major** All **Organisational unit** Generic subjects **Study level** any level **Form of study** Full-time studies **Profile** General academic	**Didactic cycle** 2023/2024 **Course code** POGJOS.A100000O.e25698f0bfc64babb1774dd33bc0cec4.23 **Lecture languages** english **Mandatoriness** Elective **Block** General Modules **Course related to scientific research** Yes **USOS code** 693-INT-xS-010

Course coordinator	Marcin Sikora
Lecturer	Marcin Sikora, Joanna Stępień

Period	**Method of verification of the learning outcomes**	**Number of ECTS credits**
Winter semester	Exam **Activities and hours** Lectures: 10 Laboratory classes: 10 Workshop classes: 10	4

Goals

C1	The ASR course familiarizes students with state-of-the-art analytical techniques available at synchrotron light sources. In addition to lectures students practice preparation for beamtime application and learn perform experiment at the PIRX beamline at synchrotron Solaris.

Course's learning outcomes

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
Knowledge – Student knows and understands:			
W1	Students acquire knowledge on the methods of generation of the intense electromagnetic radiation as well as on the basic phenomena related to its interaction with matter. They become familiar with the experimental techniques available at synchrotron laboratories, including their effective use to solve technical and scientific problems related to material science, chemistry, biology, geology and physics.		Participation in a discussion, Examination, Report, Completion of laboratory classes
Skills – Student can:			
U1	Students shall acquire experience in preparation of the synchrotron based experiments, execution and conclusion of the measurements at large scale facilities, methods of data analysis and their interpretation. In addition, the skills related to reporting and scientific writing will be improved.		Execution of laboratory classes, Completion of laboratory classes, Preparation and conduct of scientific research
U2	Students shall gain experience in literature research, understanding of scientific writing as well as preparation of presentation and lecturing. Finally, the skills related to effective discussion and defending of ideas will be improved.		Activity during classes, Participation in a discussion, Presentation
Social competences – Student is ready to:			
K1	The ability to teamwork is developed during laboratory classes, especially with respect to coordination of the team, knowledge exchange and task sharing. In addition, active participation in the discussions during lectures and laboratory classes shall develop skills related to effective exchange of ideas and learning via discussion.		Activity during classes, Participation in a discussion, Involvement in teamwork, Completion of laboratory classes

Program content ensuring the achievement of the learning outcomes prescribed to the module

The course shall familiarize students with unique research opportunities available at synchrotron light-sources, including examples of application and practicals at Solaris facility.

Student workload

Activity form	Average amount of hours* needed to complete each activity form
Lectures	10
Laboratory classes	10
Workshop classes	10
Preparation for classes	20

Realization of independently performed tasks	20
Examination or final test/colloquium	5
Preparation of project, presentation, essay, report	30

Student workload	**Hours** 105
Workload involving teacher	**Hours** 30

* hour means 45 minutes

Program content

No.	Program content	Course's learning outcomes	Activities
1.	Laboratory classes shall familiarize students with practical issues regarding experiments at synchrotrons. They consist of discussion of the experimental strategy, writing up a proposal, preparation of the samples, experiment at Solaris synchrotron, data treatment, discussion of the results, and preparation of the final report. Many of these activities will be finalized by students at home.	U1, U2, K1	Laboratory classes
2.	First lecture introduce students with the origin of synchrotron light and review its extraordinary properties and general applications. Further lectures are reviewing the state-of-the-art techniques and advantage of using synchrotron light in materials characterization. Methodology of experiments and main results will be explained, followed by the discussion of their impact on current and future technologies. In this way a comprehensive overview of synchrotron techniques, namely diffraction (XRD, XRS), spectroscopy (XPS, ARPES, XAS, XES, RIXS, XMCD), microscopy (STXM, X-PEEM), X-ray tomography and ptychography, is provided.	W1, K1	Lectures
3.	During the workshops classes students prepare samples for synchrotron experiment and participate in experiment conducted at XAS beamline of Solaris. Student will conduct measurements, perform data processiong and prepare report in small groups. Results of each group will be analyzed and discussed on the basis of scientific literature.	U1, U2, K1	Workshop classes

Extended information/Additional elements

Teaching methods and techniques:

Workshop, Lectures, Discussion, Case study, Group work, Problem based learning

Activities	Methods of verification	Credit conditions
Lectures	Participation in a discussion, Examination, Completion of laboratory classes	oral exam passed

Activities	Methods of verification	Credit conditions
Lab. classes	Activity during classes, Participation in a discussion, Execution of laboratory classes, Involvement in teamwork, Presentation, Completion of laboratory classes	attendance in more than 80% of classes and written proposal score at least 50%
Workshop	Activity during classes, Participation in a discussion, Report, Involvement in teamwork, Completion of laboratory classes, Preparation and conduct of scientific research	full attendance in workshop classes and report score at least 50%

Method of determining the final grade

The final grade is calculated as weighted average of: - report from workshop classes 40%), - proposal prepared during laboratory classes (30%), - oral exam (30%).

Prerequisites and additional requirements

Basic course in physics, chemistry and/or material science. Understanding of electronic structure of atoms, molecules and crystals. Basic knowledge on coordination chemistry and crystallography.

Rules of participation in given classes, indicating whether student presence at the lecture is obligatory

Lectures are voluntary, laboratory and workshop classes are obligatory

Literature

Obligatory

1. Philip Willmott, An Introduction to Synchrotron Radiation: Techniques and Applications, Wiley 2011, https://doi.org/10.1002/9781119970958
2. https://lightsources.org/what-is-a-light-source/
3. https://www6.slac.stanford.edu/research/slac-science-explained/synchrotrons

Optional

1. https://synchrotron.uj.edu.pl/en_GB/linie-badawcze/pirx

Scientific research and publications

Publications

1. 1. Joanna Stępień, Marcin Sikora, Czesław Kapusta, et al., Local atomic structure evolution in YSZ solid solutions upon Mn doping, Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms 2017, https://doi.org/10.1016/j.nimb.2017.06.016.
2. 2. Marta Waśniowska, Marcin Sikora, Andrzej Kozłowski, et al., Investigating the difference between Co adatoms states on surfaces of selected Bismuth-chalcogenides, Physical Review B 2015, https://doi.org/10.1103/PhysRevB.92.115412.
3. 3. Jacinto Sa, Jakub Szlachetko, Marcin Sikora, et al., Magnetic manipulation of molecules on a non-magnetic catalytic surface, Nanoscale 2013, https://doi.org/10.1039/C3NR02237D.
4. 4. Marcin Sikora, Amélie Juhin, Pieter Glatzel, et al., Strong K-edge Magnetic Circular Dichroism Observed in Photon-in–Photon-out Spectroscopy, Physical Review Letters 2010, https://doi.org/10.1103/PhysRevLett.105.037202.
5. 5. Joanna Stępień, Damian Rybicki, Marcin Sikora, et al., Effects of Ni/Co doping on structural and electronic properties of 122 and 112 families of Eu based iron pnictides, Scientific Reports 2023, https://www.nature.com/articles/s41598-023-40419-8
6. 6. Juliusz Kuciakowski, Joanna Stępień, Marcin Sikora, et al., Thermal Decomposition Pathways of ZnxFe3–xO4 Nanoparticles in Different Atmospheres, Industrial & Engineering Chemistry Research 2022, https://doi.org/10.1021/acs.iecr.2c01572