2020/2021

Electroscopies with Synchrotron Radiation

Code: 43438
ECTS Credits: 6

Degree	Type	Year	Semester
4314939 Advanced Nanoscience and Nanotechnology	OT	0	1

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

Name: Javier Rodríguez Viejo

Email: Javier.Rodriguez@uab.cat

Use of Languages

Principal working language: english (eng)

Other comments on languages

All activities will be carried out in the English language

External teachers

Eric Pellegrin

Francois Fauth

Klaus Attenkofer

Prerequisites

Willingness to learn

Objectives and Contextualisation

1. Learn the basics of synchrotron radiation.

2. Get familiar with the work and research carried out at large facilities.

3. Understand the uses of synchrotron radiation for characterizing samples, materials, processes, etc.

Competences

- Analyse research results to obtain new products or processes, assessing their industrial and commercial viability with a view to transferring them to society
- Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
- Continue the learning process, to a large extent autonomously
- Identify the characterisation and analysis techniques typically adopted in nanotechnology and know the principles behind these, within one's specialisation.
- Seek out information in the scientific literature using appropriate channels, and use this information to formulate and contextualise a research topic.

- Show expertise in using scientific terminology and explaining research results in the context of scientific production, in order to understand and interact effectively with other professionals.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Learning Outcomes

1. Analyse research results to obtain new products or processes, assessing their industrial and commercial viability with a view to transferring them to society.
2. Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
3. Continue the learning process, to a large extent autonomously
4. Correctly interpret the results obtained from material characterisation techniques regarding condensed matter.
5. Describe the main characteristics and differences between analysis techniques on the basis of their application to problems of condensed matter.
6. Describe the potential of a large synchrotron light facility for determining the fundamental properties of condensed matter.
7. Efficiently use the different instruments for the scientific characterisation of materials through synchrotron radiation.
8. Recognise the main elements of diffraction, absorption and scattering of X-rays in matter.
9. Seek out information in the scientific literature using appropriate channels, and use this information to formulate and contextualise a research topic.
10. Show expertise in using scientific terminology and explaining research results in the context of scientific production, in order to understand and interact effectively with other professionals.
11. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
12. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

Content

Theme #1. Introduction to interaction radiation-matter and synchrotrons. Program of the module. Brief overview of the interaction photons-matter. Existing Synchrotron Facilities and history.

Overall description of the components of a Synchrotron Light Source.

Theme #2. Introduction to accelerators, sources for synchrotron radiation and main photon beam properties. Linac, booster and storage ring. Bending magnets, superbend, and insertion devices (wigglers and undulators).

Key properties of synchrotron radiation: flux and brilliance, tunability, polarization, time structure, (partial) coherence.

Theme #3. Overall description of a Beamline. Front End, Primary Optics, Microfocus and Nanofocus Optics (different types of lenses). Sample environment. Detectors.

Theme #4. Infrared spectroscopy and Microspectroscopy. Basic principles and applications in physics, nanotechnology and medicine.

Theme #5. Synchrotron Powder Diffraction-I. Principles and applications to quantitative phase analysis.

Theme #6. Synchrotron Powder Diffraction-II. General applications. Characterization of microstructure from peak shape analysis. Pair Distribution Function.

Theme #7. Small-Angle X-ray Scattering. Fundamentals and applications.

Theme #8. Hard X-ray EXAFS and XANES-I. Fundamentals.

Theme #9. FF. Hard X-ray EXAFS and XANES-II. General applications. Micro-XAS and micro-fluorescence.

Theme #10. EP. Soft X-ray XAS and XMCD. Electronic and magnetic structure of a solid. Basic principles and applications of soft x-ray XAS and XMCD.

Theme #11. EP. Soft X-ray Scattering and Reflectometry.Fundamentals and applications.

Theme #12. EP. Photoemission Spectroscopies. Classic UHV-based photoemission spectroscopies and near-ambient pressure photoemission. Angular-resolved photoemission.

Theme #13. EP. PhotoEmission Electron Microscopy (PEEM). Basics of PEEM, LEEM (low-energy electron microscopy), and LEED (low-energy electron diffraction). Chemical and magnetic mapping. Dark field imaging.

Theme #14. MAGA. Imaging techniques-I: Computed Microtomography. Absorption based Tomography and Phase-Contrast based Tomography. Soft X-ray Tomography.

Theme #15. MAGA. Imaging techniques-II: Lensless Imaging & Future Sources of Synchrotron Light. Use of coherence for lensless imaging. Ptychography. Future Sources of Synchrotron Light: X-ray Free-Electron Laser & Tabletop Synchrotrons.

Final activity #16. *(8 hours)* 2 days visit to ALBA including demos on data recording and reduction. Selected data sets may be given to the students for further analysis at home.

No on-line data collection is foreseen. Preliminary (relatively simple) data analysis could/should be carried out autonomously.

Methodology

1. Teaching at the classroom.

2. Visit to ALBA synchrotron with selected (simple) excercise (data treatment / data analysis) on site.

3. Reports done by the student dedicated to a subject related to synchrotron radiation.

4. Easy data analysis done by the student autonomously after the visit to ALBA in selected examples.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Theoretical Lectures	37.5	1.5	4, 8
Type: Supervised			
Visits to ALBA	7.5	0.3	6, 5, 4, 11, 2, 8, 12, 7
Type: Autonomous			
Data analysis	35	1.4	1, 9, 10, 4, 11, 2, 3, 12, 7
Report on Syncrotron subjects	66	2.64	1, 9, 6, 5, 10, 11, 3, 8, 12

Assessment

Extra work as informs/memo/etc. about a given topic given in the classroom: 30%

Demonstration(s) at ALBA including some data analysis: 30%

Final synthesis test (about 2 hours): 40%

It is possible to have the chance to increase the final synthesis mark in a second test, if it has been carried out the first test, irrespective of the mark.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Demonstrations at ALBA-CELLS	30%	1	0.04	5, 10, 11, 8, 12, 7
Extra work as informs/memo/etc.	30%	1	0.04	1, 9, 6, 5, 10, 4, 11, 2, 3, 8, 12
Final test exam	40%	2	0.08	1, 6, 5, 10, 4, 11, 2, 8, 12, 7

Bibliography

1. Philip Willmott (2011). Print ISBN: 9780470745793 Online ISBN: 9781119970958.DOI: 10.1002/9781119970958

An Introduction to Synchrotron Radiation: Tehcniques and Applications.

2. S. Mobilio, F. Boscherini, C. Meneghini (2015). ISBN: 978-3-642-55314-1 (Print) 978-3-642-55315-8 (Online)

Synchrotron Radiation: Basics, Methods and Applications.