Course guides
230853 - LF - Large Facilities: Synchrotron and Neutron Sources

Last modified: 12/05/2020

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: MASTER'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2018). (Compulsory subject).

Academic year: 2020 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Pere Bruna Escuer

Others: Pere Bruna Escuer, Youri Alexandrovich Koubychine Merkulov, Luis Carlos Pardo Soto

PRIOR SKILLS

- Basic general physics, specially electromagnetism, propagation of electromagnetic waves in vacuum, metals and dielectrics
- General background in instrumentation
- Solid state physics, specially crystalline structures
- Basics of probability
- Some background in special relativity could be helpful but not mandatory

REQUIREMENTS

None

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Basic:
CB6. (ENG) Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación
CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.
CB10. (ENG) Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

TEACHING METHODOLOGY

- Master classes
- Practical exercises using software tools
- Laboratory practice

LEARNING OBJECTIVES OF THE SUBJECT

- To get acquainted with the main concepts of charged particle acceleration and principles of operation of synchrotrons
- To understand the principles of generation of synchrotron radiation and neutron beams and know their main characteristics
- To know the main instrumentation used in large facilities
- To recognize the complementarity of each technique (synchrotron and neutron scattering)
- To know the fundamentals of the main techniques in synchrotron and neutron sources
- To know the physical properties of the materials that are possible to measure in large facilities
- To know the fundamentals to analyze the data obtained in large facilities

STUDY LOAD

Type	Hours	Percentage
Self study	81,0	62.79
Hours large group	48,0	37.21

Total learning time: 129 h

CONTENTS

1. Basics of particle accelerators

Description:
General introduction. Types of accelerators. Methods of acceleration. Circular accelerators. Magnetic systems. Main accelerator systems (RF, diagnostics). Beam characteristics.

Full-or-part-time: 8h
Theory classes: 8h

2. Generation of electromagnetic radiation

Description:
Bremsstrahlung. X-ray applications. Synchrotron radiation. Methods of SR generation. Insertion devices. Characteristics of SR. Beamlines and experiments. Alba SR facility.

Full-or-part-time: 4h
Theory classes: 4h

3. Examples of large facilities: colliders, ion accelerators, synchrotron radiation and spallation sources

Description:
CERN accelerator complex and LHC. Neutron sources. European Spallation Source and other examples. Spanish synchrotron radiation source ALBA. New types of synchrotron radiation facilities.

Related activities:
Laboratory practices: Magnetic measurements, RF measurements, Linac energy dispersion measurements

Full-or-part-time: 4h
Theory classes: 4h

4. The basics of X-ray and neutron scattering

Description:
The interaction of X-rays with matter. Scattering from one electron. Scaterring from a cloud of electrons. Scattering function for neutrons. Scattering function for X-rays. Absorption.

Full-or-part-time: 2h
Theory classes: 2h

5. Beamlines

Description:
Front end: Primary aperture, front end slits, low energy filters. Primary optics: x-ray mirrors, monochromators. Microfocus and nanofocus optics. Beam Intensity monitors. Detectors.

Related activities:
Speciallized seminars by ALBA staff

Full-or-part-time: 2h
Theory classes: 2h

6. Inelastic neutron scattering

Description:
Coherent and incoherent scattering. Van –Hoff functions (localized, delocalized and intramolecular motions).

Full-or-part-time: 4h
Theory classes: 4h

7. Neutron applications

Description:
Inelastic Neutrons Scattering Methods (Time of flight, Spin Echo, Backscattering). Magnetism using neutrons. Imaging using neutrons.

Full-or-part-time: 2h
Theory classes: 2h

8. Diffraction at Synchrotron Sources

Description:
Crystals and Bragg peaks. Reciprocal lattice. Atomic planes and Bragg's Law. Influence of the basis. The phase problem. Powdered samples. Liquids and amorphous materials: radial distribution functions, structure factors.

Full-or-part-time: 6h
Theory classes: 6h

9. Fundamentals of X-ray Absorption Fine Structure (XAFS)

Description:
X ray absorption and fluorescence. Simple theoretical description. Multiple Scattering. Data analysis. Experiment design. Sample preparation.

Full-or-part-time: 4h
Theory classes: 4h

10. Hard X-Ray Synchrotron Imaging Techniques and other technics

Description:
Hard X-Ray Synchrotron Imaging Techniques. Other applications: Photoemission spectroscopy , Resonant and magnetic XRD , X-ray microscopy , Infrared synchrotron radiation , Inelastic X-ray scattering.

Full-or-part-time: 2h
Theory classes: 2h

11. Frequentist data analysis

Description:
Data and errors: an statisitical view. An overview on classical fitting methods. Statistical distributions. Hypothesis testing in classical statistics.

Full-or-part-time: 2h
Theory classes: 2h

12. Bayesian data analysis

Description:
Bayesian statistics: from numbers to Probability Distribution Functions (PDF). Bayes theorem and measurement: where are the PDFs hidden? Fitting functions using a Bayesian approach. Marcov Chain Montecarlo method to obtain Posterior PDFs. Model selection in Bayesian statistics.

Full-or-part-time: 4h
Theory classes: 4h

GRADING SYSTEM

Written examns: 40%
Written assignements: 25%
Project: 20%
Laboratory practices: 15%

BIBLIOGRAPHY

Basic:
- Mobilio, S.; Boscherini, F.; Meneghini, C. Synchrotron radiation: basics, methods and applications [on line]. Berlin, Heidelberg: Springer Berlin Heidelberg, 2015 [Consultation: 02/06/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1802923. ISBN 9783642553158.
- Als-Nielsen, J.; McMorrow, D. Elements of modern X-ray physics [on line]. 2nd ed. West Sussex: John Wiley & Sons, 2011 [Consultation: 18/05/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119998365. ISBN 9781119998365.
- Willmott, P.R. An introduction to synchrotron radiation: techniques and applications [on line]. 2nd ed. Hoboken, New Jersey: John Wiley & Sons, Inc., 2019 [Consultation: 18/05/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119280453. ISBN 9781119280453.
- Sivia, D.S. Elementary scattering theory: for X-ray and neutron users. Oxford: Oxford University Press, 2011. ISBN 9780199228683.
- Wiedemann, H. Particle Accelerator Physics. Vol. I. Basic Principles and Linear Beam Dynamics [on line]. Berlin/Heidelberg, DEU: Springer, 2007 [Consultation: 13/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3062807. ISBN 9783540490456.

RESOURCES

Other resources:
- Course presentations (through the UPC Atenea digital campus)