PhD course "Small Angle Scattering: Theory and Practical"

SYLLABUS

1 Lecturer information

Name and Surname: Jitendra Mata

Affiliation:

Principal Instrument Scientist, Australian Centre for Neutron Scattering (ACNS), Australian Nuclear Science and Technology Organisation (ANSTO), Lucas Heights, NSW 2234, Australia

and

Adjunct Associate Professor, School of Chemistry, University of New South Wales, Sydney, NSW 2052, Australia

Tel: +61 2 9717 7221

Mobile: +61 430 193 021

Email: jtm@ansto.gov.au

Proposed by: Emiliano Fratini (for courses taught by an external lecturer)

Email: emiliano.fratini@unifi.it

2 Title of the course

Small Angle Scattering: Theory and Practical

3 Course program

Small Angle Scattering (SAS) is a versatile field encompassing various techniques, including Small Angle X-ray Scattering (SAXS), Small Angle Neutron Scattering (SANS), Ultra-small Angle X-ray Scattering (USAXS), and Ultra-small Angle Neutron Scattering (USANS). These techniques are instrumental in exploring the nanoscale and microscale structures of diverse hard and soft condensed materials, such as minerals, alloys, magnetic materials, food, surfactants, polymers, proteins, hydrogels, colloids, and emulsions. In recent years, SAS has proven invaluable in deciphering complex materials with intricate hierarchical architectures.

By combining SAS with traditional methods, researchers can gain unparalleled insights into material properties, enabling the characterisation of factors like structure, size, shape, and morphology. SAS facilitates the direct investigation of processes such as aggregation, structural transitions, crystallisation, porosity, and phase separation. These techniques are well-established for characterising length scales ranging from 1 nm to ~10 µm, offering non-destructive means to explore

systems both in situ and within complex sample environments. The use of deuterated molecules and partial deuteration has expanded the applicability of SAS methods, particularly in soft materials using SANS/USANS.

Our proposed course offers a comprehensive introduction to the theoretical and practical aspects of SAS, covering scattering theory, data collection, data processing, data analysis and modelling, applying for beam time, and the application of SAS to specialised research areas. Designed to cater to the needs of both PhD students and early-career researchers, the course is intended for those who have experience with SAS instruments or plan to use them in their research endeavours.

4 Course content detailed per lesson of two hours (possibly with dates and room real and virtual)

Lesson 1 – Small Angle Scattering (SAS) overview

- Fundamental of Neutron Scattering.
- Small Angle Scattering (SAS) Theory and General introduction

Lesson 2 – Technical aspect of SAS

- Instrumentation
- Sample Environments
- Deuteration.

Lesson 3 – Data Processing

- Data collection,
- Data reduction,
- Interpretation and Modelling

Lesson 4 – Applications of SAS

- Applications in various research area
- Software overview
- Proposal writing

Lesson 5 – Applications of SAS

- Practical data fitting

5 Suggested reading

The following is a comprehensive list of reading materials. While it is encouraged to read some of these, they are not prerequisites or compulsory.

1. SANS Tutorials and Presentations (nist.gov)
2. Small-Angle Scattering of X-Rays, Authors: André Guinier and Gérard Fournet, New York: John Wiley & Sons (1955)
3. Small-Angle X-Ray Scattering, Editors: Glatter O and Kratky O, London: Academic Press (1982), Structure Analysis by Small-Angle X-Ray and Neutron Scattering, Authors: Feigin LA and Svergun DI, New York: Plenum Press (1987)

4. Scattering Methods and their Application in Colloid and Interface Science | ScienceDirect
5. Small Angle Scattering - Ian W. Hamley, Wiley, 2021
6. Biological Small Angle Scattering: Theory and Practice - Eaton E. Lattman, Thomas D. Grant, and Edward H. Snell, 2018

6 Learning Objectives

In this course, you will grasp the fundamentals of SAS techniques, including SAXS, SANS, USAXS, and USANS, and apply them to analyse nano and microscale materials. You will become adept at data collection, processing, and analysis, exploring specialised research applications. You will also explore the use of SAS for in situ studies and the significance of deuterated molecules in SANS/USANS. Throughout the course, you'll develop proficiency in non-destructive analysis and gain the skills needed to confidently apply SAS in your research projects.

7 Knowledge and Skills to be acquired

In this course, you will acquire a comprehensive knowledge of SAXS, SANS, USAXS, and USANS, their applications in analysing diverse materials, and the nuances of data handling. You will develop practical skills for proficient data analysis, utilising SAS as a non-destructive tool for material characterisation and conducting in situ studies. Additionally, you'll understand the relevance of deuterated molecules in SANS/USANS techniques, particularly in soft materials. With this knowledge and skill set, you will be well-equipped to plan and execute SAS experiments, enhancing your research projects and contributing to the field of material analysis.

8 Prerequisites

Bring laptop with SasView software installed (download it from here SasView - Small Angle Scattering Analysis)

9 Teaching Methods

☐ MODE 1 - Pre-recorded lessons uploaded on the moodle platform (a meeting must be organized with PhD students in order to clarify eventual doubts)

☒ MODE 2 (preferred) - Lessons delivered in-person and in remote with simultaneous recording by the WEBEX platform

10 Further information

https://www.ansto.gov.au/facilities/australian-centre-for-neutron-scattering/neutron-scattering-instruments/quokka-small

https://www.ansto.gov.au/our-facilities/australian-centre-for-neutron-scattering/neutron-scattering-instruments/kookaburra

https://www.youtube.com/watch?v=DnGsILwnUrw&t=5s

https://www.ansto.gov.au/facilities/australian-synchrotron/synchrotron-beamlines/small-angle-x-ray-scattering-saxs-wide

11 Type of Assessment

This assessment comprises two parts to evaluate your understanding and application of Small Angle Scattering (SAS) techniques.

In Part 1, you will be given a short essay topic at the end of the course, related to a specific aspect of SAS, which may encompass theoretical principles, practical experiments, or real-world applications. This essay will assess your ability to articulate your knowledge and insights.

In Part 2, you will be presented with calculations and SAS data that require analysis and fitting. This practical component of the assessment will test your proficiency in applying SAS techniques to real data, further gauging your practical skills in data analysis and interpretation.

Both parts of the assessment are designed to provide a comprehensive evaluation of your SAS knowledge and practical capabilities.

12 Period

Monday, 12 April 2024 to Tuesday, 14 May 2024 inclusive