

University of Maryland
Dept of Materials Science and Eng.
ENMA 475/681

Diffraction Techniques in Material Science:
Synchrotron X-ray Scattering

August 28, 2018 (Office hours will be official the second week of classes or when announced.
Approximate presentation times will be official when the number of students is known, usually the
second week of classes)

Course description: This course looks at advanced methods of x-ray scattering/diffraction available thanks to the more powerful sources available to us. The availability of these sources enables us to study liquid crystals, polymers, nanomaterials, quasiorganized materials (including nano) and disordered materials.

Pre-requisites (undergrads): Math 246, Phys 270, 271.

Text: Elements of Modern X-ray Physics, Jens Als-Nielsen and Des McMorrow, 2nd. Edition, Wiley and Sons, 2011. Professor's PPTs will be posted; however, please note that the instructor reserves the right to add any notes that she feels may clarify some of the points given during class on the board – these will **not** be added to the PPT. Recommended: X-ray diffraction, B. E. Warren, Dover, republication of the work published by Addison-Wesley, 1969.

Course objectives:

1. *How does synchrotron x-ray illustrate the physical principles that govern diffraction and scattering?* (MESMS question)
2. What is the advantage that synchrotron radiation has on the following techniques?
 - a. Reflectivity
 - b. Grazing Incidence Scattering
 - c. Small Angle X-ray Scattering
 - c. Diffuse scattering and Speckle diffraction
 - d. Absorption: Resonant scattering
 - e. Imaging (introduction)
3. How does synchrotron radiation help in the study of:
 1. Disordered materials
 2. organics (biomaterials, new mono- and polymeric materials)
 3. nanoparticles
 4. thin films

Topics covered:

- I. Introduction (parts of Chap 2 – (Secs; 2.1, 2.2, 2.3 [Figs. 2.3 and 2.4], 2.4.1, 2.4.6 [Fig. 2.13])
 - A. Some historical insights
 - B. What is the synchrotron
 - II. How X-rays interact with matter (Chap 1)
 - A. A pictorial view of what makes synchrotron scattering a powerful tool:
 1. What is the advantage of synchrotron radiation over elemental sources
 2. Brilliance, Divergence (resolution)
 - B. Overview: How do X-rays interact with matter?
 - C. Beyond the scattering of a crystal
 1. Absorption
 2. Reflection
 3. Magnetic scattering
- Note: Chaps 1 and 2 will be covered at the same time, alternating between the two.
- III. Reflection and Refraction of X-rays (Chap 3 , Sections 3.1 – 3.5; parts of 3.6, Sections 3.7 – 3.9)
 - A. Refraction from interfaces:
 1. Index of refraction
 2. Absorption
 - B. Reflection from interfaces

1. How does this benefit from advanced sources
2. Specular reflection
3. Roughness
4. Index of refraction: Grazing incidence X-ray scattering
5. Intro to Small Angle X-ray Scattering (SAXS)

C. Examples

First presentation

IV. Kinematical diffraction [Chap 4, Sections 4.1 – 4.3, parts of 5.1, 5.2, 5.3, 5.4,5.5, 5.6, and Chap 7, Section 7.2.2]

- A. From two electrons (review)
- B. From an atom and a molecule (review)
- C. Microbeam diffraction
- D. Speckle structure (reference)
- E. Examples

Written report

V. Revisit scattering from a perfect crystal: Dynamical scattering (Chap 6, parts of sections 6.1 – 6.4).

VI. X-ray absorption (Chap 7, 7.1) and Resonant scattering (Chap 8 Sections 8.1 – 8.4, parts of 8.6 and Section 8.7)

VII. Imaging (Chap 9, Secs 9.1.1 – 9.2.2, parts of Secs. 9.4 and 9.5)

Final presentation

Class organization: Class Tue-Thurs 9:30 – 10:45 AM RM2136.

Two presentations, based on individually assigned papers, a mid-term written report on one or two papers related to the lessons and homeworks, distributed as needed, will be required of this class.

The schedule and weight for the different activities is:

Homeworks- all through the semester. These may include in-class exercises – 20%

Partial Presentation – Oct. 11, 16 or 16, 18 – 25% (May have a meeting on the 11, so it will be on the 16, 18. I will know by the third week)

Mid-Term written report – approximately Nov. 13 or 15 (due date) – 25%

Final presentation – Nov. 27, 29 or Nov. 29, Dec. 4 - 30%. Those attending the MRS meeting must report this *before* Nov. 15, so appropriate re-assignments can be done. (Dr. Martínez-Miranda will be away at a meeting on Dec. 7 – See below)

These days are *approximate*, except the last presentation – the presentation and/or reports may occur within a week before or after the dates given. They are given here so that you may be able to prepare a schedule. All presentations will take at least two days to complete. All presentations *may include* a question to turn in the day following the second day of presentation, except the last presentation, when it will be due after the presentations. All presentations will be on articles that the instructor chooses and either assigns to you (first presentations) or you can choose (first come, first serve basis) from a list.

Weather is generally not a problem during the Fall. However, **in case of bad weather:** Check the website or call (301) 405-SNOW. If it is during a regular class, the class will be flipped and will be made available in canvas. If there is a presentation, the presentation will happen the next day that classes are supposed to meet. The class corresponding to the next day will be flipped and made available in canvas. The flipped class will not be repeated: only questions will be entertained. If it is during the last presentations, these presentations will either be turned into a report or slid into the final exam day, depending on the time – Dr. Martínez-Miranda makes this decision.

➔ Please turn off all cellphones or Ipads or any other means of social texting or computing, or put the phones in vibration mode. Do not text during class or the presentations.

Note:

1. There will be NO final exam. The presentations and report will tell me if you have understood the material given in this course. However, if someone thinks they need a final, I need to know by Tuesday, Sept. 4. The final will be given to everybody. I cannot have two systems of grading. It is scheduled for Thursday, Dec. 13, 8 – 10 AM (this is scheduled by the registrar and it cannot be changed).

2. Homeworks must be turned in at 9:30AM, either in person or via canvas. No late homeworks will be accepted since the solutions will be posted. No email homeworks will be accepted.
3. Attendance is required for the presentations, and the group discussions. All of these count as exams.
 - a. No credit will be given for whichever of the presentations and group discussions you are not present.
 - b. 15% of each presentation grade will be for attendance.
 - c. Make up presentations will be given on a case by case basis. The make up day for the second presentation will be the day of the final exam, Dec. 13, 8 – 10 AM, if no final is chosen. Dr. Martínez-Miranda will be at a meeting between Dec 5 – Dec 12 (inclusive dates, leaving at 3 AM and returning at 12 midnight) and will not be available to answer questions or to give a make-up. Please note: the make up presentation day will be decided by Dr. Martínez-Miranda.
4. Religious holidays must be reported at least a week ahead of the holiday to enable appropriate make-ups if needed. It is your responsibility to identify the holiday.

Contribution of course to meeting the professional component: This course is an elective course that provides information the advantages of synchrotron sources in scattering and diffraction.

Relationship of course to program objectives: This course provides information on x-ray scattering and diffraction and provides complementary course to the course in TEM and Neutron diffraction.

Honor Code: The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit <http://www.shc.umd.edu>.

To further exhibit your commitment to academic integrity, remember to sign the Honor Pledge on all examinations and assignments: "I pledge on my honor that I have not given or received any unauthorized assistance on this examination (assignment)."

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Office hours available second week of classes

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