MatSci 326: X-ray Science and Techniques

Course Information

Basic info

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The course home page can be found on Canvas. I will regularly post assignments, schedules, announcements etc there.

Textbook

There is no required textbook but I will in some parts of the course follow the book *Elements of Modern X-ray Physics* by Jens Als-Nielson and Des McMorrow, 2nd Edition. This book is quite good and I highly recommend it. There is a free electronic version of this available at from the Stanford libraries but if you are serious about x-rays this is a great book to actually have on your shelf. I consult mine all the time!

Other recommended books for outside reading:

Soft X-rays and Extreme Ultraviolet Radiation: Principles and Applications, David Attwood.
X-ray Diffraction, B.E. Warren.
Theory of X-ray Diffraction in Crystals, William H. Zachariasen
X-ray Diffraction in Crystals, Imperfect Crystals and Amorphous bodies, A. Guinier
An Introduction to Mechanics, D. Kleppner (this book has a good overview of special relativity which you may find useful when we discuss how x-ray sources work).

There are many others, mostly focused on diffraction and crystallography.

Problem Sets

There will be problem sets assigned throughout the quarter, roughly every other week, maybe a little bit less than this depending on how fast we go. You are encouraged to work together on the problems but everyone needs to write up his or her own solutions.

Grading

In addition to the problem sets, there will be a final paper and presentation written as a beamtime proposal on a topic of your choice (see more below). Grades will be determined as follows:
Problem sets: 35%
Paper/Presentation: 65%

Course Summary and Goals

This is a course about x-ray fundamentals, methods and techniques. This is a huge topic and we will not be able to cover everything. The goal of the course is to introduce you to this rapidly developing field and its associated array of powerful new techniques, and to set the groundwork for future research in this area that you may undertake or are perhaps already in the middle of. By the end of the quarter, you should have a firm understanding of the applications of x-rays to a wide range of problems, and be capable of applying these techniques to your own research. Hopefully you come away from this course with new ideas for how this powerful characterization method can be applied to problems you are interested in. In particular you are taking this course during a time of tremendous development and revolutionary new sources just up the road from us at SLAC and there are opportunities for you as a student to take leading efforts in the first science carried out.

Info on paper/presentation

This is a beamtime proposal to carry out an experiment that has never been done before. You are free to choose any topic that involves the use of x-rays as a tool to help understand something new. This could be one particular scientific problem you are interested in or already working on, or you could take this as an opportunity to learn something new The paper should not just be a summary of existing knowledge on a subject nor should it be a recapitulation of research you have already done. Your goal is to design and propose an experiment that hasn't been carried out before. You will want to show in your writeup in a quantitative way how the experiment is feasible, describe what new information will be gained or questions that will be answered, and describe in some detail how the experiment will be carried out. A useful way to think about this is to answer the following: WHO is going to do WHAT, WHERE (beamline), WHEN, WHY, HOW. The project should describe the background/significance of the effort, the specific planned experiments, and the need for synchrotrons/XFELs.This is good practice if you ever go on to do any experiment at a synchrotron or other user facility where such a beam time proposal is the standard first step. Choose a topic that interests you and then think about how x-rays might illuminate the issue. I would like each of you to talk to me about your topic. I can provide some guidance and make some suggestions on possible sources of information/references.
The paper will be due on the last day of class and should be approximately 5-7 pages long (with figures). You are also asked to make a short presentation (about 5 minutes long) of your work to the class at the end of the quarter. In the past these writeups have been turned into real (and successful) proposals at SSRL/LCLS.

Tours

I am working on organizing tours of SSRL and LCLS and an opportunity to carry out some real experiments there. More details to follow.

Course outline

-Fundamentals of x-ray interactions with matter: scattering from electrons, atoms, molecules, and crystals. Structure determination.
-Effect of lattice vibrations and the Debye-Waller factor; Probing disorder in materials; Diffuse x-ray scattering, small angle scattering.
-Sources: Synchrotron radiation, Free electron lasers; basics of bending magnets, wigglers and undulators and how they work.
-Dynamical diffraction and effects in perfect crystals; applications to x-ray monochromators/x-ray optics etc. X-ray standing wave techniques.

-X-ray absorption spectroscopy, RIXS, and other techniques. Theory of EXAFS from a microscopic, quantum mechanical perspective

This list is very open. Please come talk to me if you would like to include additional specific topics.