

APPLIED PHYSICS 216
X-RAY AND VUV PHYSICS
(Sept. – Dec., 2006)

Course Meeting: [Monday, Wednesdays 11-12:15](#)

Professor: Zhi-Xun Shen
McCullough Building, Room 342
725-8254
zxshen@stanford.edu

Office Hours: 2:30-3:30 Pm Fridays

Secretary: [Lily Tsukakoshi](#)
McCullough Building, Room 340
725-0440
tsukakoshi@stanford.edu

Mid Term: Oral Presentation
Selected Current Topics

Final Exam: Oral Presentation + Term Paper
Selected Current Topics

Another Course: Introduction to Synchrotron Radiation

Students with documented disabilities: Students who have a disability which may necessitate an academic accommodation or the use of auxiliary aids and services in a class must initiate the request with the Disability Resource Center (DRC). The DRC will evaluate the request with required documentation, recommend appropriate accommodations, and prepare a verification letter dated in the current academic term in which the request is being made. Please contact the DRC as soon as possible; timely notice is needed to arrange for appropriate accommodations. The DRC is located at 123 Meyer Library (phone 723-1066; TDD 725-1067).

SURVEY OUTLINE

1. X-Ray and its properties
 - a. Definition and basic properties
 - b. History
 - c. Scope of x-ray Science
2. X-ray generation
 - a. Continuous x-ray ... Bremsstrahlung
 - b. Characteristic x-ray
 - c. Synchrotron radiation
 - d. Free-electron laser
 - e. Laser plasma/Laser up-conversion
3. X-ray matter interaction - principles underlying absorption/reflection/scattering processes.
 - a. Classical theory – matter based approach: forced oscillator, refractory index, dielectric constant, absorption and dispersion theory.
 - b. Semi-classical theory – photon based approach, $\mathbf{A} \cdot \mathbf{p}$, \mathbf{A}^2 , $(\mathbf{A} \cdot \mathbf{P})^2$
4. Techniques
 - a. Spectroscopy (electronic structure, bonding, ...)
 - i. Photoelectron spectroscopy (and its variants)
 - ii. X-ray absorption spectroscopy (and its variants, e.g., MCD)
 - iii. EXAFS
 - iv. X-ray emission and Raman spectroscopy
 - b. Scattering
 - i. Elastic x-ray scattering – key to structure, phase problem
 - ii. Inelastic x-ray scattering
 - iii. Anomalous (Resonance) scattering
 - iv. Magnetic x-ray scattering
 - c. Imaging
 - i. Tomography
 - ii. X-ray microscopy
 - iii. Spectromicroscopy
 - iv. Angiograph
 - v. Speckle
 - vi. Scattering/imaging – scattering of non-periodic specimens.
 - d. Holograph and interferometers
5. Comparison/combination of x-ray and other techniques
 - a. Optical spectroscopy
 - b. Electron microscopy – SEM, TEM, STM

- c. Neutron scattering
- d. High magnetic field
- e. NMR/EPR
- f. High pressure.

6. Cases Studies – topics

POSSIBLE TOPICS

1. Synchrotron Radiation Sources
2. Other X-ray Sources – X-ray Tubes, Laser-Plasmon, Harmonic Generation, Inverse Compton
3. Grating and Crystal Monochromators / Spectrometers
4. Photon Detectors for the Ultraviolet and X-ray Region
5. Photon – Matter Interaction: Formulism and Experimental Probes, Spectral function, Correlation functions
6. Photoelectron Spectroscopy – UPS and XPS (ESCA)
7. Angle-Resolved Photoemission Spectroscopy
8. Resonance Photoemission Spectroscopy
9. Spin Resolved Photoemission Spectroscopy / Circularly polarized light
10. Time Resolved Photoemission
11. Photoelectron Spectrometer/Detectors – Electrostatic, Magnetic and Time of Flight Spectrometer.
12. EXAFS and Surface EXAFS
13. X-Ray Diffraction, Principles and Applications – case study of powder diffraction.
14. Anomalous X-Ray Scattering
15. Small-Angle X-Ray Scattering
16. Soft X-Ray Speckle and Dynamic Scattering
17. X-Ray Magnetic Scattering
18. Inelastic X-Ray Scattering - Electronic Excitations, Phonons and collective modes
19. Scattering from Non-Crystalline Systems – Lensless X-ray Imaging
20. X-Ray Dynamic Scattering and X-Ray Standing Wave Technique
21. Crystal-Structure Analysis of Biological Macromolecules by Synchrotron-Radiation Diffraction
22. Basics of Radiation Biology
23. Medical applications: Iodine Dichromography, Microtomography, Angiography,
24. Synchrotron X-ray and Modern Molecular Environmental Science
25. Surface Science with Synchrotron Radiation

26. X-ray Microscopy and Imaging
27. X-Ray Magnetic Circular Dichroism and Linear Dichroism: Also Applications
28. X-Ray Scattering from Charge, Spin and Orbital Densities in Condensed Matter Systems
29. X-Ray Absorption Spectroscopies, High-Resolution X-Ray Florescence Spectroscopy and its Applications
30. Compton Scattering
31. X-Ray Free-Electron Laser
32. Soft X-ray Inelastic Scattering and Soft X-Ray Emission Spectroscopy.