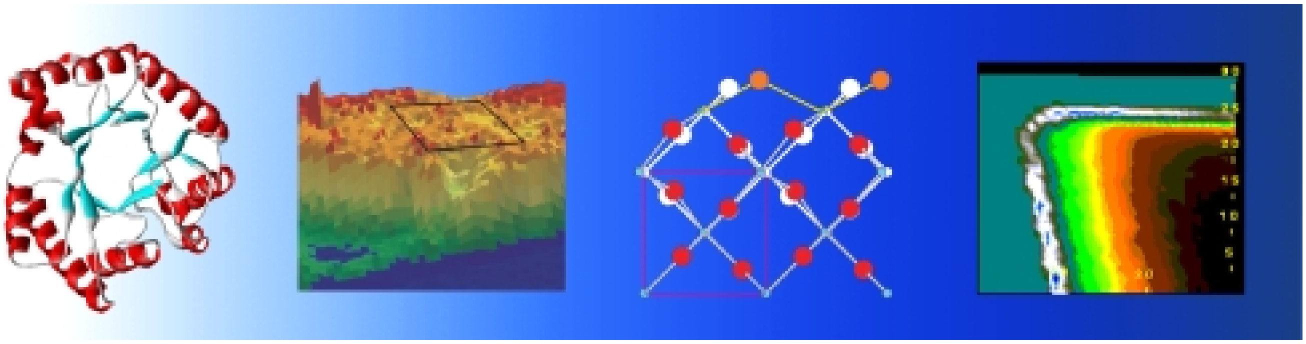
Workshop 4: APS 101: Introduction to the APS

Dean Haeffner, organizer

Tuesday, October 9, 2001
7:00–9:30 pm



This workshop is designed to introduce new or inexperienced users to the radiation properties and potential applications of the APS. The first lecture will provide an overview of the unique properties of synchrotron radiation at the APS. The remaining speakers will highlight a variety of synchrotron radiation techniques and provide background information for other workshops at the meeting.

7:00–7:30 pm **Radiation Properties from Third-generation Synchrotron Sources**
Dennis Mills, *Advanced Photon Source, Argonne National Laboratory*

7:30–8:00 pm **Synchrotron Radiation Research Techniques in Geosciences**
Mark L. Rivers, *Department of the Geophysical Sciences and Consortium for Advanced Radiation Sources (CARS), The University of Chicago*

8:00–8:30 pm **Biological Research at the Advanced Photon Source**
Andrew J Howard, *Illinois Institute of Technology and Industrial Macromolecular Crystallography Association Collaborative Access Team, Advanced Photon Source*

8:30–9:00 pm **Industrial Applications of Synchrotron Radiation**
John P. Quintana, *Northwestern University*

Radiation Properties from Third-generation Synchrotron Sources

Dennis Mills, *Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439 USA*

The general properties of synchrotron radiation, namely high flux, tunability, high collimation, and high degree of polarization, have made it an attractive tool for scientists performing experiments with x-rays. Third-generation sources, such as the APS, are specially optimized for the production of high-brilliance x-rays produced from undulators and the properties of undulator-generated x-ray beams are qualitatively and quantitatively different not only from laboratory sources but also from those generated by bending magnet or wiggler sources on first- and second-generation sources. This talk will focus on the general properties of synchrotron radiation with an emphasis on the characteristics of undulator-generated x-rays at the APS.

Synchrotron Radiation Research Techniques in Geosciences

Mark L. Rivers, *Department of the Geophysical Sciences and Consortium for Advanced Radiation Sources (CARS), The University of Chicago, Chicago, IL 60637 USA*

Synchrotron radiation techniques have permitted major advances in many aspects of earth sciences. Some of the most important areas in which the APS will be applied to geosciences research include the following:

High-pressure research: The APS allows high-pressure crystallography to be extended to pressure, temperature and compositions currently inaccessible leading to new knowledge in the following example areas: (1) mechanisms of the olivine-spinel transition (origins of deep-focus earthquakes), (2) phase transition and thermal expansion of perovskites (composition and state of planetary interiors), (3) structure of solid hydrogen (structures of Jovian planet interiors), (4) behavior of volatile species at high P, T (volatile budget of the planets), and (5) properties of iron and its alloys at core conditions.

X-ray absorption spectroscopy: The APS allows x-ray absorption spectroscopy studies to be extended to smaller volumes and lower concentrations than currently possible. Examples of planetary science applications include (1) pressure and temperature induced coordination changes of cations in silicate melts (transport properties of silicate magmas), (2) oxidation states of meteorites (chemical homogeneity of the solar nebula), and (3) surface chemistry at sub-monolayer coverage (studies of toxic element sorption in soils).

X-ray microprobe: The high sensitivity and spatial resolution of the x-ray microprobe at the APS can be used for studies such as: (1) oxygen fugacity inferences of solar system bodies through cation partitioning studies on meteoritic minerals, (2) trace element contaminant concentration and speciation in contaminated environmental materials, (3) volatile trace element chemistry in micrometeorites, chondrule rims and meteoritic matrices, and (4) oxidation state of mantle minerals including inclusions in diamonds (chemical homogeneity of the Earth's mantle).

X-ray diffraction: The APS permits diffraction studies to be carried out on lower-dimensional structures, such as surfaces and interfaces. It also permits single-crystal diffraction studies of micron-sized crystals that would otherwise be studied only with powder diffraction.

Microtomography: Microtomography at the APS is used for studies such as (1) visualization of cracks and pores in waste repository rocks, (2) non-destructive imaging of fossils, (3) *in situ* chemical and oxidation state mapping of friable materials such as carbonaceous meteorites, interplanetary dust particles, chondrule rims and ices, and (4) real-time, *in situ* studies of soil drainage.

Biological Research at the Advanced Photon Source

Andrew J. Howard, *Illinois Institute of Technology, Chicago, IL 60616 USA and Industrial Macromolecular Crystallography Association Collaborative Access Team, Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439 USA*

Second- and third-generation storage rings were built primarily to accommodate the needs of materials scientists and physicists. Nonetheless, these facilities have provided impressive results in the biological sciences as well. The APS has had biological facilities from the very beginning, and the majority of the "second-generation" collaborative access teams now under development at the APS are geared toward biological studies. Macromolecular crystallography is responsible for more than half the biological experiments at the APS. SBC-CAT (sector 19) is a DOE-funded national resource for macromolecular crystallography, and has provided the data for several of the ground-breaking structural studies in the last two years—including the determination of the structure of the 50S ribosome in 2000. BioCARS (sector 14) is an NIH-funded national resource that has been a home to numerous structural studies, including some time-resolved studies that cannot be done anywhere else in the US. IMCA-CAT (sector 17) is the only entirely industrially funded CAT at the APS, and provides crystallographic capabilities for twelve pharmaceutical companies as well as academics. New facilities for macromolecular crystallography are rapidly coming online. SER-CAT (sector 22) provides crystallographic access for structural biologists from academic and governmental labs in the southeastern US. SGX-CAT, NE-CAT, GM/CA-CAT, and possibly one or two other facilities will offer crystallographic data collection sites for various constituencies. The APS offers ther biophysical and biological capabilities. Biophysics CAT (sector 18) is an NIH-funded national resource offering world-class facilities for biological fiber diffraction, x-ray absorption spectroscopy, and solution scattering. SRI-CAT (sectors 1–4) provides facilities for trace-elemental analysis in plant tissues and other specialized experiments. Other CATs whose primary research focus lies outside of biology nonetheless accommodate biological experiments from time to time. The talk will summarize the capabilities available at the APS, some examples of successful biological research at the APS, and an assessment of the impact of these experiments.

Industrial Applications of Synchrotron Radiation

John P. Quintana, *Northwestern University, Evanston, IL 60208 USA*

Industrial uses of synchrotron radiation range from basic analysis of materials to *in situ* studies of reactions and processes. Techniques commonly used by industrial users of the DND-CAT beamlines will be reviewed. Beamline operational specifications and requirements for industrial users will also be discussed.