Science and Accelerators for Next Generation Storage Ring X-ray Sources: The Advanced Photon Source at Argonne National Laboratory

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X-ray light sources are indispensible tools for addressing critical problems across an extremely diverse array of disciplines, including chemistry and chemical engineering, materials science, physics, environmental and geosciences, biology and life sciences, and engineered systems research. Within the international portfolio of x-ray facilities, the Advanced Photon Source (APS) at Argonne National Laboratory is a U.S. Department of Energy Scientific User Facility with a core mission to serve the scientific community by providing high-energy x-ray science techniques that allow users to address the most important basic and applied research challenges. The APS is optimized to provide the nation’s highest-brightness hard x-rays (i.e., photon energies above 20 keV), making it ideally suited to explore the time-dependent structure, elemental distribution, and chemical, magnetic, and electronic states under *in situ* or *operando* environments. This talk will provide an introduction to the APS, summarize recent technical directions, and give examples of scientific impact resulting from the APS’ capabilities.

Additionally, research challenges that require vastly brighter hard x-rays or higher coherent flux than the APS currently produces are now within reach because of revolutionary new storage ring lattice designs that dramatically reduce the stored electron beam emittance and thus greatly increase photon beam brightness. There is world-wide interest in such diffraction-limited storage rings, with projects under development in Europe, Asia, South America and the United States to deploy this fourth-generation storage ring technology. Plans are underway at Argonne National Laboratory to upgrade the Advanced Photon Source storage ring with a multi-bend achromat lattice to reduce the beam emittance by more than a factor of 50 relative to that achieved in present operation. Coupled with superconducting insertion devices, an upgraded APS will deliver hard x-ray brightness and coherent flux levels that are two to three orders of magnitude greater than that which can be achieved today. The conceptual design for APS-U, and an outline of the science drivers envisaged for the upgraded APS will be given.