Advanced X-ray Imaging Collaborative Development Team (AXI-CDT) LOI
Jon Harrison (Arizona State University), Jianwei Miao (UCLA), and Ian McNulty (APS)

Executive Summary:

Imaging is a premier method of scientific inquiry and has found applications in nearly every field. A number of imaging tools can probe objects at nanometer spatial resolution, but few can image the internal structures of three-dimensional objects from nanometer to centimeter scales. Synchrotron x-ray imaging has become such a tool and is uniquely suited for (a) investigating a broad range of objects in biological and materials sciences with complex hierarchical internal or buried structures that cannot be properly preserved or studied by sectioning, and (b) dynamic and real-time studies of biological and materials processes intrinsic to function such as physiology and biomechanics in small animals and mass transport ranging from fluid flow to electrodeposition. In addition, the high degree of coherence in a synchrotron x-ray beam has enabled new and exciting image contrast modalities, such as phase contrast for study of low absorption objects in dense matrices, and coherent diffraction for achieving nanometer-scale spatial resolution.

This Letter of Intent proposes to form a new Collaborative Development Team (CDT) to build a dedicated Advanced X-ray Imaging (AXI) facility based on dual insertion devices in a long straight section at one of the undeveloped sectors at the Advanced Photon Source. The new AXI facility aims to establish the following novel x-ray imaging capabilities not currently available in the United States: (a) a 200 m long beamline for high sensitivity, wide field x-ray phase imaging, (b) a beamline with a 20 m long experimental hutch for coherent diffraction imaging (CDI) accommodating next-generation focusing optics and high dynamic range area detectors, and (c) coherence-conditioning and focusing x-ray optics that provide well-defined wavefronts for CDI under both plane and curved-wave conditions. Scientific programs enabled by the new AXI capabilities will focus on three broad areas:

- Real-time imaging of physiology and biological function in live insects and small animals;
- Time-resolved in-situ studies of materials processing and transient fluid dynamics;
- Nanoscale-resolution imaging of intact, thick biological specimens;
- Structure of nanoparticles, domain formation, and strain in extended materials specimens.

A potential future expansion of the AXI facility will include structure determination of laser-aligned macromolecules by serial crystallography.