WK9: Nanoscience for Quantum Science: Developing, Characterizing, and Harnessing Optically Active Defects
Organizers: Jeffrey Guest, Stephen Gray, and Xuedan Ma (Center for Nanoscale Materials, Argonne National Laboratory)
Location: Bldg. 440, Room A105/106

Systems for storing and manipulating quantum information, particularly optically addressable spin systems, are intrinsically nanoscale objects; they are structured and function on nanometer length scales. However, experimental efforts have largely avoided nanoscience approaches to understanding and controlling such systems due to the additional complexity introduced, relying instead on defects buried inside 'perfect' crystals or laser-cooled ions trapped in vacuum far from surfaces. This workshop will explore emerging efforts and untapped potential in this overlapping space, particularly where nanoscience characterization, synthesis, fabrication and theory tools can help understand and control the underlying physics determining the behavior, the governing interactions, and the de-coherence mechanisms of these quantum systems.

For example, the local environment of optically-active defects is known to play an important role in determining the energetics and coupling of electronic and spin states to each other and the local strained lattice; the ability to probe this environment directly will be possible with nanoscale x-ray probes. Additionally, surfaces are typically eschewed by the quantum science community. However, they are a powerful platform for atomic scale development and an intrinsic part of any nanoscale quantum sensor. Questions this workshop would like to answer are whether there are fundamental limitations to coherence properties of quantum states at or near surfaces and what can surface science approaches do to reach these limits. To date, defects explored by the quantum science community have largely been naturally occurring, but combined with improved theoretical approaches, new developments in synthesis and atomic scale control by scanning probes has opened up new frontiers in artificial nanostructures. Hybrid quantum systems are likely to play a critical role in converting long-lived quantum information into 'flying' qubits for quantum communication; engineering systems for this purpose is likely to require developments in materials science and the harnessing of nanofabrication capabilities, for example in nanomechanical systems that couple optically-active defects to solid-state phonons. Theoretical efforts that marry atomic-scale understanding of quantum properties to mesoscopic behaviors and de-coherence physics will also play a pivotal role.

8:30—8:40	Introductory remarks
8:40—9:30	David Awschalom (U. of Chicago/Argonne National Laboratory) *Controlling Defect Spin States with Photons, Magnons, and Phonons*
9:30—10:10	Alec Jenkins (University of California Santa Barbara) *The NV Center in Diamond: A Versatile Quantum Sensing Technology*
10:10—10:40	Break

10:40—11:20	Cyrus Dreyer (Rutgers University) *Carrier Capture and Recombination at Point Defects from First Principles*
11:20—12:00	Giulia Galli (University of Chicago) *Harnessing Point Defects in Solids and Nanostructures*
12:00—1:40	Lunch
1:40—2:20	Jay Gupta (Ohio State University) *Tunable Control over Individual Defects in Semiconductors at the Atomic Scale Via STM*
2:20—3:00	Greg Fuchs (Cornell University) *The Electronic and Vibronic Properties of Single Photon Emitters in Hexagonal Boron Nitride*
3:00—3:30	Break
3:30—4:10	Ajit Srivastava (Emory University) *Phonon-photon Entanglement in* WSe_2 *Quantum Dots*
4:10—4:50	Tian Zhong (University of Chicago) *A Nanophotonic Platform Integrating Quantum Memories and Single Rare Earth Ions*
4:50—5:00	Closing remarks