

WK3: Next-Generation Quantum Systems Based on Topological Phases and Integrated Quantum Photonics

Organizers: Xuedan Ma and Dafei Jin (Center for Nanoscale Materials, Argonne National Laboratory)

Location: Building 401, Room A5000

Quantum information science is an emerging field that can potentially revolutionize multiple technologies extending from sensing and measurement precision to quantum computation and communication. The field leverages explicit quantum properties of matter such as entanglement and superposition to enable phenomena that break classical limits. The quest to understand and control such intriguing phenomena, in turn, stimulates progress in the development of quantum materials.

The goal of this workshop is to bring together researchers working on various aspects of topological materials and quantum photonic systems, and create synergies between Argonne/CNM and the worldwide scientific community. Main topics in this workshop include:

- (1) Exotic topological materials
- (2) Photonic quantum networks exploiting quantum entanglement effects
- (3) Novel photonic metamaterials and cavities

Quantum materials transforming electronics and photonics from the classical to the quantum regime may enable fundamentally new approaches to information technologies. One vibrant research area in quantum materials is topological materials, including topological insulators and superconductors, semi-metals, and more. These systems feature remarkable properties such as gapless boundary modes and fractionalized quasi-particle excitations. These topological properties remain stable even if the system is subject to external perturbation. Qubits encoded in such states are topologically protected and permit creation of topological quantum computers that are robust against noise and disorder.

Aside from the exotic topological phases, rich interactions between light and quantum materials offer promising opportunities for secured quantum communication, vast increase of data-storage capacity, and ultrasensitive quantum metrology. While photons are excellent quantum-state carriers for long-distance transmission, their entanglement with matter qubits in quantum materials implement deterministic quantum interfaces. On-chip solid-state qubit architecture has emerged as one of the most promising implementations of quantum photonic circuits. Integration of functional photonic cavities and metamaterials may lead to groundbreaking technologies such as quantum repeaters that enable globally entangled quantum networks.

Session 1: Quantum and Nano Photonics (Session Chair: Xuedan Ma)

8:30—9:15 Arka Majumdar (University of Washington)
Towards Single Photon Nonlinear Nanophotonics

9:15—10:00 Edo Waks (University of Maryland)

Quantum Nanophotonics: Controlling Photons with Spin on a Semiconductor Chip

10:00—10:30 Break

Session 2: Quantum and Topological Materials (Session Chair: Dafei Jin)

10:30—11:15 Michael Manfra (Purdue University)
Hybrid Superconductor/Semiconductor Systems for Topological Quantum Computing with Majorana Zero Modes

11:15—12:00 Lu Li (University of Michigan)
Quantum Oscillations in Kondo Insulators

12:00—1:30 Lunch

Session 3: Quantum and Nano Photonics (Session Chair: Xuedan Ma)

1:30—2:15 Koray Aydin (Northwestern University)
Nanophotonics in the Flatland: Engineering Novel Photonic Platforms from 2D Materials to Metadevices and Metamaterials

2:15—3:00 Han Htoon (Los Alamos National Laboratory)
Electronic Structure and Quantum Optics of Carbon Nanotube Defects

3:00—3:30 Break

Session 4: Quantum and Topological Materials (Session Chair: Dafei Jin)

3:30—4:15 Weida Wu (Rutgers University)
Direct Evidence of Ferromagnetism in a Quantum Anomalous Hall System

4:15—5:00 Ulrich Welp (Argonne National Laboratory)
Bulk Topological Superconductors, Gap Structure, and Effect of Electron Scattering