Title: Visualizing atomically resolved electronic, spin, and lattice motion using novel ultrafast X-ray Raman spectroscopy.

Abstract:
Understanding the complex interplay between electron and spin dynamics coupled with lattice motion in solid-state devices is an important challenge with both scientific and technological relevance as it drives the efficiency of energy harvesting information storage and processing and quantum technologies. Systematic control of such processes and further advancement in materials discovery require atomically resolved visualization of coupled electron, spin, and lattice motions in real time, however, challenging to probe experimentally. In this talk, I will describe a proposed approach to establish a tabletop ultrafast soft-X-ray light source to atomically resolve electron, spin, and lattice degrees of freedom simultaneously. The proposed approach integrates X-ray absorption with time-domain Raman spectroscopy, which will provide a unique tool to answer key intellectual questions on how the atom-specific local electronic structure and spin states are coupled to the lattice structural motions. In particular, I will describe how this method can provide detailed signatures of polarons in energy harvesting, phonon-driven spin transitions in magnetic materials, and non-equilibrium dynamics in quantum materials. This proposed method extends the benefits of time-domain Raman spectroscopy to obtain lattice structural dynamics with the atomic and spin state resolved electronic structure information of X-ray absorption. This information is critical for materials design since these processes determine the fate of electrons, which are needed to participate in charge transport, energy transfer, and information storage and processing.