Novel Spectroscopic Probes for Quantum Materials and Simulators

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ABSTRACT

The physics of impurities lies at the heart of many fundamental and applied problems in quantum matter. In materials, static defects modify electronic structure and determine device performance, while in lattice systems described by the Hubbard model, mobile dopants in a Mott insulator give rise to exotic, strongly correlated phases at low temperatures. Spectroscopic techniques that can experimentally resolve the signatures of doping and disorder are essential for understanding how quantum phenomena emerge, whether in real materials or their cold-atom analogs.

In this talk, I will illustrate how advances in spectroscopy are forging new connections between condensed-matter systems and cold-atom quantum simulators, drawing on my work in both areas. I will first describe efforts to develop a table-top ultraviolet photoemission system with applications to quantum materials and semiconductor heterostructures. The light source, based on efficient nonlinear photon upconversion to sub-150 nm wavelengths, combines high photon flux with excellent energy resolution and opens new frontiers for probing AMO systems. In the second part, I will present recent work in a Fermi-Hubbard quantum simulator based on ultracold atoms in optical lattices, including the observation of a pseudogap metal at ultralow temperatures through spectroscopic and thermodynamic measurements.