“Shedding Light on Quantum Matter"

Quantum materials are those in which the interactions between constituent particles are too strong to be treated semiclassically, resulting in exotic emergent properties such as high $T_c$ superconductivity. They represent the front line in the quest to understand the organizing principles that lead to complex collective behavior, and to eventually apply these principles to do something useful.

In this talk I will discuss the application of a wide range of optical and electron spectroscopies to quantum materials. In the cuprate superconductors, for example, we have used femtosecond pulses of laser-light to excite collective modes of the charge density wave order recently discovered in these materials. In these experiments we are able to directly observe the coupling between Cooper pairs and charge density waves, which may hold the key to high $T_c$ superconductivity. In similar experiments, we have studied the collective modes of exotic spin textures like the Skyrmion lattice in MnSi. These experiments are complimented by time-resolved x-ray scattering to directly observe the dynamics of spin, charge and orbital order. I will also discuss the use of transient four-wave mixing to manipulate spins in a spin-orbit coupled 2D electron gas. And, finally, I will discuss some of our very recent work on Iridium oxides, which possess both strong electron-electron interactions and strong spin-orbit coupling, providing an ideal playground for demonstration of exotic new ground states.

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