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ABSTRACT:

When Charge Order Meets Superconductivity: Insights from Transition-Metal Dichalcogenides

Quantum materials have emerged as a rich platform to explore novel electronic phases that arise from strong interactions between electrons and the lattice. Among these systems, transition-metal dichalcogenides have attracted particular interest because they host both charge-density-wave order and superconductivity, two collective phenomena that often coexist and compete.

In this talk I will present our recent experimental efforts to investigate the microscopic origin of charge order and its relation to superconductivity in layered dichalcogenides. Using a combination of muon spin rotation (μSR), inelastic x-ray scattering (IXS), and angle-resolved photoemission spectroscopy (ARPES), we probe both the lattice dynamics and the superconducting ground state in these materials.

First, I will discuss our studies of the charge-density-wave transition in 2H-TaS_2. Momentum-resolved phonon measurements reveal a strongly localized Kohn anomaly associated with the charge order, while ARPES measurements show the opening of a sizeable electronic gap at the transition. Together these results highlight the central role of electron–phonon coupling and lattice dynamics in driving the ordered state. I will then present μSR measurements of the superconducting phase of 2H-TaS_2, demonstrating that the superconductivity is consistent with a conventional nodeless BCS-like state.

Finally, I will show how superconductivity evolves when charge order is suppressed in 1T-$TiSe_2$ under pressure. Our μSR measurements reveal a two-gap superconducting state, where the superfluid density is strongly enhanced near a Lifshitz transition associated with changes in the Fermi surface.