Soft X-ray scattering and imaging of collective electronic orders in quantum solids

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Strongly-correlated electron systems with competing collective electronic phases are often inherently granular. The spatial organization of the electronic degrees of freedom is essential to understand the phenomenology of these complex systems, yet there are currently no probes of the charge, spin, and orbital degrees of freedom that can simultaneously afford momentum-space sensitivity and nanoscale spatial resolution.

In this talk, I will show recent resonant soft X-ray scattering and imaging studies of the spatial textures of electronic orders (charge/spin-density-waves) in cuprate high-Tcs and rare earth nickelate thin films. For the cuprates, I will present evidence of a doping-induced transition from a 'Wigner glass' to a 'Wigner crystal' state in electron-doped Nd2CuO4, that occurs around the characteristic doping of the Fermi surface reconstruction (~10%).

For thin films of rare earth nickelate NdNiO3, I will discuss scanning resonant magnetic nanodiffraction (<100 nm resolution) experiments to elucidate the spatial organization of spin-density-wave domains as a function of temperature across the Neel transition. Intriguingly, we have observed a return-point-memory effect in the spin degrees of freedom and intrinsic scale-invariant textures with power-law correlations that suggest proximity to a critical regime and second-order magnetic transition in this material.

I will conclude with some perspectives and a glimpse to very recent resonant coherent diffractive imaging experiments performed at latest-generation, highly-coherent synchrotron X-ray sources to resolve the complex (amplitude/phase) density-wave order parameter down to an ultimate resolution below 30 nm (and beyond).