Tipping the Length Scales with ARPES

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The ability to directly probe electronic structure in energy-momentum space has made ARPES a critical spectroscopic tool for studying quantum materials. The high momentum end energy resolutions available in standard experiments enable it to be productive in a wide array of systems including metals, complex oxides, topological materials, and 2-dimensional materials. One particular shortcoming has been its traditional lack of high-spatial resolution, which has limited the impact of ARPES in untangling the complexities of heterogenous systems and in materials and geometries too small for successful measurement. Significant effort in the community has been spent developing spatially resolved ARPES capabilities to expand its impact with the intrinsic power of microscopy at various length scales. I will give an overview of these approaches at the MAESTRO beam line at the ALS, where we aim to maximize impact across the 10 um to 100 nm scales. I will also discuss several opportunistic doors these lengths scales open to ARPES, including in-operando measurements with applied electric and magnetic fields, current pulses, strains, and laser pulses, and present recent work with these techniques in 2D heterostructures and metastable phases in $1T$-TaS_2.

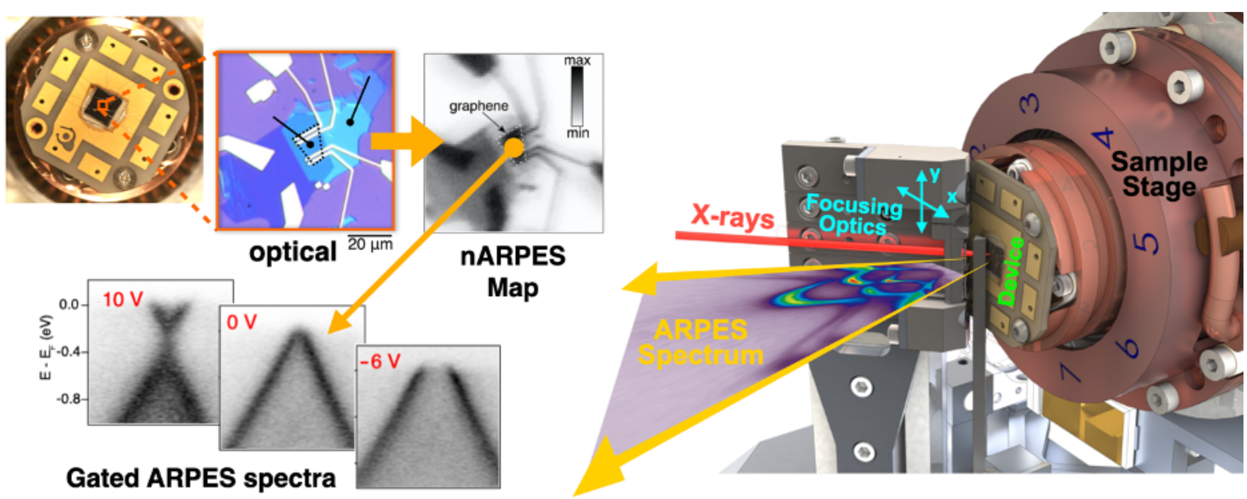

Fig: In-operando NanoARPES characterization of heterostructure device. Right: X-rays are focused onto the sample to beamspots ranging from 1 um to 100 nm, and scanned across the sample surface, collecting ARPES as a function of (x,y) sample positions on the sample surface. Left: An example sample, corresponding optical image of the 2D heterostructure device, corresponding nARPES spatial map, and ARPES-measured bandstructure of the center active material as a function of applied gate voltage [data from: R. Muzzio, et al., Phys. Rev. B 101, 201409(R), (2020)].