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Probing Local Interactions at the Nanoscale

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Interactions at the nanometer length scale in hard and soft condensed matter give rise to intriguing phases in correlated electron materials, lead to the design of exotic metamaterials, and offer enormous opportunities for the development of novel optoelectronic devices. I will give representative examples of high-resolution probing of fundamental nanoscale physical phenomena and interactions in quantum materials at infrared (IR), terahertz (THz), and optical frequencies. At mid IR frequencies, we probe the local interaction of a heterostructure of isotopically enriched hexagonal boron nitride (hBN) in direct contact with the phase-change material (PCM) single-crystal vanadium dioxide (VO_2) and demonstrate a reconfigurable hyperbolic metasurface. At THz frequencies, in the truly THz frequency range 13 cm^{-1} - 60 cm^{-1} we probe and quantify local charge carriers in correlated and complex oxides and heterogeneously doped semiconductors. In the visible spectral range, we probe propagating surface waves that are excited at sharp edges of layered transition metal dichalcogenides (TMDC) such as molybdenum disulfide and tungsten diselenide.