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LIGHT-MATTER SEMINAR

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Title: Confined light-matter interactions in Van der Waals heterostructures probed by scanning near-field optical microscopy

Abstract: The physics of light-matter interaction-central to cavity and waveguide QED-is often governed by length scales far smaller than the free-space wavelength of light. Van der Waals (vdW) materials offer a particularly promising platform for hosting confined optical modes, naturally occurring in thin flakes of these layered compounds. However, direct visualization of these modes is prohibited by the diffraction limit of conventional far-field microscopy. Here, we utilize scanning near-field optical microscopy (SNOM) to image nanoscale light-matter interactions in van der Waals heterostructures, including phonon polaritons in twisted hexagonal boron nitride moire superlattices and plasmon polaritons in ultrahigh-doping bilayer graphene/$RuCl_3$ heterostructures. I will then show how these confined excitations are suitable for controlling spontaneous emission from nearby vdW semiconductors, exemplified by nano-imaging of monolayer MoTe2 photoluminescence into confined WSe2 waveguide modes. Finally, I will highlight a new “self-cavity” vdW system, where photoluminescence and cavity confinement occur in the same material. Taken together, the diverse range of confined modes and steady advances in quantum emitter quality suggest that all-vdW heterostructures are a highly promising platform for future cavity and waveguide QED studies, with nano-imaging serving as a critical tool for their characterization.