Poster-2-22

Superresolution Localization and Control of 2D Quantum Emitters

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In transition-metal dichalcogenide (TMD) heterobilayers, lattice mismatch and reconstruction create localized traps for interlayer excitons, forming quantum emitters with potential as nanoscale sensors of correlated phases of matter [1]. These emitters are electrically tunable and inherit spin-valley selection rules and strong light-matter coupling, yet deterministic spatial control remains challenging due to subwavelength confinement and disorder. In this talk, I will present a platform that combines cryogenic optical spectroscopy with scanning probe microscopy to investigate trapped interlayer excitons in WSe2/MoSe2 bilayers [2]. By exploiting AFM-based local Stark shift, we achieve super-resolution localization of emitters separated by only a few tens of nanometers and demonstrate deterministic control of individual charge states, including trion formation. Time-resolved measurements further allow us to resolve radiative and non-radiative decay channels, revealing controlled manipulation of individual exciton dynamics and opening a path toward coherent inter-dot coupling. These results establish a platform for sensing and trapping anyons in semiconducting FCIs [3].

[1] W. Li, et al., arXiv:2111.09440 (2024)..
[2] B. Lyu*, V. Vento*, et al., in preparation (2026)..
[3] W. Li, et al., Nature 651, 48 (2026)..