O-I-M Seminar Series

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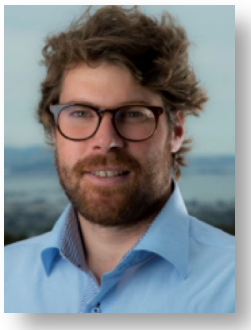

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Friday, Oct. 30, 2020 • 1—2 pm PST [Zoom*]

Chemistry/Physics Joint Seminar

Engineering 0-D and 1-D heterostructures in 2-D materials to define new localized quantum states with quantum coherent properties

We explore how atomically sharp hetero structures such as boundaries, vacancies and substitutes in 2-D materials create new protected quantum states using photo low temperature Scanning Tunneling Microscopy and time resolved optical spectroscopy.

The concept of quantum coherence is well established in fields such as atomic physics and quantum optics. In solid state systems or the emerging field of quantum biology, quantum coherence plays a critical role defining new phenomena such as coherent transport through topological states, coherent exciton transport between organic antenna complexes or coherent emission from color centers, to name just a few. However, the associated material complexity makes the direct measurement, the simulation and in some cases the meaning of quantum coherence not straightforward.

Understanding how heterogeneous materials can create localized quantum states and how to control their interaction with the environment to foster coherent transport or coherent emission, is at the core of my research interest. In my presentation I will focus on our work on 0-D and 1-D heterostructures in 2-D Transition Metal Dichalcogenides (TMDs). 2-D TMDs provide atomically well-defined heterostructures and environment, making correlations between atomic structure and quantum phenomena easier compared to more complex material systems.

We have used photo STM/AFM and correlation microscopy spectroscopy to study vacancies, atomic substitutes and 1-D twin boundaries to correlate the local morphology with the resulting electronic and optical properties with atomic precision. I will discuss mirror twin boundaries that form charge density waves in the midst of semiconducting 2-D MoSe2 (nature physics 16), how 2-D MoSe2 and 2-D WS2 carry a zoo of intrinsic point defects (ACS nano 19) that modify substantially electronic properties (nature communications 19), such as individual S vacancies that host very sharp defect states in the band gap with extremely high spin orbit coupling (PRL19). These S defects can be artificially induced (Nano Letter 20), and mediate single photon emission via optical stimulation as well as electric stimulation (Science Advances 20). C-H for S or Se substitutes in 2-D WS2 and 2-D WSe2 (2-D Materials 20) form locally charged hydrogen like states (PRB 20). Upon deprotonation the localized carbon radical hosts a localized deep in gap state with a net spin and electron-phonon coupling that bears strong similarities to NV color centers in diamond, but in this case with atomistic control. Especially the control of point defects and substitutes opens exciting possibilities to create and study next generation color centers (APL Perspective 20).

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