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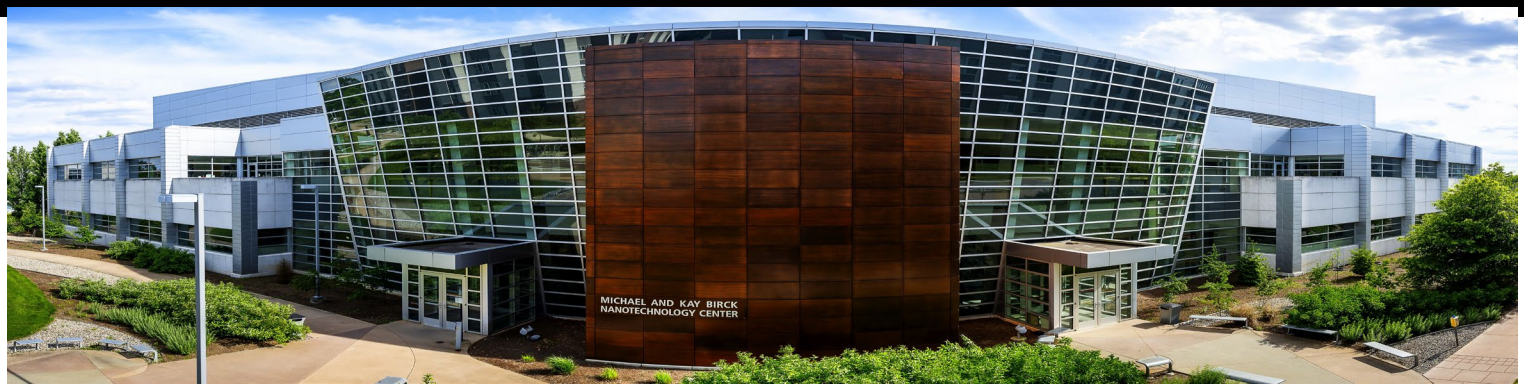

Probing Engineered 2D Quantum Materials with Atomic Precision

Dr. Tiancong Zhu

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Date: Tuesday April 9 @ 3.30pm in BRK 1001
(Coffee & Snacks @ 3.15pm)

Zoom Link: https://purdue-edu.zoom.us/j/99524580757

Abstract: Two-dimensional (2D) materials offer a rich platform for studying quantum phenomena since their properties can be profoundly altered through defect manipulation, heterostructure stacking, and lattice alignment. I will discuss several examples demonstrating the remarkable potential of engineered 2D materials. Specifically, I would like to highlight the new opportunities for exploring novel quantum phases of matter by combining functional nano-devices of 2D materials with atomic-resolved scanning tunneling microscopy. I will first discuss the formation of tunable 1D quantum well states in twin boundary structure 1H-$MoSe_2$, where a perfect 1D particle-in-a-box state can be formed. I will show how spin degeneracy can be lifted through electrostatic gating, and how a series of quantum dots can be formed along a single boundary state through atomic manipulation. I will then discuss how STM can be used to investigate momentum resolved electronic band structure in 1T'-WTe_2, and how the measurement brings insight into the proposed excitonic insulating states in such material.[1] I will also discuss our recent work on visualization and manipulation of 1D chiral edge states in a moiré quantum anomalous Hall (QAH) insulator of twisted monolayer-bilayer graphene (tMBLG).[2,3] I will show the transport phenomena of QAH effect can be detected with STM by tracing the gap evolution as a function of magnetic field. Spectroscopic mapping allows us to directly identify QAH edge states, while combining electrostatic gating and tip-induced doping enables us to create and manipulate QAH edge states on-demand. I will conclude by providing a glimpse into new avenues of 2D materials engineering involving advanced atomically precise characterization in the growing field of quantum materials.

bio: Dr. Tiancong Zhu is an Assistant Professor at the Department of Physics and Astronomy, Purdue University. Prior to joining Purdue, he was a Postdoctoral Scholar at UC Berkeley and Lawrence Berkeley National Lab working in collaboration with Prof. M. F. Crommie studying correlated and topological phenomena in 2D materials and heterostructures using scanning tunneling microscopy. He received his Ph. D. degree in Physics from Ohio State University in 2019, under the supervision of Prof. Roland K. Kawakami working on spin transport in graphene, MBE synthesis of 2D magnets and heterostructures, and spin-polarized STM. He received his bachelor's degree in physics from Peking University in China in 2012.

References:

[1] T. Zhu, et al., Local spectroscopy study of gate-controlled energy gap in monolayer 1T'-WTe_2. *In preparation.*

[2] C. Zhang, T. Zhu, et al., Local spectroscopy of gate-switchable Chern insulating states in twisted monolayer-bilayer graphene. *Nat. Commun.*, 14, 3595 (2023)

[3] C. Zhang, T. Zhu, et al., Visualizing and manipulating chiral edge states in a moiré quantum anomalous Hall insulator. Accepted in *Nat. Phys.* (2024)