Condensed Matter Physics Seminar Series

Atomic SET: a new technique for high-resolution potential imaging

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Imaging the local electrostatic potential of quantum materials plays a crucial role in understanding charge order, broken symmetries, and phase transitions. Until now, the most sensitive tool for such imaging is the scanning single electron transistor (SET), which has unearthed a wealth of information in van der Waals systems. However, it is spatially limited by the lithographically defined dimensions of a quantum dot on a tip or cantilever hovering above the sample of interest, resulting in a resolution on the order of 100 nanometers. In this talk, we introduce a new experimental approach, which we call Atomic SET, to image the electrostatic potential in 2D systems. It achieves two orders of magnitude improvement in spatial resolution and operates from room temperature down to cryogenic temperatures. This scanning charge detector is built from the same platform as the quantum twisting microscope (QTM): we assemble in situ van der Waals heterostructures by bringing 2D tip and sample surfaces into contact while simultaneously scanning the sample. This geometry overcomes the limits of previous scanning SETs, enabling resolution of about 1 nanometer. Our technique promises to open up wide-ranging opportunities for direct nanoscale visualization of electronic phenomena with unprecedented spatial resolution in a number of 2D systems, including imaging topological edge states and within moiré length scales.

Dr. Dahlia Klein completed her PhD in Physics at Massachusetts Institute of Technology in the lab of Prof. Pablo Jarillo-Herrero in 2021. During her PhD, she focused on studying two-dimensional magnetic materials through several experimental tools, including electrical tunneling devices and magneto-optical measurements. Since 2021, she has been a Zuckerman Postdoctoral Fellow at the Weizmann Institute of Science in Israel. In Prof. Shahal Ilani's lab, she is developing a new scanning probe technique, called Atomic SET, to access thermodynamic information of van der Waals materials on the nanoscale.

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