Mesoscopic Quantum Transport in Gate-defined Graphene Nanostructures

Layers of two-dimensional materials stacked with a small twist-angle give rise to beating periodic patterns on a scale much larger than the original lattice, referred to as a "moire superlattice". As the twist angle approaches ~1.08 degree, isolated flat-bands emerge near zero energy. Correlated superconducting and insulating states were reported near the half-filling of such flat-bands. In this talk, we will discuss a higher-order moiré superlattice of moiré superlattices in a twisted-trilayer graphene architecture [1]. We report transport signatures of superconducting and correlated insulating states near the half filling of the moire of moire superlattice, at an extremely low carrier density on the order of ~1010 cm-2. We also show that the temperature dependence of v=-4 and v=4 states are semi-metallic, distinct from the insulating behavior in twisted bilayer systems, demonstrating that moiré superconductivity may emerge from continuous and non-isolated flat-bands. Towards further understanding and utilizing the rich underlying physics in twisted-trilayer-graphene, we will also talk about our recent effort in building gate-defined nanostructures to locally manipulate charge carriers with electrostatics in graphene [2].

[1] X. Zhang*, K. Tsai*, Z. Zhu, W. Ren, Y. Luo, S. Carr, M. Luskin, E. Kaxiras, K. Wang, Phys. Rev. Lett. 127, 166802 (2021).
[2] X. Zhang*, W. Ren*, E. Bell, Z. Zhu, K. Watanabe, T.Taniguchi, E. Kaxiras, M. Luskin, K. Wang, ArXiv: 2106.09651 (2021).