Probe spin, valley, and layer degree of freedom in a moiré superlattice

Wei YANG[1,2,3]

1. Beijing National Laboratory for Condensed Matter Physics and Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China email: wei.yang@iphy.ac.cn
2. School of Physical Sciences, University of Chinese Academy of Sciences, Beijing, 100190, China
3. Songshan Lake Materials Laboratory, Dongguan 523808, China

Key Words: Correlated insulator; isospin polarization; quantum oscillation; first-order quantum phase transition; twisted double bilayer graphene.

Abstract: New phase of matter usually emerges when a given symmetry breaks spontaneously, which can involve charge, spin, valley, and layer degree of freedom. Twisting graphene multilayer to form a moiré superlattice leads to moiré flat bands where various correlated states are developed. Twisted double bilayer graphene (TDBG) is an electrical displacement field (D) tunable moiré system. Here, I will focus on the high-quality TDBG device with a twist inhomogeneity of ~0.01°, and present the experimental observations of the field-tunable exotic phases, such as isospin polarized correlated insulators and spin/valley long-range orders, first-order quantum phase transitions, anomalous quantum oscillations (QOs) of insulating states, and layer polarized phases in the weakly coupled regime, where interplays among correlation, isospin polarization, layer polarization, and Landau quantization are important.

References

[1] L. Liu, et al., Isospin competitions and valley polarized correlated insulators in twisted double bilayer graphene, Nat. Commun. 13, 3297(2022).
[2] L. Liu, et al., Quantum oscillations in field-induced correlated insulators of a moiré superlattice, Science Bulletin 68, 1127(2023).
[3] L. Liu, et al., Observation of first-order quantum phase transitions and ferromagnetism in twisted double bilayer graphene, Phys. Rev. X 13, 031015(2023).
[4] Y. Yuan, et al., Interplay of Landau quantization and interminivalley scatterings in a weakly coupled moiré superlattice, Nano Letters 24, 6722 (2024).