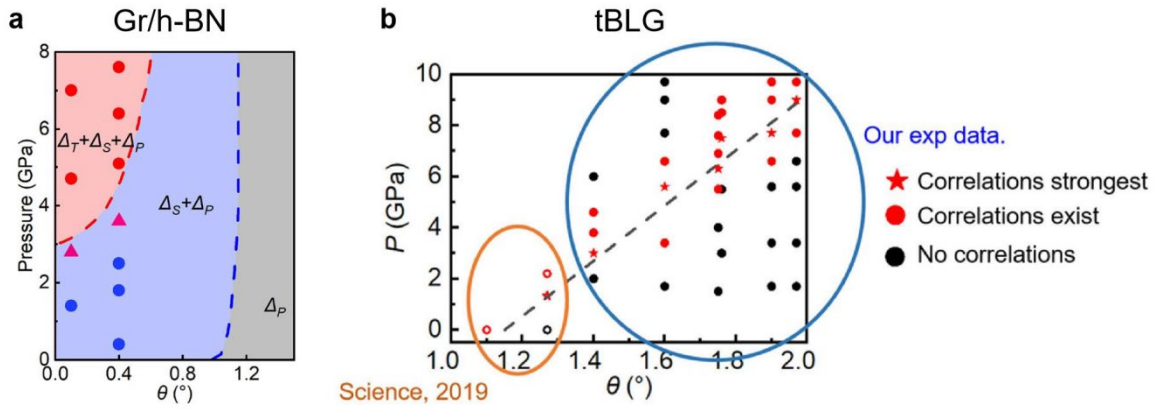
High-Pressure Tuning of Dynamic Magic-Angle Correlated States in Twisted Bilayer Graphene

Yupeng WANG (University of Science and Technology of China, PRC),
Chunhui YE (University of Science and Technology of China, PRC),
Chiyu PENG (University of Science and Technology of China, PRC),
Zengming ZHANG* (University of Science and Technology of China, PRC)

Abstract

Hydrostatic pressure offers a clean and reversible route to dynamically tune the magic-angle condition in twisted bilayer graphene (TBG) by modifying interlayer coupling and the bandwidth of moiré flat bands. Here we develop a diamond-anvil-cell-based multi-terminal quantum-transport platform, enabled by post-fabrication transfer and a custom transferable-electrode scheme, and use it to investigate pressure-controlled correlated and topological states in graphene moiré systems. As a benchmark, measurements on graphene/hBN superlattices reveal pressure-enhanced moiré potentials and the opening of higher-order Dirac gaps, in good agreement with first-principles structural relaxation and large-scale tight-binding calculations[1]. Applying this approach to TBG across different twist angles allows us to map a pressure–angle phase diagram of correlated insulators and establish a pressure-dependent magic-angle relation. In a 1.9° device, correlated insulating states emerge at integer fillings and are strongest near 7.7 GPa, consistent with maximal band flattening. In the same pressure window, transport near ν = -2 shows an enhanced superconducting dome with $T_{50\%}$ up to ~6 K and a Berezinskii–Kosterlitz–Thouless transition temperature of ~3 K. We further observe pressure-induced signatures of zero-field Chern insulating states at ν = 1 and 2, with large hysteretic anomalous Hall signals, Curie temperatures around 6 K, and anomalous Hall resistances reaching ~20 kΩ and ~10 kΩ, respectively, suggesting pressure-driven spontaneous breaking of $C_{2z}T$ symmetry. These results demonstrate that high pressure is a powerful control knob for engineering flat bands, strong correlations, and non-trivial topology in moiré graphene.



Our work on pressure-tuned moiré superlattices. This figure is partially adapted from Ref. [2].

[1] Y. Wang, J. An, C. Ye, X. Wang, D. Mai, H. Zhao, Y. Zhang, C. Peng, K. Watanabe, T. Taniguchi, X. Sun, R. Dai, Z. Wang, W. Qin, Z. Qiao, **Z. Zhang**, Pressure-Driven Moiré Potential Enhancement and Tertiary Gap Opening in Graphene/h-BN Heterostructure. *Physical Review Letters*, 2025, 135, 046303.

[2] M. Yankowitz, S. Chen, H. Polshyn, Y. Zhang, K. Watanabe, T. Taniguchi, D. Graf, A. F. Young, C. R. Dean, Tuning superconductivity in twisted bilayer graphene. *Science*, 2019, 363, 1059-1064.