Correlated Phases in Two-dimensional Twisted Moiré Materials

Myungchul Oh[1]

[1]*Department of Semiconductor Engineering, POSTECH, Pohang 37673,, Republic of Korea*

*E-mail: myungchul@postech.ac.kr

In a flat band system, interactions between electrons become dominent due to the suppressed kinetic energy and many-body effect begins to occur. The recent breakthrough in engineering the band structure by creating a moiré superlattice in a twisted two-dimensional system has paved the way for the exploration of numerous strongly correlated quantum phenomena that emerge from the symmetry broken many-body ground state, such as correlated insulators, non-trivial topological phases, and unconventional superconductors [1-4].

In this talk, I will discuss the moiré superlattice flat band engineering in twisted two-dimensional van der Waals heterostructure and the correlated phases in the moiré superlattice systems, and describe underlying many-body physics in those phases.

I will also highlight the novel scanning probe microscopy technique that has enhanced our understanding of the microscopic electronic structures of their ground states [2,4,5].

At the end of this talk, I will discuss on prospects of twisted two-dimensional systems putting recent research progress together.

keywords : many-body physics, correlated phases, twisted materials, STM

[1] Cao, Y., Fatemi, V., Fang, S., Watanabe, K., Taniguchi, T., Kaxiras, E. & Jarillo-Herrero, P. Unconventional superconductivity in magic-angle graphene superlattices. *Nature* **556,** 43–50 (2018).

[2] Wong, D.*, Nuckolls, K. P.*, Oh, M.*, Lian, B.*, Xie, Y., Jeon, S., Watanabe, K., Taniguchi, T., Bernevig, B. A. & Yazdani, A. Cascade of electronic transitions in magic-angle twisted bilayer graphene. *Nature* **582,** 198–202 (2020).

[3] Nuckolls, K. P.*, Oh, M.*, Wong, D.*, Lian, B.*, Watanabe, K., Taniguchi, T., Bernevig, B. A. & Yazdani, A. Strongly correlated Chern insulators in magic-angle twisted bilayer graphene. *Nature* **588,** 610–615 (2020).

[4] Oh, M.*, Nuckolls, K. P.*, Wong, D.*, Lee, R. L., Liu, X., Watanabe, K., Taniguchi, T. & Yazdani, A. Evidence for unconventional superconductivity in twisted bilayer graphene. *Nature* **600,** 240–245 (2021)

[5] Nuckolls, K. P.*, Lee, R. L.*, Oh, M.*, Wong, D.*, Soejima T.*, Hong, J. P., Călugăru, D., Arbeitman, J. H., Bernevig, B. A., Watanabe, K., Taniguchi, T., Regnault, N., Zaletel M. P. , Yazdani, A. *Nature* **620**, 525-532 (2023)

** These authors are equally contributed.*