Title

Tadpole diagram - not the hero moiré materials want, but the hero they need?

Abstract

The family of moiré materials exhibits a panoply of many-body phenomena that are intimately tied to the appearance of narrow electronic bands. Early theoretical considerations suggested that, at the magic angle, the Dirac velocity vanishes, and the entire width of the moiré bands becomes extremely narrow. Yet, this scenario contradicts experimental studies that reveal a finite Dirac velocity as well as bandwidths significantly larger than predicted. In the first part of my talk, motivated by recent scanning tunneling microscopy measurements [1], I will discuss how Coulomb interaction-driven band renormalization affects the electronic properties of twisted bilayer graphene and how it facilitates the formation of correlated states. I will then argue how such a band-flattening mechanism increases the tendency towards superconducting pairing thus possibly explaining the experimentally observed robustness of superconductivity over a wide range of twist angles [2]. In the second part of my talk, I will then apply this understanding of band renormalization effects towards recent transport [3] results on magic-angle twisted tri-, quadri-, and pentalayers that report on superconductivity which extends over an enhanced filling-factor range. In particular, I will focus on twisted pentalayers where superconductivity is seen to persist well beyond the filling of four electrons per moiré unit cell. I will propose a concrete theoretical scenario that can account for this trend and that demonstrates the non-trivial role of the additional bands that arise in multilayer moiré graphene systems.

[1] Choi, Y., Kim, H., Lewandowski, C. et al. Interaction-driven band flattening and correlated phases in twisted bilayer graphene. Nat. Phys. 17, 1375–1381 (2021).
[2] Lewandowski, C., Nadj-Perge, S. & Chowdhury, D. Does filling-dependent band renormalization aid pairing in twisted bilayer graphene?. npj Quantum Mater. 6, 82 (2021).
[3] Zhang, Y., Polski, R., Lewandowski, C. et al. Ascendance of Superconductivity in Magic-Angle Graphene Multilayers. arXiv:2112.09270 ———