Spring 2025 Physics Colloquium

Friday, April 25th

3:00 PM

PAS 201 or Zoom

(https://arizona.zoom.us/j/86395646910)

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Moiré Materials

Abstract: Recent progress in fabricating two-dimensional material devices has enabled a new way to fabricate quantum metamaterial in which electrons exhibit strongly-correlated and topologically non-trivial properties, including ones that are rare in naturally occuring crystals. For example, two-dimensional van der Waals crystals that are overlaid with a difference in lattice constant or a relative twist form a moiré pattern. In semiconductors and semimetals, low-energy electronic properties are accurately described by Hamiltonians that have the periodicity of the moiré pattern – thereby realizing artificial crystals with lattice constants on the 10 nm scale. Since the miniband widths in both graphene and TMD moiré materials can be made small compared to interaction energy scales (by mechanisms [1,2] that differ), these materials can be used both for quantum simulation and for quantum design. An important property of moiré materials is that their band filling factors can be tuned over large ranges without introducing chemical dopants, simply by using electrical gates.

In addition to realizing Mott insulators, density waves, a variety of different types of magnets, and superconductors – states of matter that are familiar from the study of strongly correlated atomic scale cyrstals – moire materials have emerged as perhaps the best plaform uncovered to date for studies of topologically non-trivial matter, especially strongly interacting topologically non-trivial matter. The role of band topology is natural in graphene moirés, where it derives from the interesting band topology of graphene monolayers, but has been an unexpected bonus [3] in the case of TMD moires where it derives from the layer degree of freedom. I will discuss some of the latest developments in this evolving story.

[1] R. Bistritzer, and A.H.MacDonald, Proceedings of the National Academy of Sciences 26, 12233 (2011).
[2] F. Wu, T. Lovorn, E. Tutuc, and A.H.MacDonald, Phys. Rev. Lett. 121, 026402 (2018).
[3] F. Wu, T. Lovorn, E. Tutuc, I. Martin, and A.H.MacDonald, Phys. Rev. Lett. 122, 086402 (2019).

**** Refreshments served in PAS 218 at 2:30 PM – 3:00 PM ****

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