Special Seminar

Theoretical Condensed Matter Physics

Wednesday, February 17, 2021 → Zoom → 9:30 AM

"Moiré Materials: A Tunable Platform for Interacting Quantum Phases"

Understanding the nature of strong electronic correlations is one of the central problems of condensed matter physics. Despite intense efforts, several aspects of the strong correlation problem remain unsolved due to the theoretical difficulty, structural complexity, and limited tunability of most strongly correlated materials. In this talk, I will discuss an exciting new platform that overcomes many of these limitations: Moiré materials.

Moiré materials are simple, highly tunable strongly correlated systems that display a wide array of exotic phases: correlated insulators, unconventional superconductors, orbital magnetism, and topological phases. The simplest Moiré material is twisted bilayer graphene (TBG) consisting of two graphene sheets twisted by a small angle relative to each other. Despite TBG being such a strongly interacting system, I will show how we can understand its basic features using a simple toy model that relates it to a pair of time-reversed multilayer quantum Hall systems. This model explains the appearance of correlated insulators as seen in recent experiments and predicts the nature of their collective excitations. The model also suggests a new topological mechanism for strong-coupling unconventional superconductivity that is distinct from conventional weak coupling mechanisms as well as strong coupling mechanisms proposed in other unconventional superconductors such as cuprates. I will show how this mechanism provides insights into the essential ingredients of superconductivity in TBG and explains why superconductivity is not observed in other related Moiré systems. Furthermore, I will show how insights gained from this model have led to the discovery of a new Moiré superconductor, twisted trilayer graphene, and how they can be used in the future to predict new platforms for unconventional superconductivity and other exotic phases. At the end, I will discuss how insights from Moiré materials can help develop a new understanding of the effects of band topology in strongly interacting materials in general.

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