Pseudo-magnetic Fields in Moire Materials
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``Moire” materials produced by stacking monolayers with small relative twist angles are of intense current interest for the range of correlated electron phenomena they exhibit and for their high degree of experimental controllability. The emergent low energy electronic theory includes a `pseudo-magnetic field’ arising from the interplay of interplane hybridization and Moire twist angle. This talk shows how the pseudo-magnetic field arises, what are the observable consequences, and how it constrains the structure of interparticle interactions.

In Moire materials based on transition metal dicalcogenides such as WSe2, the strong spin-orbit coupling in the valence bands of the monolayer material leads to a spin-dependent staggered flux, which may be tuned by the voltage difference between layers [1,2,3]. I will discuss experimental consequences, including tunable Hall sign changes, Hofstadter butterfly and spin currents at sample interfaces [1]. The recent experimentally observed continuous Mott insulator transitions will also be compared with a comprehensive Hartree Fock and dynamical mean field theory study [2,3].

In the second part, I will discuss the interacting physics in twisted bilayer graphene, where the quenched kinetic energy means the interacting physics is controlled by the momentum space “pseudo-magnetic field”, or the “quantum geometry” of the Bloch wavefunctions including the Fubini-Study metric and Berry curvature. We show that the analytical solution of the twisted bilayer graphene wavefunction at the chiral limit has a special quantum geometry, endowing the Brillouin zone with a complex structure [4]. Inversely, we show such special quantum geometry highly constrains the Bloch wavefunction, endowing it with a universal form closely related to the lowest Landau level wavefunction. We discuss the origin of this momentum space complex structure [5], its implications to electron-electron interactions in moire materials [4], and microscopic models that generalize to flatbands of arbitrary Chern numbers [6].

References: