Ferromagnetism and quantum anomalous Hall effect in twisted bilayer graphene

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Recent experiments have established that moire graphene materials are a platform for several many-body phenomena, including correlated insulators, superconductivity, ferromagnetism, and a (quantized) anomalous Hall effect. In this talk, I will focus on the last two phenomena, which have been observed [1,2] when conduction and valence bands are nearly flat and are separated by a single-particle gap. This is for example the case in magic angle twisted bilayer graphene (TBG) when one of the graphene layers is aligned with its hexagonal Boron Nitride (hBN) substrate. After explaining the origin of its peculiar band structure, I will turn to the strong interaction regime. I will provide analytical and numerical evidence for spin and valley polarization in these systems at integer filling of the active band [3]. Using the results of exact diagonalization, I will discuss the stability of this 'flat-band ferromagnet' upon increasing the bandwidth. The nearly flat conduction band of TBG aligned with hBN has a Chern number C=1; can it also host a fractional quantum Hall state (without a magnetic field) at fractional filling? Using exact diagonalization results [4], I will show that these topologically ordered states may indeed emerge in twisted bilayer graphene, albeit with a spin polarization different from what is expected in usual quantum Hall systems.

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