Electronic and Mechanical Properties of Twisted Bilayer Graphene

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Abstract

We first consider the quantum dynamics of an electron in twisted bilayer graphene. The challenge is that fundamental tight-binding models of the dynamics are aperiodic for generic twist angles because of the incommensurability of the layers. We have shown that the Bistritzer-MacDonald PDE model, which is periodic with respect to the bilayer's moiré pattern, rigorously describes these dynamics in a parameter regime that includes the special case of the ``magic angle'' where the dispersion relation (band) is flat and where superconductivity and correlated insulator phases have been experimentally observed.

We have recently proved that the dynamics of the tight-binding model of incommensurate twisted bilayer graphene can be approximated by computations on finite domains, and we have done extensive numerical computations which clarify the range of validity of the Bistritzer-MacDonald model. We have further developed and analyzed extended Bistritzer-MacDonald models that improve the accuracy by including the effects of structural relaxation.