Electron and phonon properties of twisted bilayer graphene

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Twisted bilayer graphene (TBG) is a rotationally stacked graphene bilayer system governed by a nanoscale moiré interference pattern between the mismatched layers. The physical properties of TBG are sensitive to the twist angle, and the flat band formation which occurs at a certain twist angle (the magic angle) gives rise to various unusual properties such as the emergent superconductivity. In this talk, we present our recent theoretical works on twisted bilayer graphenes and their electron and phonon properties. We show that the flat band of TBG can be regarded as an effective atomic band composed of the nanometer-sized Wannier orbitals [1]. At the same time, the phonon spectrum is also strongly modified by the moiré -superlattice period, where the linear dispersion of graphene's acoustic phonons are reconstructed into the moiré phonons, i.e., collective vibrations of the nanoscale supercrystal (Fig. 1). We also study the electron-phonon interaction in TBG and show that the coupling between the moiré electrons and moiré phonons leads to the strong electron-electron interaction, which may be related to the superconductivity in TBG. Lastly, we introduce the electronic properties of TBG at 30-degree twist angle. Unlike the low-angle TBG governed by the long-ranged moiré pattern, the 30-degree TBG is characterized by the 12-fold quasicrystalline nature with nearly flat dispersion and non-periodic wavefunctions.[3]

References

[1] M. Koshino, N. F. Q. Yuan, T. Koretsune, M. Ochi, K. Kuroki, L. Fu, Phys. Rev. X 8, 031087 (2018).
[2] M. Koshino and Y.-W. Son, Phys. Rev. B 100, 075416 (2019).
[3] M. koshino and N. N. T. Nam, Phys. Rev. B 101, 195425 (2020).
[4] P. Moon, M. Koshino and Y.-W. Son, Phys. Rev. B 99, 165430 (2019).

Figures

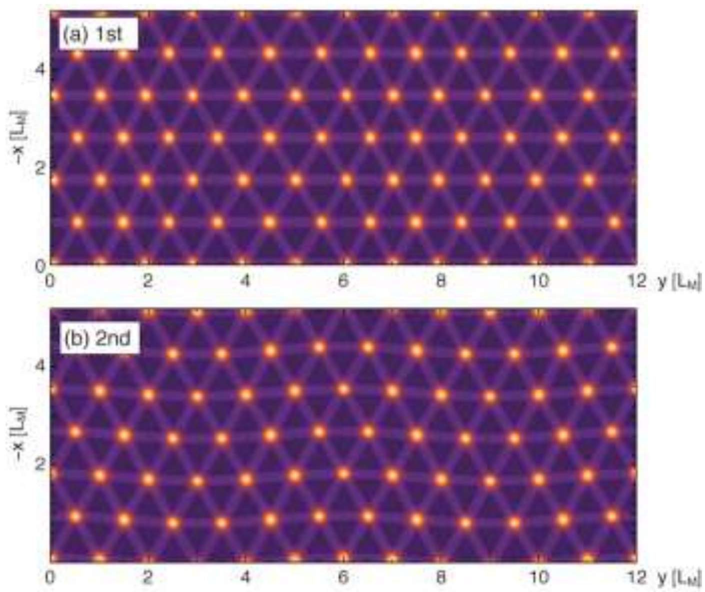

Figure 1: Low-energy phonon wave functions in TBG of = 1.05 deg. [2]