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Effective theory for the flat band in the twisted bilayer graphene

The recent discovery of the superconductivity and strongly correlated insulating state in the twisted bilayer graphene (TBG) attracts enormous attention [1,2]. TBG is a sandwitch of two graphene layers stacked with a rotational orientation [Fig.1(a)]. There a slight rotation gives rise to a long-period moiré pattern, substantially modifying the electronic property. Due to the huge moire pattern, the unit cell of TBG includes more than 10,000 carbon atoms. It is a challenging problem to theoretically describe the many-body physics in such a complex system. Here we develop an effective theory to describe the many-body physics in TBG [3]. By using the realistic band model and with the aid of the maximally localized algorithm, we construct the Wannier orbital, which works as the effective composite “atom” on the moiré pattern. The effective atomic orbital has a characteristic three-peak structure [Fig.1(b)], and it leads to unexpected properties of many body states. For example, we find that an electronic excitation can be viewed as a pair creation of the fractional charges in units of e/3, which would possibly give rise to exotic physics. Our effective model dramatically reduces the fundamental complexity of the electronic system in TBG, and it would be greatly beneficial to future theoretical studies. It opens the way to explore the many-body physics in TBG.

References

[1] Y. Cao, et al, Nature (556), 2018, 43.
[2] Y. Cao, et al, Nature (556), 2018, 80.
[3] M. Koshino, N. F. Q. Yuan, T. Koretsune, M. Ochi, K. Kuroki, and L. Fu, arXiv:1805.06819, to be published in Phys. Rev. X