Perpendicular electronic transport in twisted 3D graphite and twisted 3D superconductors

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We theoretically study a perpendicular electronic transport in twisted three-dimensional (3D) systems using the effective continuum model and recursive Green's function method [1].
Recently, twisted two-dimensional (2D) systems, where a pair of 2D materials are stacked with a twist, have attracted significant attentions. Our research question is what are the properties of a twisted 3D system, which is a pair of 3D materials stacked with a twist?
Here we study how the perpendicular electronic transport depends on the twist angle in twisted 3D systems. The perpendicular electric conduction in twisted systems was probed in a recent experiment [2] while the transmission across the twisted interface has not been well examined theoretically. In this study, we develop a formulation for the electronic transport in the twisted 3D system, which is a pair of 3D materials stacked with a twist angle, by using the effective continuum model and recursive Green's function method.
We apply the method to twisted graphite (rotationally-stacked graphite pieces), which is one of the simplest twisted 3D systems.
In the twisted graphite, we found that the perpendicular conductivity depends on the twist angle non-monotonously, and it cannot be explained by a simple picture based on the Fermi-surface overlap. We reveal that the anomalous twist-angle dependence is due to the Fano resonance by an interface-localized state, which is a remnant of the flat state of magic-angle twisted bilayer graphene. The existence of the interface-localized state is confirmed by calculating the local density of states using the recursive Green's function method. In addition, we will report the extension of our formulation to 3D superconductors, and the Josephson current calculated by our method.

References

[1] T. Tani, T. Kawakami, M. Koshino, Phys. Rev. B **108**, 165422 (2023).
[2] A. Inbar *et al.*, Nature **614**, 682 (2023).

Figures

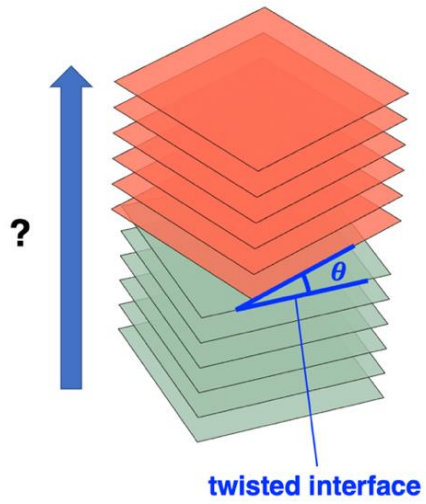

Figure 1: The schematic figure of twisted 3D system.