Coulomb drag and interlayer coupling in quantum moiré materials

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Abstract

When two conductive layers are separated by a thin insulator, the charge carriers in the two layers can be coupled with each other through interlayer Coulomb interactions, leading to a finite non-local drag signal—the voltage induced in one layer when current is sent through another. This Coulomb drag effect had been used to investigate the coupling between diverse electronic systems and explore the nature of the interlayer couplings. Here, we discuss our on-going efforts to use the drag experiment as well as others to investigate interlayer couplings in quantum moiré systems where a quasi-periodic moiré structure is formed between the two 2D layers and significantly modify their electronic band structures. After showing that interlayer interaction in van der Waals (vdW) heterostructures is strong enough to modify graphene band using our recent study on graphene on WSe_2 as an example [1], we will show that the charge carriers in moiré mini-bands formed in graphene aligned with hexagonal boron-nitride (hBN) can be strongly coupled with those in original Dirac bands by measuring Coulomb drag effect in graphene-hBN-graphene moiré heterostructures [2]. This study demonstrates that the drag experiment can be used to investigate interlayer interactions in different 2D moiré systems that may lead to new discovery. We will discuss potential impacts of our works and possible new directions. Financial supports from the MOST China (2020YFA0309600) and the UGC/RGC of Hong Kong SAR (AoE/P-701/20, C7037-22G, 17300020, 17300521, 17309722, and 17301424) are acknowledged.

References

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[2] Y. Wang, H. Xue, X. Wang, K. Watanabe, T. Taniguichi, and D.K. Ki, Phys. Rev. Lett., 133 (2024) 186301

Figures

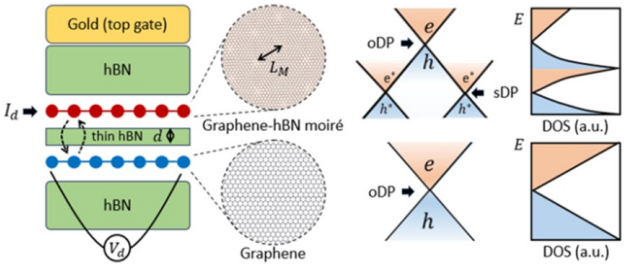

Figure 1: Left: Schematic of graphene-hBN-graphene moiré heterostructures and the Coulomb drag measurement configuration. Right: Electronic band structure and density of states (DOS) of graphene-hBN moiré lattice (top) and intrinsic graphene (bottom).

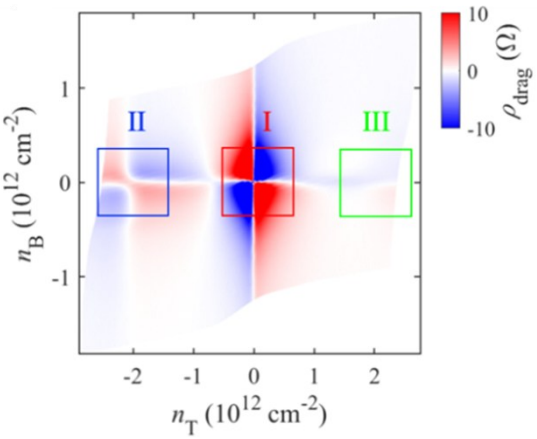

Figure 2: Drag resistance as a function of top and bottom graphene density in a color scale. The data were taken at 210 K.