Mixed-dimensional moiré tuning of transport properties in graphite thin films

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Moiré systems have attracted attention as a host of correlated states and non-trivial topology, as in the case of magic-angle twisted bilayer graphene. Recently, it has been shown that these moiré tuning capabilities persist in few layer graphene systems, such as in the twisted tri/tetra/penta-layer graphene, twisted mono-bilayer graphene (t1+2), and twisted double bilayer graphene (t2+2). However, it remains unclear if significant moiré modification will occur when each layer of the twisted structure is composed of more than a graphene mono- or bilayer, since additional low energy bands must be hybridized as the layer number increases towards the bulk graphitic limit. In this work, we present transport studies of graphitic thin films with a single rotated interface, primarily focusing on the case of t1+Z systems where Z≥6. We find that such systems constitute a new class of mixed-dimensional moiré materials, where localized moiré surface states interact with and modify the bulk graphitic states, even up to around Z=40 layers of graphite. Our results are generally applicable to other layered semimetals and establish mixed-dimensional moiré systems as an exciting path for future research.

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Figures

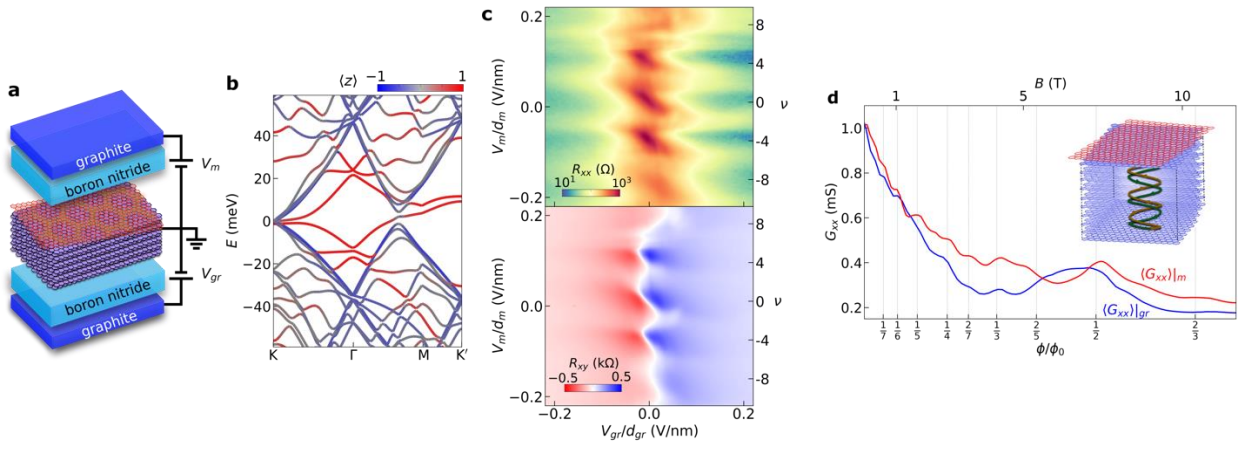

Figure 1: a) Schematic showing our t1+Z devices, V_m and V_{gr} denote gates that are closest to the moiré interface and outer graphite surface, respectively. **b)** Band structure for a t1+10 device, with states denoted by the expectation value along the z-axis, with red (blue) corresponding to the moire interface (outer graphite surface). **c)** R_{xx} and R_{xy} maps taken at B=0.5 T for a t1+10 device, with filling factor denoted on the right-hand axis. **d)** Conductance as a function of magnetic field sweeping both the graphite and moiré gates. Select values of rational flux fillings indicated, where peaks can be observed as Brown-Zak oscillations. (inset) Schematic illustrating the high field coupling of the 2D moiré states with the bulk 3D graphite states.