Indications of spatially correlated electrons near the band insulators in twisted bilayer graphene

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Twisted bilayer graphene at small angles has band insulators at full filling of the moiré superlattice, which are absent the Bernal stacked material [1]. Furthermore, multiple experiments have shown correlated electronic phases near fractional filling of the moiré lattice [2]. In our experiments, we observe periodic conductance oscillations near the band insulators of twisted bilayer graphene, with a remarkably high frequency that depends on the gate voltage [Figure 1(a—c)]. These oscillations are interpreted as the Coulomb blockade effect in localized regions on the sample, which are periodic because the charging energy is large compare to the quantum level spacing [3]. Remarkably, the frequency of these oscillations increases as we tune the Fermi level into the band gap. This implies that the capacitance of the localized region increases near this point. However, we expect the geometric and chemical quantum contributions to result in a minimum total capacitance near this bandgap. We therefore consider a negative quantum capacitance contribution, and find that a simple model for spatially correlated electrons in a 2D electron gas [4] can describe the observed increase in capacitance remarkably well [Figure 1(d)], which strongly indicates the relevance of correlated electrons near the band insulators of twisted bilayer graphene.

References

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Figures

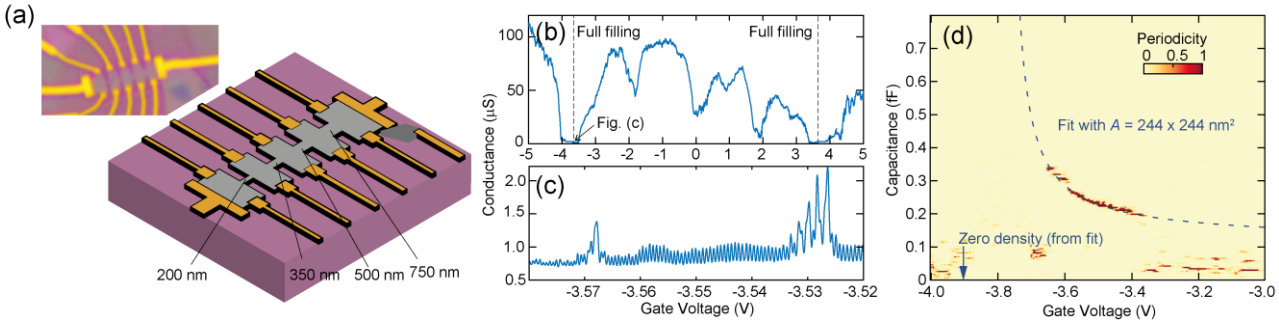

Figure 1: (a) Optical image and drawing of the sample, which consists of twisted bilayer graphene in a constricted Hall-bar geometry and a global graphite gate. (b) Conductance as a function of gate voltage for the 750 nm constriction (twist angle 1.02°), showing the band insulators (labelled "full filling") and further insulating states near -1/2, +1/4, +1/2 and +3/4 filling of the superlattice. (c) Zoom-in of the conductance, showing the periodic high-frequency conductance oscillations. (d) Frequency component converted to capacitance at full filling on the hole-side and a fit to the data considering spatial electron correlations.