https://files.magnet.fsu.edu/Public/AToth/2017_Research_Reports_Science_Council/2D Materials/ALL/rep1_cat23_user4722_facility16_text_anke.pdf**Conductance at half-filled Landau levels in hybrid graphene**

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Introduction

The isolation of graphene has led to the observation of new sets of quantum Hall (QH) states, not found in conventional two-dimensional electron gasses. Monolayer, bilayer, and trilayer graphene each have shown distinct versions of the QH effect, which differ in the Landau energy-level spacing and hierarchy, field-dependence of the energy gaps, the degeneracy of the ground state, the Berry phase, and the symmetry-breaking of degenerate states. While examinations of each of these new QH states have occurred in the past few years, yielding insights into both the QH effect and the physics of graphene, there have been few studies of what happens when these differing QH effects are combined in a single device that links mono, bi-, and trilayers into a hybrid graphene structure.

Experimental

Clean-interface hybrid graphene was fabricated through standard exfoliation techniques and measured on SiO_2 substrates. Measurements on mono-bilayer samples, focusing on transport sourced and drained though the monolayer section of a mono-bilayer flake, were performed at NHMFL's DC field facilities, where the fields were used to examine the transitions to the QH states in hybrid graphene.

Results and Discussion

While previous investigations have focused on Landau level symmetry breaking and fractional states at high fields, our results here examine the lower-field transition to the QH regime. For carrier densities set to the point of half-filling for the n=0, +1, and -1 Landau levels, there exist conductance anomalies at fields corresponding to the establishment of phase coherence in cyclotron orbits. Most notably, the conductance at the charge neutral point of graphene, which decreases monotonically at higher fields, increases to a maximum in this regime for one field polarity, while the half-filled n=1 and -1 levels exhibit a conductance maximum at the opposite polarity (fig 1a and b). The spatial, field-polarity, and level asymmetry of these conductance anomalies suggests that the nascent extended QH states act in competition with the 0-field extended states in manner unique to hybrid graphene. As shown schematically in fig 1c and d, a model where the mono-bilayer interface breaks the 4-fold spin-valley symmetry of the n=0 monolayer QH state in a different manner than it is broken at the monolayer-vacuum interface would account for the observed conductance.

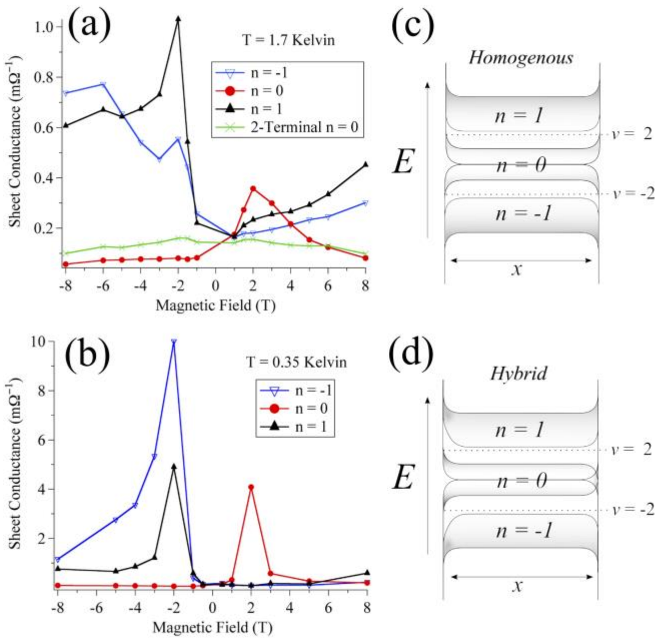

Fig.1 a) & b) conductance at half-filling of the n=0, n=+1, and n=-1 Landau levels for two different samples. c) & d) show schematics of potential edge bending of these levels for homogenous and hybrid graphene that would account for the anomalous conductance at the transition to the QH regime.

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References

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