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Interlayer Fractional Quantum Hall Effect in a Coupled Graphene Double-Layer

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Introduction

In two-dimensional (2D) electron systems under strong magnetic fields, interactions can cause fractional quantum Hall (FQH) effects. Bringing two 2D conductors to proximity, a new set of correlated states can emerge due to interactions between electrons in the same and opposite layers. This year we discovered novel interlayer correlated FQH states in a system of two parallel graphene layers separated by a thin insulator.

Experimental

We performed Coulomb drag and counterflow resistance measurements to probe the interlayer correlation at various temperatures and under different magnetic fields (5-36T). Cells 9 and 14 were used for this experiment.

Results and Discussion

Our previous experiment [1] shows that when two graphene layers are separated only by a thin hexagonal boron nitride layer, particles in the two graphene layers interact through Coulomb interaction and form interlayer quantum hall states with integer total filling factors. The interlayer states can also be described by exciton condensations. In our present study [2], the high sample quality enabled us to observe more exotic interlayer Quantum Hall States with fractional filling factors. As figure 1(a) shows, with the top and bottom layers at equal filling $\nu_{eq}=\nu_{top}=\nu_{bot}$, $\nu_{eq}=2/5$ and $\nu_{eq}=3/7$ exhibit vanishing longitudinal drag resistance and very unusual quantized Hall responses. The behaviors of $\nu_{eq}=2/5$ state can be understood with a generalized composite fermion picture, where electrons are bound with two inner layer flux and one interlayer flux. Under the same picture, $\nu_{eq}=3/7$ state is a condensation of composite fermion excitons.

Figure 1(b) shows that away from the equal filling, the vanishing longitudinal drag resistance persists along the segments of two symmetric lines (labeled by L1 and L2) that intersect at $\nu_{eq}=2/5$, indicating that the strong interlayer interaction persists along these line segments. We understand such states as “semi-quantized”, where a full composite fermion Landau level couples to a continuously varying partially filled composite fermion Landau level.

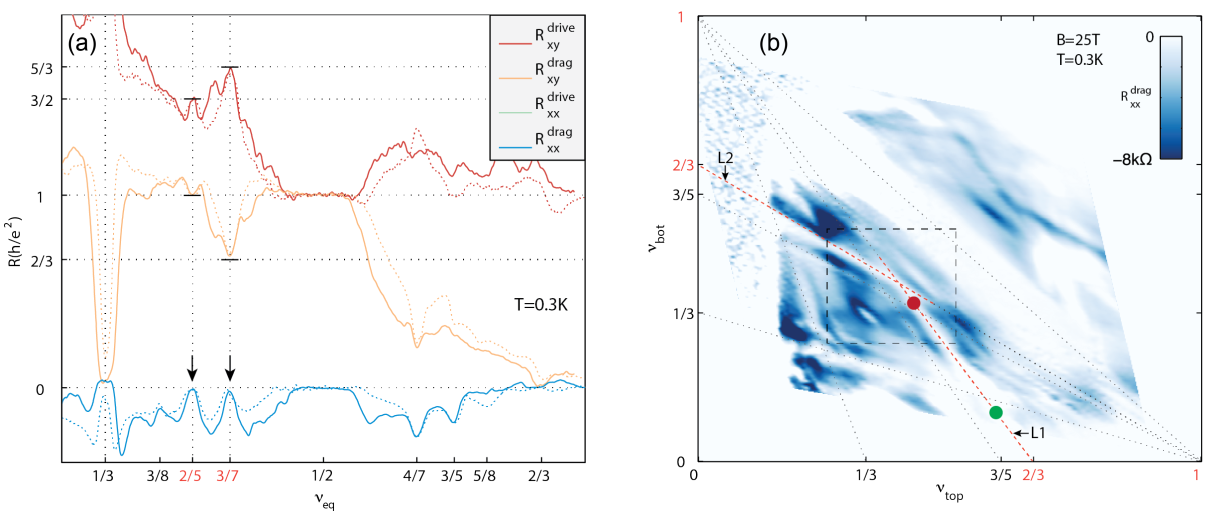

Fig.1 (a) longitudinal and Hall resistances in drive and drag layers at equal carrier densities. (b) longitudinal drag resistance as a function of filing factors in the top and bottom layer.

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References

[1] Liu, X., *et al.*, Nature Physics, **13**, 746-750 (2017).
[2] Liu, X., *et al.*, arXiv:1810.08681, under review in Nature Physics