One-Dimensional Edge Modes in Biased Bilayer Graphene

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Introduction

This project seeks to investigate the properties of the kink state, a new one-dimensional topological edge state predicted to exist at the line junction of two oppositely biased bilayer graphene. We seek to understand the origin of its resistance and identify potential spin-related ordering using high magnetic fields.

Experimental

We have obtained solid evidence of the kink state at our home institution and studied its behavior systematically at low magnetic fields up to 9 T. At the magnet lab, we measured the magneto-resistance of the kink state at different tilt angles using the 31 T DC field and a rotating sample holder in a ^{3}He system from Oct 20-24, 2014.

Results and Discussion

As Fig. 1(a) shows, at B=0, the kink state exhibits resistance $R_{junction}$ of several tens of kΩ, in contrast to $4h/e^2$=6.5 kΩ expected for the ballistic transport of four non-interacting 1D modes. The increased resistance suggests valley mixing. To probe the origin of the mixing, we have measured the magneto-resistance of the kink state in perpendicular and in-plane fields. A three-terminal geometry allows us to subtract lead resistance and measure $R_{junction}$ accurately at low B_{perp}. However, the quantum Hall effect of the leads starts to play a significant role at high B_{perp} and $R_{junction}$ can no longer be accurately determined. Nonetheless, a general trend exhibited by several traces appears to show that $R_{junction}$ overall decreases with increasing B_{perp}, but in a non-monotonic fashion. Future experiments will use improved device design to circumvent the lead issue and further study the B_{perp} dependence. In particular, we will seek to make connections with the predicted domain wall modes of the ν=0 bulk bilayer graphene quantum Hall states, which are present in our samples. Fig. 1(c) shows the in-plane field dependence of the kink state. The non-universal and small magneto-resistance rules out the possibility of anti-ferromagnetic correlation as the origin of the increased kink state resistance.

Conclusions

The in-plane magneto-resistance of the kink state eliminates anti-ferromagnetic correlation as a potential origin for the observed kink state resistance. The perpendicular magneto-resistance exhibits large and intriguing B_{perp} dependence that requires further investigations to clarify.

Acknowledgements

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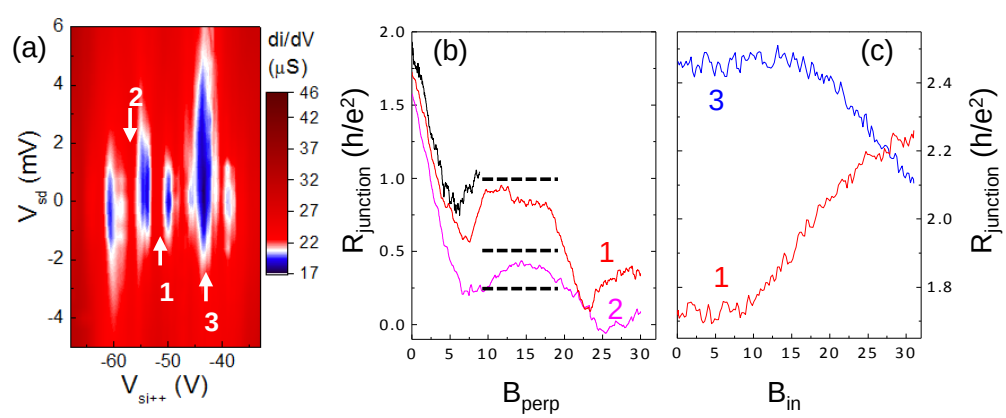

Fig. 1: (a) dI/dV of the kink region showing three exemplary positions studied in high magnetic fields. (b) $R_{junction}$ vs B_{perp} at positions 1 and 2 marked in (a). The black trace was taken at home institution. Dashed lines mark quantized conductance values $1e^2/h$, $2e^2/h$ and $4e^2/h$. (c) $R_{junction}$ vs B_{in} at positions 1 and 3 showing small positive or negative magneto-resistance.