Large Tunable Intrinsic Gap in Rhombohedral-Stacked Tetralayer Graphene at Half Filling

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Introduction

Rhombohedra-stacked tetralayer graphene (r-4LG) has highly an unusual dispersion, which can be approximated as E~k4, where k is the wave vector. Thus, it has extremely flat bands near the charge neutrality point (CNP), affording diverging (for N>2) density of states and enormous electronic interactions. Thus, electronic states of broken symmetries are expected to emerge.

Experimental

We performed low temperature transport measurements on dual-gated suspended tetra-layer graphene. Some experiments were performed in SCM2 and Cell 12.

Results and Discussion

We observe an insulating state in r-4LG, with a gap up to 80 meV (**Fig. 1)**. The energy gap increases further with a perpendicular magnetic field, but closes upon the application of an out-of-plane electric field of either polarity, increasing charge density or raising temperature. Our results are consistent with the LAF states that were found in bilayer graphene and rhombohedra-stacked trilayer graphene [1].

Conclusions

The large magnitude of the gap also suggests that, at least in tetralayer graphene, the band flattening effect “wins” over the increasing screening and charge de-confinement in thicker samples, in agreement with a first principle calculations [57]. Conversely, the rate of increase in gap size with the addition of another atomic layer is smaller (see Table 1). Whether the gap will continue to increase and the nature of the ground state in rhombohedra-stacked pentalayer and thicker graphene warrant future studies.

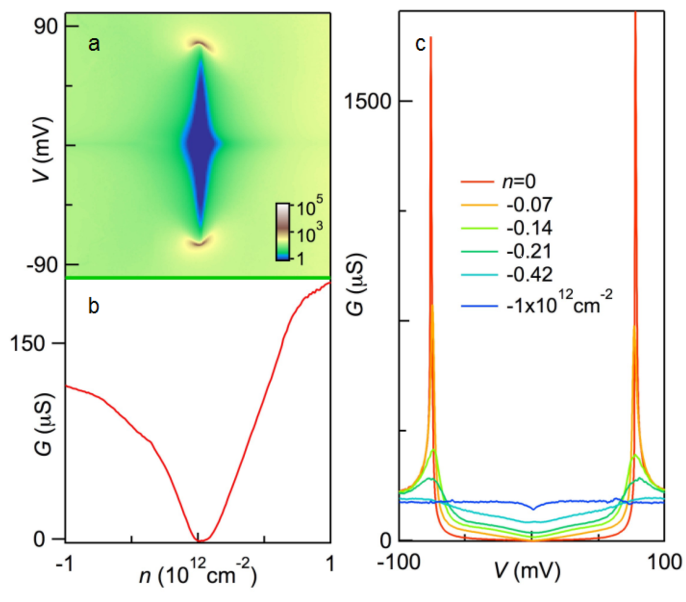

Fig. 1. Charge density n dependent transport spectroscopy at $B=E_{\perp}=0$ at T=1.5 K **a.** Two-terminal differential conductance $G(V, n)$ in □S. Note the logarithmic colour scale. **b.** $G(n)$ line cut at V=0. **c.** $G(V)$ line cut at different charge densities.

Acknowledgements

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References

[1] Myhro, K. et al. Large tunable intrinsic gap in rhombohedral-stacked tetralayer graphene at half filling. 2D Materials 5, 045013 (2018).