Competition Between Spontaneous Symmetry Breaking and Single Particle Gaps in Trilayer Graphene

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Introduction

Many physical phenomena can be understood by single particle physics, i.e. treating particles as non-interacting entities. When this fails, many-body interactions leads to spontaneous symmetry breaking and phenomena such as fundamental particles' mass generation, superconductivity and magnetism. Competition between single-particle and many-body physics leads to rich phase diagrams. Trilayer graphene (TLG) offers an exciting platform for study of such interplay, as the relative magnitudes of single particle effect and electronic interactions can be tuned by external parameters such as density, electric field and magnetic fields.

Experimental Results and Discussion

Using low temperature transport measurements, we investigate high mobility dual-gated ABC TLG devices. At the charge neutrality point, we observe a giant interaction-induced gap □~41meV, suggesting a spontaneous layer antiferromagnetic ground state with broken time reversal symmetry. This state is suppressed by a critical temperature T_c~30K, by an in-plane magnetic field, and by an interlayer potential $U_{\square}$ that facilitates a single-particle gap. The most likely candidate for this state is the layer antiferromagnetic state, where electrons n the top and bottom layers have opposite spin polarization[1]. These results reflect the interplay between externally induced and spontaneous symmetry breaking whose relative strengths are tunable by external fields, and provide insight into other low dimensional systems.

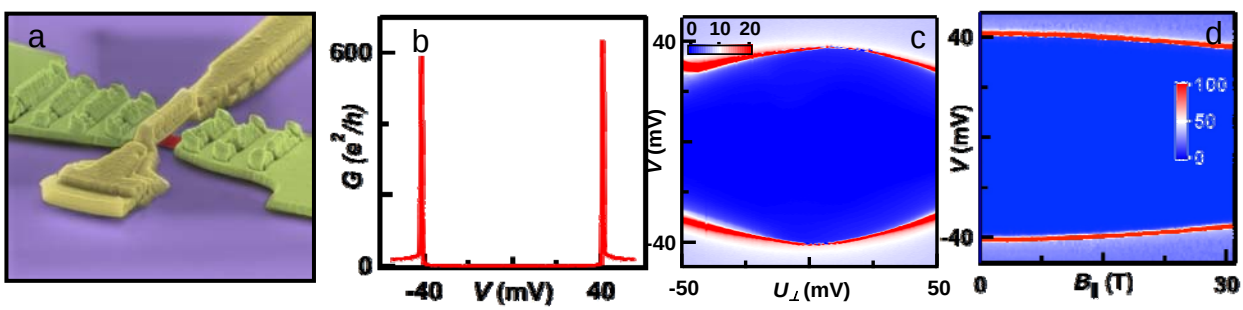

Fig. 1. Transport data from dual-gated suspended trilayer graphene device. (c). Device image. (b). *G(V)* at *n*= $U_{\perp}$=0 and *T*=300 mK, showing a gap of ~41 meV. (c). *G(V, $U_{\perp}$)*. The gapped region (dark blue) is reduced by interlayer potential $U_{\perp}$. (d). *G($B_{||}$)* at n=$U_{\perp}$=0. The gap is reduced by large $B_{||}$.

Conclusions

The thermodynamic ground state of ABC-stacked TLG is most likely a layer antiferromagnetic state, which is expected to transition into a layer polarized state and a canted ferromagnetic state upon the application of external electric and magnetic fields, respectively.

Acknowledgements

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References

[1] Y. Lee, D. Tran, K. Myhro, J. V. Jr., N. Gillgren, C. N. Lau, Y. Barlas, J. M. Poumirol, D. Smirnov, and F. Guinea, Competition Between Spontaneous Symmetry Breaking and Single Particle Gaps in Trilayer Graphene, *Nature Communications* **5**, 5656 (2014).