Magnetic Transitions in the Proximity-Doped Mott insulator α-$RuCl_3$

Zhou, B., Balgley, J., Henriksen, E.A. (Washington University in St. Louis, Dept of Physics), Lampen-Kelley, P., Yan, J.-Q. (Oak Ridge Nat'l Laboratory), Mandrus, D.G. (Oak Ridge Nat'l Laboratory and University of Tennessee, Knoxville)

Introduction

We studied the electronic transport in graphene/α-$RuCl_3$ heterostructure devices with strong in-plane magnetic fields, as a function of temperature and applied gate voltage, with the goal of understanding the gate-voltage-dependent magnetic transitions arising at the interface of graphene and the Mott insulator/quantum spin liquid system α-$RuCl_3$. In this system, the α-$RuCl_3$ has been found to be heavily electron-doped simply by contacting the graphene sheet, and the magnetic transitions of bulk α-$RuCl_3$ are altered [1,2].

Experimental

Low-frequency electronic transport was measured in graphene Hall bars in proximity to ~10-nm-thick α-$RuCl_3$ flakes were measured from room temperature to 2 K with strong in-plane fields up to 18 T in SCM2, and 35 T in Cell 12.

Results and Discussion

The temperature derivative of the resistivity for graphene/α-$RuCl_3$ devices shows peak and peak-dip lineshapes in the 20-40 K range, which are signatures of ferromagnetic and anti-ferromagnetic transitions, but with critical temperatures up to three times higher than the Néel temperature of pristine bulk α-$RuCl_3$. In-plane magnetic fields of 8 T suppress the anti-ferromagnetic transition in the bulk material [3]. Surprisingly, in these graphene/α-$RuCl_3$ devices, fields as high as 35 T only barely impact the magnetic transitions, as shown in Figure 1. The weak impact of such high fields likely reflects a more robust set of magnetic couplings or an enhanced magnetic anisotropy, already indicated by the higher transition temperatures seen in the transport in Fig. 1.

Conclusions

α-$RuCl_3$ becomes conducting in proximity to graphene [2]. These measurements demonstrate that the magnetic transitions are also impacted, becoming more robust and difficult to eliminate with applied in-plane fields.

Acknowledgements

This work was supported by the NSF under DMR-1810305. The National High Magnetic Field Laboratory is supported by the National Science Foundation through NSF/DMR-1157490/1644779 and the State of Florida.

References

[1] Zhou, Boyi *et al.,* J. Phys. Chem. Sol *online*, doi:10.1016/j.jpcs.2018.01.026 (2018).
[2] Zhou, Boyi *et al*., submitted to Nature Physics.
[3] Johnson, R. D. *et al*., Phys Rev B **92**, 235119 (2015).

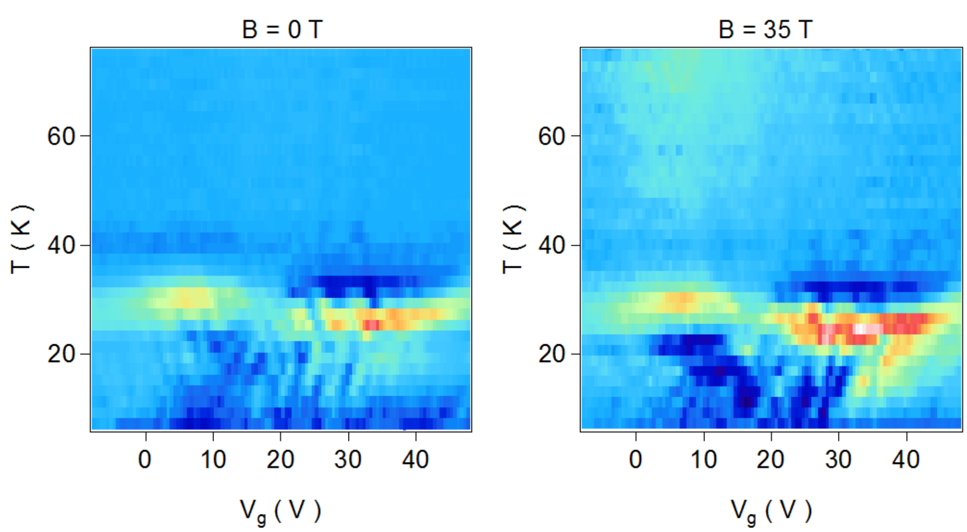

Fig.1 Temperature derivative of resistivity, dρ/dT, at B = 0 (left) and 35 T (right). The peaks in yellow and red, and dip structures in dark blue, are indicators of magnetic transitions and vary only weakly with a strong in-plane magnetic field.