Viscous Point Contacts in Magnetic Field in Graphene and GaAs

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Abstract

In clean electron systems where the electron-electron mean-free path is much shorter than both the characteristic sample size and the transport mean-free path, electron transport is similar to viscous flow of a classical fluid [1]. Signatures of viscous electron transport have been observed in different materials, including graphene [2] and GaAs [3]. One of these signatures is the so-called superballistic flow, or the conductance of the point contact exceeding the ballistic (Sharvin) limit due to the collective movement of electrons [2, 4]. We investigate carrier transport through point contacts in graphene and GaAs as a function of magnetic field perpendicular to the plane of the system at different temperatures. A peak of the magnetoconductance is observed in both materials around zero magnetic field (see Figure). This peak is pronounced at elevated temperatures (~100 K for graphene, ~10 K for GaAs) and disappears at low temperatures. We interpret this peak as arising from the suppression of superballistic flow with magnetic field. We propose a scaling analysis based on hydrodynamics that makes predictions that agree with the observations.

References

[1] R. N. Gurzhi, JETP Lett. **17**, 521 (1963)
[2] R. Krishna Kumar, D. A. Bandurin, F. M. D. Pellegrino, Y. Cao, A. Principi, H. Guo, G. H. Auton, M. Ben Shalom, L. A. Ponomarenko, G. Falkovich, K. Watanabe, T. Taniguchi, I. V. Grigorieva, L. S. Levitov, M. Polini, and A. K. Geim, Nature Physics **13**, 1182 (2017)
[3] M. J. M. de Jong and L. W. Molenkamp, Phys. Rev. B **51**, 13389 (1995)
[4] H. Guo, E. Ilseven, G. Falkovich, and L. S. Levitov, PNAS **114**, 3068 (2017)

Figures

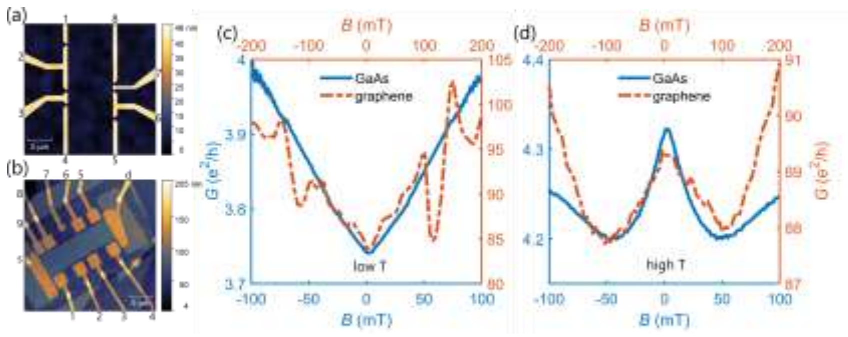

Figure 1: (a) and (b): AFM images of the GaAs and graphene devices. (c) Point contact conductance at low temperatures (0.3 K for GaAs, 4.2 K for graphene). (d) Point contact conductance at high temperatures (5 K for GaAs, 120 K for graphene).