Hall-drag and magneto-drag in graphene via kinetic equation approach

M. Schuett,[1] P. M. Ostrovsky,[2,3] I. V. Gornyi,[1,4] M. Titov, [5] B. N. Narozhny,[6] and A. D. Mirlin [1,6,7]

[1] Institut fuer Nanotechnologie, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany
[2] Max Planck Institute for Solid State Research, Heisenbergstr. 1, 70569 Stuttgart, Germany
[3] L. D. Landau Institute for Theoretical Physics RAS, 119334 Moscow, Russia
[4] A. F. Ioffe Physico-Technical Institute, 194021 St. Petersburg, Russia
[5] Radboud University Nijmegen, Institute for Molecules and Materials, NL-6525 AJ Nijmegen, Netherlands
[6] Institut fuer Theorie der kondensierten Materie, Karlsruhe Institute of Technology, 76128 Karlsuhe, Germany
[7] Petersburg Nuclear Physics Institute, 188350 St. Petersburg, Russia.

Keywords: magneto-drag, Hall-drag, Boltzmann equation, hydrodynamic equations

Only since recently Coulomb drag measurements in Graphene have been available and right from the start they have been performed in the presence of a magnetic field as well [1]. In this work we calculate the magneto-drag and the Hall-drag resistivity at finite temperature for two graphene monolayers within the kinetic equation approach [2,3]. The presented theory is valid for the hydrodynamic regime $\tau_{dis}^{-1}\alpha_g^2 T \ll 1$ and appears there as hydrodynamic equations [2]. This way our theory corresponds to a microscopic formulation supporting a phenomenological Drude-like picture which for large concentrations equals the usual Drude form and for small concentration an effective two-band-Drude equation [4]. The theory presented allows for a qualitative description for arbitrary chemical potentials (see Fig. 1). An emphasis is put on the Hall-drag which is absent when derived from the standard Drude equation. Complete asymptotics of the magneto-drag and the Hall-drag resistivity are given. In particular, we have shown that the Hall-drag vanishes along the line of opposite carrier concentration in the layers. Additional we found non trivial concentrations at which the Hall-drag vanishes (see Fig. 1).

References:

[1] R.V. Gorbachev, A.K. Geim, M.I. Katsnelson, K.S. Novoselov, T. Tudorovskiy, I.V. Grigorieva, A.H. MacDonald, S.V. Morozov, K. Watanabe, T. Taniguchi, and L.A. Ponomarenko, Nature Phys. 8, 896 (2012).
[2] M. Schütt, P.M. Ostrovsky, M. Titov, I.V. Gornyi, B.N. Narozhny, and A.D. Mirlin. Phys. Rev. Lett. 110, 026601 (2013).
[3] B.N. Narozhny, M. Titov, M. Schütt, P.M. Ostrovsky, I.V. Gornyi, A.D. Mirlin, T. Tudorovskiy, M.I. Katsnelson, in preparation.
[4] M. Titov, R.V. Gorbachev, B.N. Narozhny, M. Schütt, P.M. Ostrovsky, I.V. Gornyi, A.D. Mirlin, T. Tudorovskiy, M.I. Katsnelson, A.K. Geim, and L.A. Ponomarenko, in preparation.

Fig. 1: **Right:** The Hall-drag resistivity for equal concentration varying temperature and distance.