Plasmon-mediated Coulomb drag between graphene waveguides

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Coulomb drag is a unique physical phenomenon providing detailed information about many-particle interactions in low-dimensional systems. The physics underlying drag effects is relevant to a variety of Coulomb-coupled systems, including quantum Hall edge states, quantum dots and optoelectronic systems. Moreover Coulomb drag is expected to become increasingly important as electronic devices shrink.

In this work [1] we introduce and analyze a new device concept which allows one to study Coulomb drag in one-dimensional graphene in a technologically favorable geometry. In the proposed configuration, shown in Fig. 1, electrons are confined to two parallel quantum wires by means of graphene antidot lattice (GAL) [2], which creates locally a band gap. Nowadays there are a number of experimental techniques available for fabrication of GALs, including block-copolymer and nanosphere mask, ion beam etching and e-beam lithography. We show that despite of the relatively large separations required for isolated graphene waveguides (GWGs), the magnitude of Coulomb drag resistivity is in the experimentally measurable range (see Fig. 2). A significant enhancement of the drag at elevated temperatures we attribute to the presence of plasmons. Also we find that at very low temperatures the drag resistivity may exhibit upturn (inset in Fig. 2), a phenomenon previously predicted for Luttinger liquids, but here arising within the Fermi liquid theory. Notably, very recent experiments [3] have displayed this kind of behavior. Finally we study a dependence of drag on the interwaveguide separation and determine its functional dependence in a weak coupling regime.

References

1. A. A. Shylau and A. P. Jauho, submitted to Phys. Rev. Lett. (February 2014).
2. J. G. Pedersen, T. Gunst, T. Markussen, and T. G. Pedersen, Phys. Rev. B **86**, 245410 (2012).
3. D. Laroche, G. Gervais, M. P. Lilly, J. L. Reno, Science **343**, 631 (2014).

Figures:

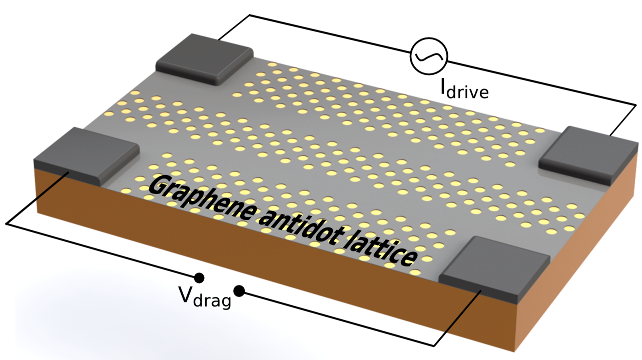

Figure 1:
Schematic illustration of the Coulomb drag setup: two parallel graphene waveguides separated by the region of GAL.

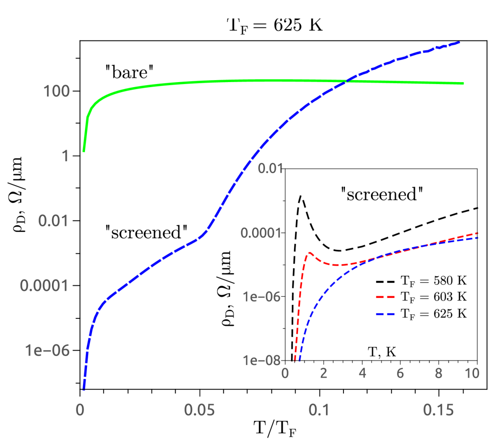

Figure 2:
Drag resistivity as a function of temperature with unscreened (green solid line) and screened (blue dash line) Coulomb interaction. Inset: low-temperature behavior of the resistivity.