Dirac Fermion Reflector as a Scattering Length Meter

Holger Graef[1,2]
M. Rosticher[1], Q. Wilmart[1], L. Banszerus[3], C. Stampfer[3], K. Watanabe[4], T. Taniguchi[4], E. Bocquillon[1], G. Fève[1], J.M. Berroir[1], E.H.T. Teo[2] and B. Plaçais[1]

1 Laboratoire Pierre Aigrain, ENS, Paris, France
2 Nanyang Technological University, Singapore
3 Institute of Physics A, RWTH Aachen, Germany
4 NIMS, Tsukuba, Japan

holger.graef@lpa.ens.fr

Electron propagation in ballistic graphene bears strong analogies with optics, with the Fermi energy as the optical index and p-n junctions acting as dioptres [1,2]. Using nano-patterned bottom gates (Fig. 1) and h-BN encapsulated graphene, we create a prism-shaped doping profile acting as a Dirac fermion (DF) reflector.

We demonstrate the reflection effect and the full tunability of the DF optical index in agreement with a scattering model (Fig. 1). The DF-reflector operates at large negative gate voltage (V_{g1}) where the DFR resistance saturates according to the finite scattering length.

The DFR device is a sensitive meter of scattering length in the range 0.6-6 µm. It is used in Fig. 2 to measure the phonon scattering length in good agreement with theory.

References

[1] Wilmart, Berada et al., 2D Mat., 1 (2014) 011006
[2] Morikawa, Wilmart et al., Semicond. Sci. Technol., 32 (2017) 045010

Figures

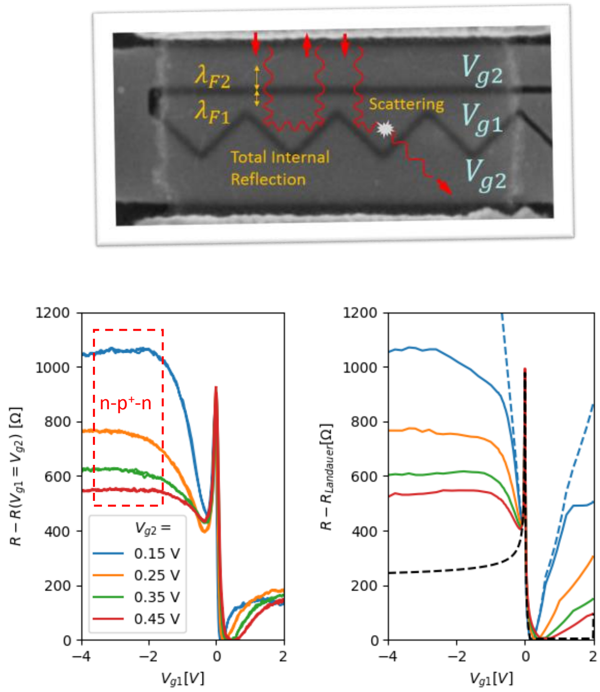

Figure 1: *Top*: Illustration of the Dirac Fermion Reflector. *Left*: Device resistance as a function of V_{g1} for various V_{g2}. The red box indicates the operation regime of the reflector. *Right*: Simulation taking into account scattering lengths ranging from 0.7 to 2.8 µm. We also show the case of no scattering and of a rectangular gate (blue and black dashed lines, respectively).

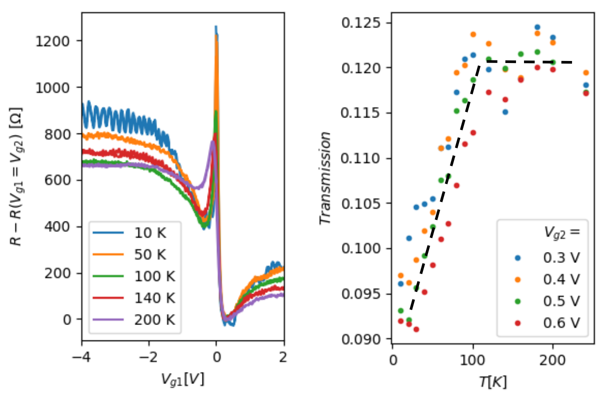

Figure 3: *Left*: Characterising the Dirac Fermion Reflector at various temperatures (V_{g2}=0.3 V). At low temperatures, resistance oscillates as a signature of coherent DF optics. As we increase the temperature, we see the plateau resistance decrease, i.e. the residual transmission (*right*) increases steeply.