Probing electron optics in a Dirac fermion reflector

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Electron propagation in ballistic graphene bears strong analogies with optics, with the Fermi energy acting as the optical index and p-n junctions as diopters. We implement the proposal of Ref. [1] to realize a Dirac fermion reflector (DFR) using a prism-shaped doping profile [1]. Unlike in Ref. [2], we use here nano-patterned bottom gates and h-BN encapsulated graphene (see Fig. 1 top), to independently control the optical indices of the prism and its surroundings [3]. We demonstrate the total internal reflection effect, which gives rise to a resistance plateau at large doping contrast (see Fig. 1 bottom). The DFR transmission is accurately described by scattering theory, which predicts the ballistic length dependence of the resistance plateau. Fabry-Pérot oscillations are observed in the low-temperature coherent regime; they are used to calibrate the DFR dwell length. The ballistic transport regime is tested against the variation of the acoustic phonon mean-free-path (see Fig. 2). Above 100 K we observe a resistance saturation which is reminiscent of a Dirac liquid effect.

References

[1] Wilmart, Berada et al., 2D Mat., 1 (2014) 011006
[2] Morikawa, Wilmart et al., Semicond. Sci. Technol., 32 (2017) 045010
[3] H. Graef, M. Rosticher et al., in preparation (2018)

Figures

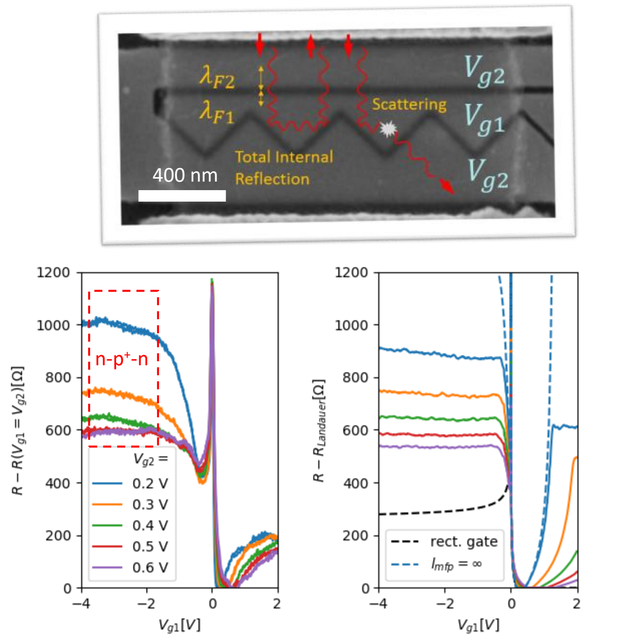

Figure 1: Top: Annotated SEM micrograph of the DFR. Left: Device resistance as a function of gate voltage at 60 K. Red box indicates the DFR regime. Right: Corresponding scattering simulation taking into account a scattering length of 2.4 µm and 9% leak transmission.

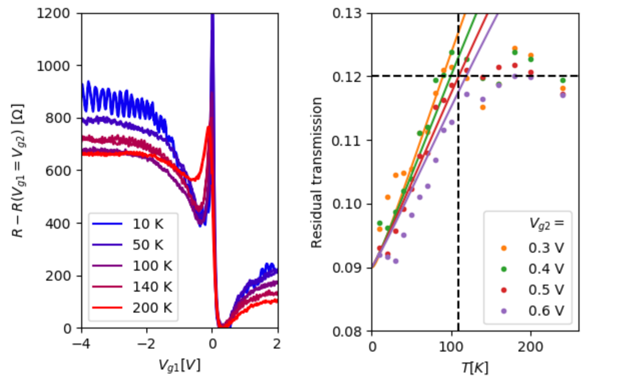

Figure 2: Left: Device resistance curves for various temperatures. At 10 K, we observe oscillations as a signature of coherent electron optics. Right: Device transmission increases as a function of temperature due to acoustic phonon scattering, in agreement with model.