Phonon-mediated room-temperature quantum Hall transport in graphene

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Abstract

The quantum Hall (QH) effect in two-dimensional electron systems (2DESs) [1] is conventionally observed at liquid-helium temperatures, where lattice vibrations are strongly suppressed and bulk carrier scattering is dominated by disorder. However, due to large Landau level (LL) separation (~2000 K at B = 30 T), graphene can support the QH effect up to room temperature (RT) [2-3], concomitant with a non-negligible population of acoustic phonons with a wave-vector commensurate to the inverse electronic magnetic length. Here [4], we demonstrate that graphene encapsulated in hexagonal boron nitride (hBN) realizes a novel transport regime, where dissipation in the QH phase is governed predominantly by electron-phonon scattering [5]. Investigating thermally-activated transport at filling factor 2 up to RT in an ensemble of back-gated devices, we show that the high B-field behaviour correlates with their zero B-field transport mobility. By this means, we extend the well-accepted notion of phonon-limited resistivity in ultra-clean graphene to a hitherto unexplored high-field realm.

References

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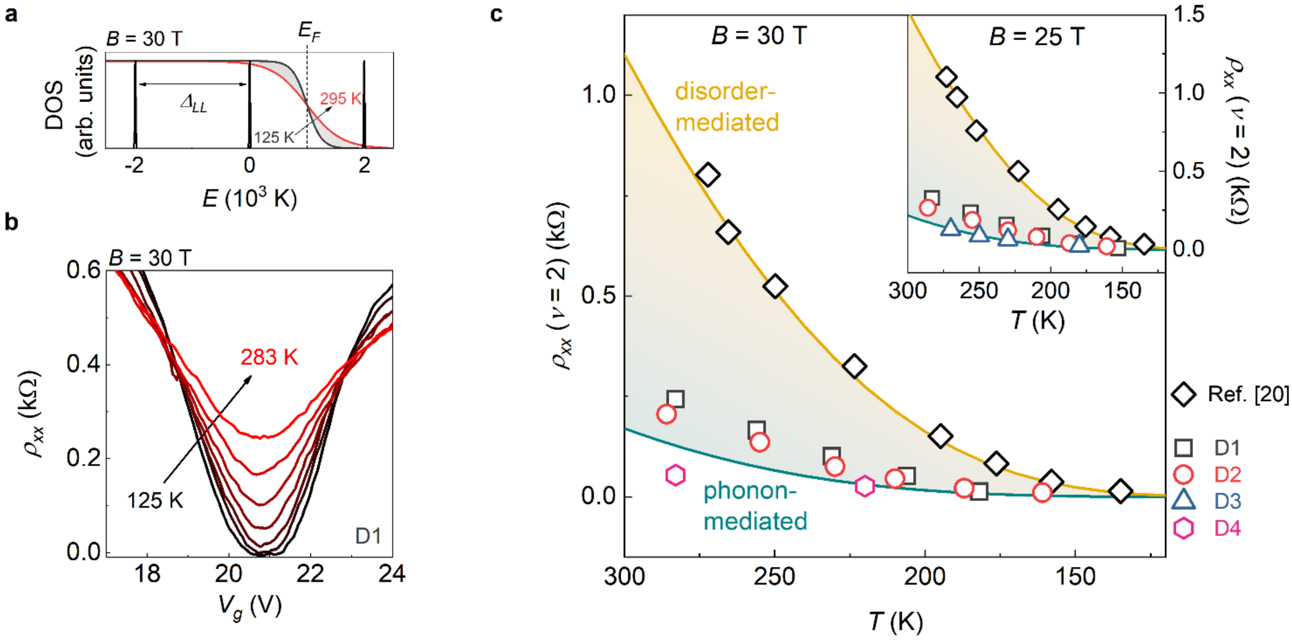

Figure 1: Temperature-activated resistivity and phonon-mediated dissipation in the quantum Hall effect. a, Density of states (DOS) of graphene as a function of energy, at B = 30 T (with a realistic value of LL broadening of 15 K). On top of the DOS we show the Fermi-Dirac distribution, with E_F positioned in the middle of the N = 0 and N = 1 LL, at two different temperatures, representative of the experimental range considered. b, Temperature-activated longitudinal resistivity in the vicinity of ν = 2, measured in sample D1. c, Minimum of ρ_{xx} at ν = 2 as a function of temperature, for the hBN-encapsulated graphene devices (D1-D4). The reference data (black diamonds) are from Ref. [3]. The yellow and dark cyan continuous line are theoretical calculations based on Ref. [5], respectively (the shading covers resistivity values within the two theoretical calculations). The magnetic field is 30 T (25 T) in the main panel (inset).