Excess resistivity from superlattice umklapp scattering in graphene/BN heterostructures

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Moiré patterns, such as those formed due to the incommensurability between graphene and hexagonal boron nitride (hBN), act as a superlattice and generate miniband structure for graphene's electrons [1]. These moiré patterns have a magnifying effect (Figure 1) on strain and other defects such as dislocations. It is therefore natural to expect that this magnifying effect leads to an additional electron scattering by the superlattice and we show that it results in the umklapp electron scattering by acoustic phonons, opening additional channels for thermally activated electron momentum relaxation. We propose a theory for an enhanced temperature dependent resistivity caused by such umklapp electron-phonon scattering, with a strong asymmetry between n- and p-doped heterostructures (Figure 2), and compare it with experimentally measured data. This temperature-dependent "electron-hole" asymmetry of the resistivity can also be used to quantify the strength the moiré SL potential.

References

[1] J.R. Wallbank, M. Mucha-Kruczyński, Xi Chen , and V.I. Fal'ko, Ann. Phys. (Berlin), 527 (2015) 359 .

Figures

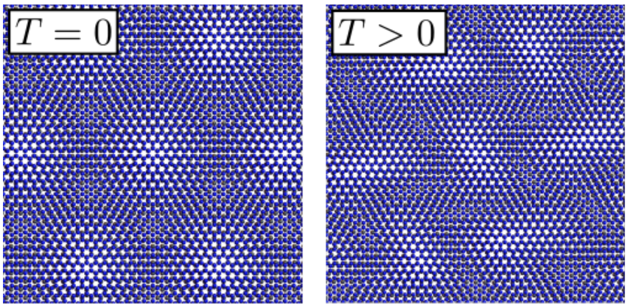

Figure 1: The perfect graphene/hBN superlattice at T=0 (left), and the distorted superlattice produced by displacements mimicking acoustic phonons (right).

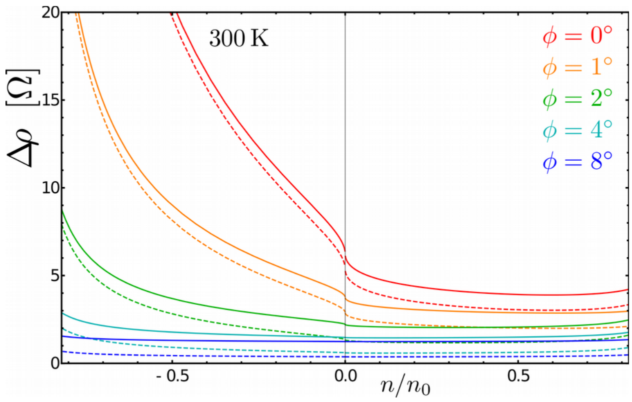

Figure 2: The resistivity from superlattice umklapp scattering as a function of the miniband occupancy, calculated for T=300K and various graphene-hBN alignments (Φ). Encapsulation with a missaligned hBN layer (dashed lines) partially suppresses the contribution from out-of-plane vibrations.