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Topological Transport in Graphene/hBN Superlattices

Abstract

Heterostructures of atomic two-dimensional materials have attracted great interests because they form superlattice structures which allow band engineering as well as use of multiple degenerate degrees of freedom. In graphene with hexagonal boron nitride (hBN), energy gaps are induced when the crystal orientation is aligned with an angle of almost zero degree. The broken inversion symmetry induces Berry curvature in graphene, and the Berry curvature also induces topological current (valley Hall effect), which has been recently observed via non-local resistance measurement [1]. Here, we have fabricated hBN/single- or bi-layer graphene/hBN heterostructures with one-dimensional edge contacts as well as a Hall-bar geometry [2, 3]. Longitudinal- and Hall-conductance oscillations in magnetic fields have been observed, originating from the Hofstadter's butterfly which indicates the good alignment of graphene and hBN crystal orientation (Fig.1). We observed the non-local resistance at both a Dirac point and a secondary Dirac point (SDP) that is generated by band modulation due to the moiré superlattice [2, 3]. In single-layer graphene/hBN superlattices, giant non-local resistance at the SDP with the order of quantum resistance was observed even at zero magnetic field, indicating the occurrence of the quantum valley Hall state [2]. As a result of all transport measurements, we conclude that the mechanism driven by the edge states is a more likely scenario for the giant nonlocal resistance in the quantum limit than a bulk-related interpretation.

References

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Figures

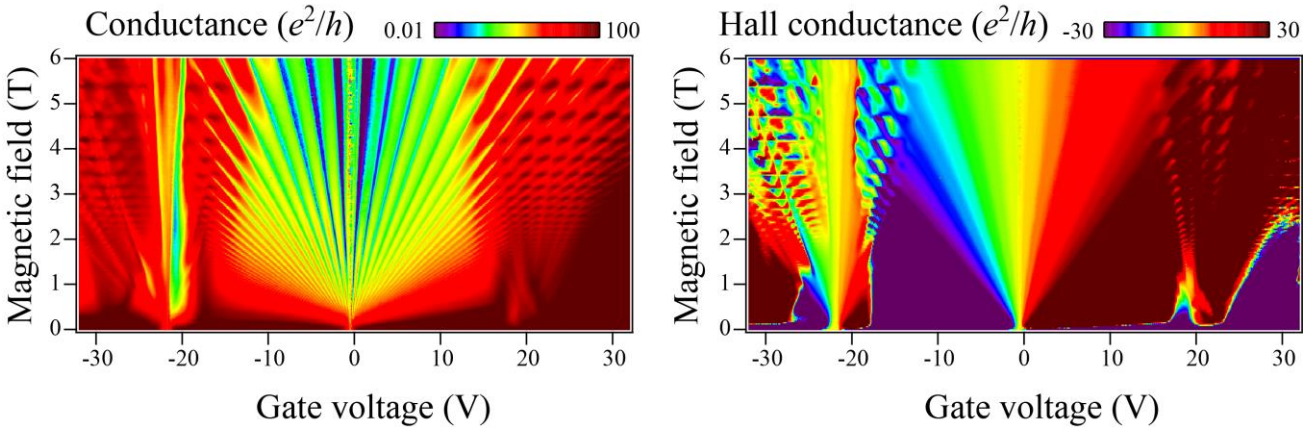

Figure 1: Longitudinal conductance and Hall conductance as a function of a gate voltage and a magnetic field applied perpendicular to the substrate at 6 K in single-layer graphene/hBN superlattice devices.