Quantum Hall Effect in Graphene

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The quantum Hall (QH) effect has offered exciting opportunities for the investigation of quantum transport in two-dimensional electron gas systems for more than three decades, and it still is the foundation for a number of research activities. QH physics is particularly interesting—for a set of different reasons—in the case of graphene, a two-dimensional (2D) layer of carbon atoms arranged in a honeycomb lattice. First of all, owing to the nontrivial Berry phase of the electron system, the QH effect in graphene displays half-integer plateaus and thus differs from what is observed in other conventional 2D systems. In addition, graphene is an ambipolar material, and opposite QH chiralities can be obtained on the same sample by simply tuning the carrier density: for instance ambipolarity was exploited to investigate Klein tunneling and the QH physics in graphene p-n junctions. Finally, graphene implements a stand-alone one-atom-thick 2D electron system, and charge conduction essentially occurs at its surface. Differently from other materials, conducting electrons can thus be approached down to any small distance: this characteristic offers unique perspectives in view of the investigation of the local conduction properties, in particular for the application of scanning probe microscopy techniques.

We demonstrate a buried split-gate architecture and use it to control electron conduction in large-scale single-crystal monolayer graphene grown by chemical vapor deposition [1]. The control of the edge trajectories is demonstrated by the observation of various fractional quantum resistances, as a result of a controllable interedge scattering. Experimental data are successfully modeled within the Landauer-Büttiker formalism. Our device architecture is particularly promising and unique in view of the investigation of quantum transport via scanning probe microscopy, since graphene constitutes the topmost layer of the device.

Furthermore, we show evidence of the backscattering of quantum Hall edge channels in a narrow graphene Hall bar, induced by the gating effect of the conducting tip of a Scanning Gate Microscope, which we can position with nanometer precision [2]. Moreover, we see intriguing junctions arise between regions of different charge carrier density, due to the gradual spatial variation of the gating potential, which manifests itself in values of the longitudinal resistance R_{xx} that have not been observed before in devices based on top- or split-gates. The solution of the corresponding quantum scattering problem is presented to substantiate these results, and possible follow-up experiments will be discussed.

[1] S. Xiang, A. Mrenca-Kolasinska, V. Miseikis, S. Guiducci, K. Kolasinski, C. Coletti, B. Szafran, F. Beltram, S. Roddaro, and S. Heun: *Interedge backscattering in buried split-gate-defined graphene quantum point contacts*, Phys. Rev. B 94, 155446 (2016).

[2] L. Bours, S. Guiducci, A. Mrenca-Kolasinska, B. Szafran, J. K. Maan, and S. Heun: *Manipulating quantum Hall edge channels in graphene through Scanning Gate Microscopy*, unpublished.