Interplay of quantum Hall edge states in graphene with the tip-induced quantum dot

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The topology of the quantum Hall effect is imprinted in the edge channel transport, but microscopic details of the edge channel structure at the scale of the magnetic length are experimentally largely unknown. Here we use scanning tunneling spectroscopy to probe the quantum Hall edge channels at integer fillings along a gate-tunable graphene pn interface. One dimensional features appear in the local density of states at the Fermi level with a finite width across the interface, i.e. along the continuous potential gradient [1,2]. They meander along the interface in width and lateral position. Moreover, Landau levels with higher index develop branches at the pn interface (see figure) related to the orbital structure of the edge states.
The appearance of additional charging lines testifies the simultaneous presence of a tip induced quantum dot (QD) [3]. It is influencing the electrostatics at the interface during tunneling similarly as in scanning gate experiments and, hence, modifies the measurement results. To disentangle the contributions from edge states and QD, we employed a tight binding model based on Poisson calculations that include the pn interface and the tip induced QD. They reproduce the branches of the Landau levels and show that they can have two different origins depending on the QD depth. If the QD depth is weak, the branches result from the nodal orbital structure of the edge states. For a deep QD, they arise from QD states that are shifted in energy by the potential gradient at the pn interface.

References

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Figures

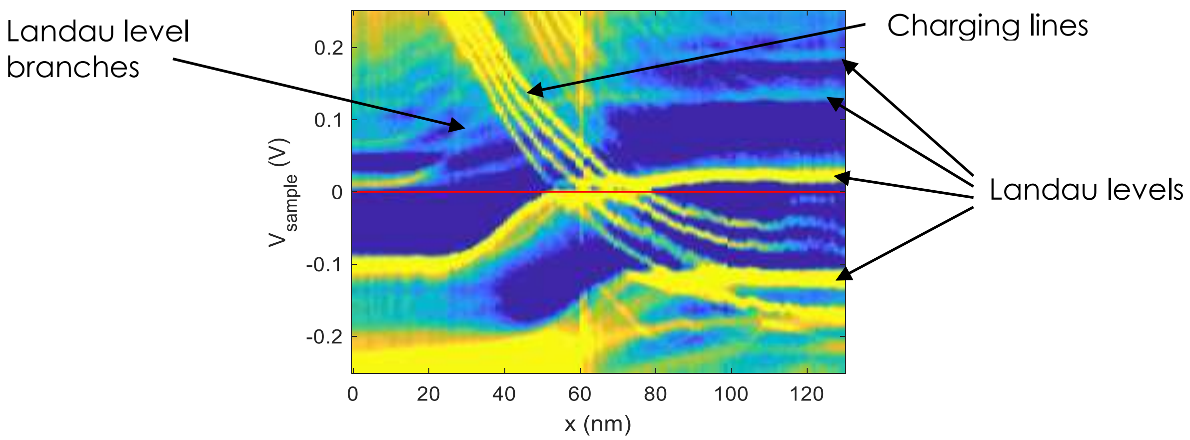

Figure 1: Scanning tunneling spectroscopy of a gate defined graphene pn interface (B=7T, T=7K).