Imaging magnetoelectric subband depopulation in ballistic constrictions

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We have measured local transport through a stadium formed by two ballistic constrictions. The conductance through the stadium is measured at 300 mK as a function of the position of a biased metallic tip which is scanned across the sample. [1, 2]. We have observed a set of unexpected fringe patterns at the constrictions (Fig. 1a) and imaged the transition from electrostatic to magnetic depopulation of subbands in one of the constrictions in a perpendicular magnetic field. We interpret the fringes as a standing wave pattern between the AFM tip and the top gates leading to quantized conductance plateaus. The fringes form a checkerboard pattern (Fig. 1b), which precisely allows determining the number of transmitted modes in each of the tip-gate constrictions.

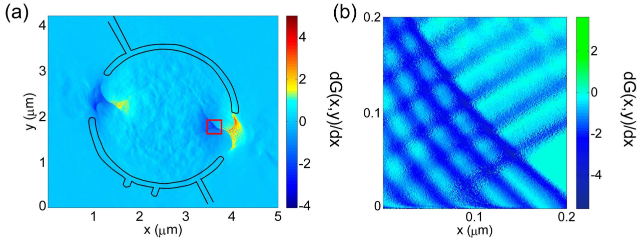

Figure 1. (a) Numerical derivative of the conductance through the stadium, d$G(x, y)$/dx, with respect to the x-axis as a function of tip position, (x, y). The position of the stadium is shown by black solid lines (top gates). (b) A zoom-in of the part (a red square in (a)) of right fringe pattern. The mentioned checker board pattern is clearly seen.

In the quantum Hall regime moving the tip inside the constriction brings edge channels closer together, which are backscattered one by one. This is seen in spatially resolved images as wide conductance plateaus, each of which corresponds to its own local filling factor. Classical and quantum simulations describe well most of our observations.

The coherent wave nature of electrons is widely studied using such interferometers as the Mach-Zehnder and Fabry-Perot. They were shown to be suitable for the investigation of exotic fractional and non-Abelian quantum Hall states. The control over the electron trajectories enclosing an Aharonov-Bohm flux is accomplished by applying a voltage to metallic top gates. A higher tunability can be achieved by using a moveable top gate. Our findings allow fine tuning potential landscape and tip position for further experiments to image Aharonov-Bohm oscillations at low and high (quantum Hall regime) magnetic fields. Not only the voltage, but also the gate-surface distance and the in-plain gate position can be changed. The variable strength and gradient of the induced potential, the control over the length and shape of electron waves or edge channels are advantages when using a moveable top gate.

[1] M. A. Topinka *et al*. Science. **289**, 2323 (2000).
[2] A. A. Kozikov *et al*. New J. Phys. **15**, 013056 (2013).