Scanning gate microscopy and individual control of edge-state transmission through a quantum point contact

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Interference phenomena are a fundamental manifestation of the quantum mechanical nature of electrons and have promising applications in solid-state quantum information technology. Two-dimensional electron systems (2DES) in the quantum Hall (QH) regime are especially suited for this purpose given the large electronic coherence length brought by edge-channel chiral transport. In particular, the realization of electronic Mach–Zehnder (MZ) interferometers in QH systems appears at present a sound technology for the implementation of quantum information schemes [1]. Despite this success, the edge topology of the single-channel MZs limits the complexity of these circuits to a maximum of two interferometers [2]. In order to overcome this constraint, new device architectures were recently proposed, where interference paths are built using two different parallel edge channels [3]. In this configuration, control over the interaction between the different edge channels is very challenging owing to the complex edge structure.

In order to address these issues we are exploring the use of scanning gate microscopy (SGM) to control the trajectory and interaction of edge channels based on our previous results on quantum point contact (QPC) devices in the QH regime [4,5]. Samples were fabricated starting from high-mobility AlGaAs heterostructures and Schottky split-gate QPCs. SGM experiments were performed at 400mK with magnetic field up to 9T.

We shall show that the SGM tip can be used to selectively control edge trajectories and discuss the impact of our findings as a crucial first step for the implementation of multi-edge beam mixers and interferometers.

References

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