Spectral analysis of inter-channel scattering in the quantum Hall regime by scanning gate microscopy

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Transport phenomena in quantum Hall (QH) systems are explained by chiral edge channels occurring at the sample edge, as pointed out by Halperin [1]. However, in some experiments the inner structure of the edge itself seems to play a role, as shown in Refs. [2-4] in which the charge transfer between *co-propagating* edge channels was studied in the limit of high imbalance. The inter-channel equilibration is a complex process that takes place along the whole length *d* over which the two parallel edges are in interaction. In all the experiments performed to date the device geometry univocally fixes the value of *d*. We demonstrate for the first time how a scanning gate microscope (SGM) can be used to realize devices in which *d* is tuned continuously. We shall argue that this level of control is crucial to shed light on the microscopic details of edge-edge interaction. In the present work we focus in particular on the spectral analysis of the equilibration in the non-linear regime.

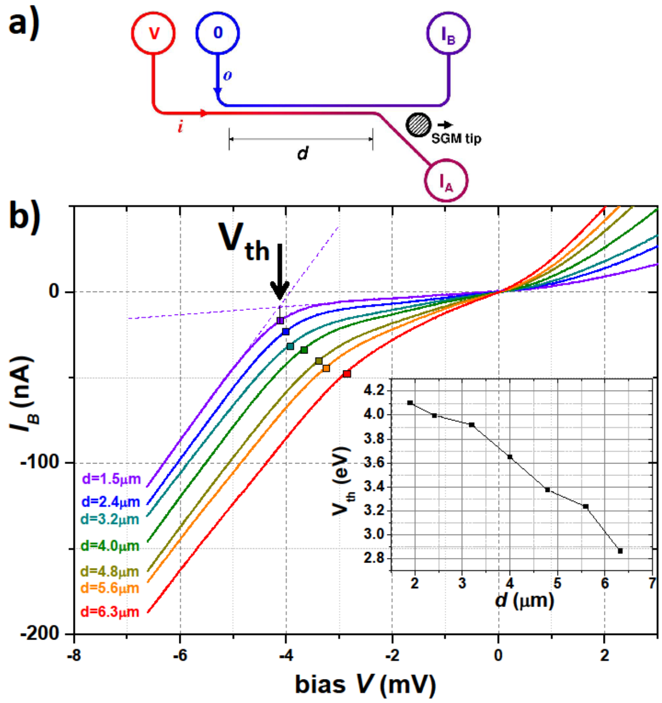

Fig. 1: (a) Sketch of the experimental setup. (b) I-V characteristics of the inter-channel equilibration. In the inset the threshold energy reduction as a function of *d* is shown.

Devices were realized starting from a high-mobility AlGaAs/GaAs heterostructure. A 6 µm-long 1D channel of two Schottky-gates with a constriction gap of 1 µm was patterned on the sample. Measurements were performed at 300 mK and bulk 2DES filling factor $\nu=4$ (two spin-degenerate edge channels). Figure 1a schematically illustrates our experiment: inner (i) and outer (o) cyclotron-split edge channels originate from two distinct voltage contacts at potential *V* and 0, respectively. The inner and outer edge channels meet at the entrance of the 1D channel and travel in close proximity for a distance *d* [5] before they are separated by the action of the SGM tip [6] and guided to two detector contacts I_A and I_B. For fixed values of the interaction distance *d* we can measure the I-V characteristics of the inter-channel charge transfer. In Fig. 1b we show such I-V curves for several values of *d*. All curves show a linear behavior for small bias and a saturation at the full equilibration conductance value e^2/h for $V<-V_{th}$. In previous works [2,4] the threshold voltage V_{th} was found to be a few mV smaller than the cyclotron gap $\hbar\omega_c$. The origin of this reduction is still under debate [4]. The degree of freedom given by the mobile tip allows us to follow both the change in the zero-bias slope [5] and the position of the threshold voltage as a function of *d* on the *same* device. The latter measurement evidences for the first time a monotonic reduction of V_{th} with increasing *d* (inset of Fig. 1b). We will discuss these data on the basis of a simple model for the transfer of carriers between the co-propagating edges, by taking into account the influence of the electron heating due to carrier injection between two highly imbalanced channels.

References

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