Eddy Currents in the Integer Quantum Hall Regime, Spatial Resolved by Multiple-SET-Electrometers

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Large eddy currents are induced in a two dimensional electron system (2DES) as the magnetic field is swept through integer quantum Hall filling factors [1-4]. Until now, it is not clear where these currents flow and if they form several small loops inside the 2DES or one big loop along the perimeter of the sample.

In this work, we employ single electron transistors (SETs) which are directly fabricated on top of the samples as local potential probes. The 2DES acts as a gate electrode to the SET and so the SET reacts very sensitive on local electrostatic changes in the 2DES [5]. In contrast to the magnetometers measuring integrally used in [1-4], SETs provide a sub-micrometer lateral resolution. Thus they allow to distinguish between local and global effects. All used samples contain more than one SET, two of which can be used simultaneously to observe a possible correlation of time-varying signals at different places in the 2DES. Each SET was part of a feedback loop which keeps the current through the SET constant by compensating variations of the local electrostatic potential with an external voltage U_{FB} [5].

Figure 1 shows the output signal U_{FB} of the feedback loop of an up- and down-sweep of the magnetic field B. During the measurement, the current and voltage contacts of the sample were grounded. The transport data shown in the same graph were measured during another field sweep.

In the quantum Hall plateau regions, strong voltages between the edge and the center of the 2DES occur. They change their sign on reversal of the direction of sweep. Stopping the sweep within such

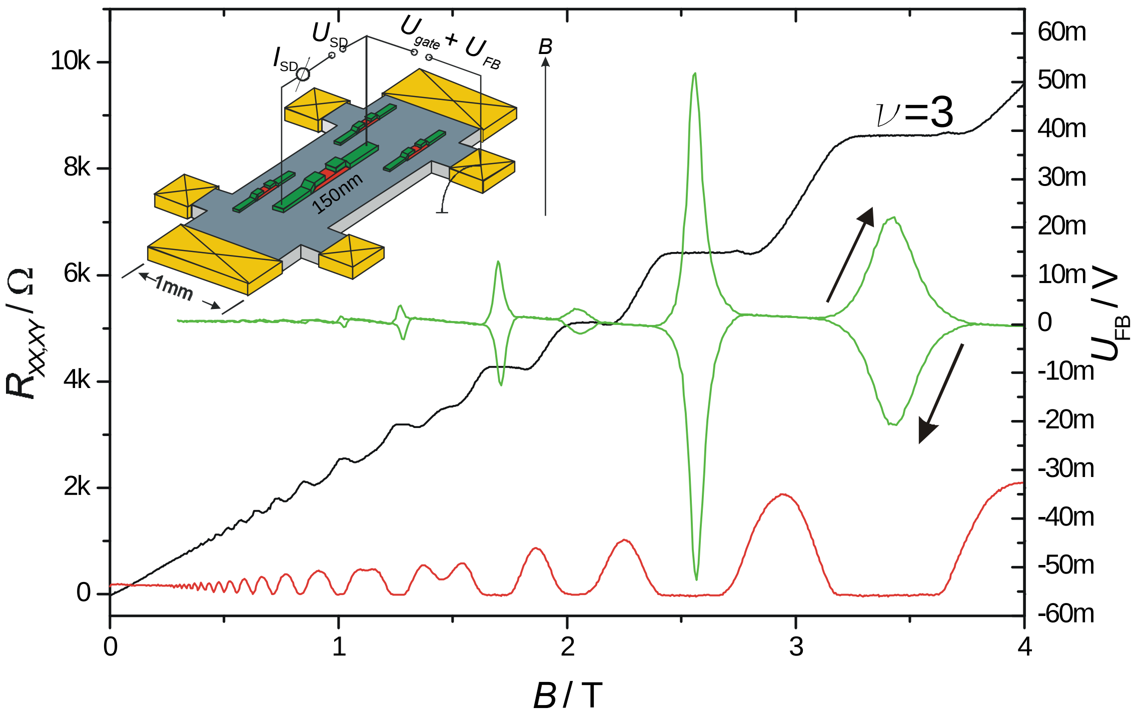

Figure 1: Feedback voltage U_{FB} of an up- and down-sweep of the magnetic field (indicated by arrows) and magnetoresistances of the sample.

a peak, the voltage relaxes immediately. We associate this voltages with the Hall voltages of eddy currents induced along the perimeter of the Hall bar.
The sample of figure 1 containes 5 SETs which are distributed across the sample. Position, shape and strength of the voltage peaks were the same for all transistors. Even a change of the local filling factor under the SET did not change this, which indicates that this effect is not due to local inhomogeneities. Thus the voltage drop is associated with an eddy current flowing close to the edge of the 2DES.
However, the SET is a stationary device and cannot be scanned towards the edge. This was circumvented by placing SETs in a distance of 1 μm from an additional sidegate overlapping the mesa edge by approx. 10 μm. A sidegate voltage of –250 mV depletes the 2DES and relocates its edge so that it is only approx. 1 μm away from the SET. Further increase of the sidegate voltage shifts the edge depletion region of the 2DES even more towards the SET [5]. Figure 2 shows traces $U_{FB}(B)$ at various sidegate voltages $U_{sidegate}$. For –250 mV < $U_{sidegate}$ < 2.5 V, the voltage peak at ν=4 is seen to be suppressed. Thus the voltage drop associated with the path of the eddy current must be between a distance of 1 μm and 10 μm to the edge where the innermost incompressible strip is known to be located [6]. This is consistent with results of scanning probe experiments by Ahlswede *et al.* [7] which also indicate current flow in incompressible regions of the 2DES at magnetic fields close to integer filling factors.

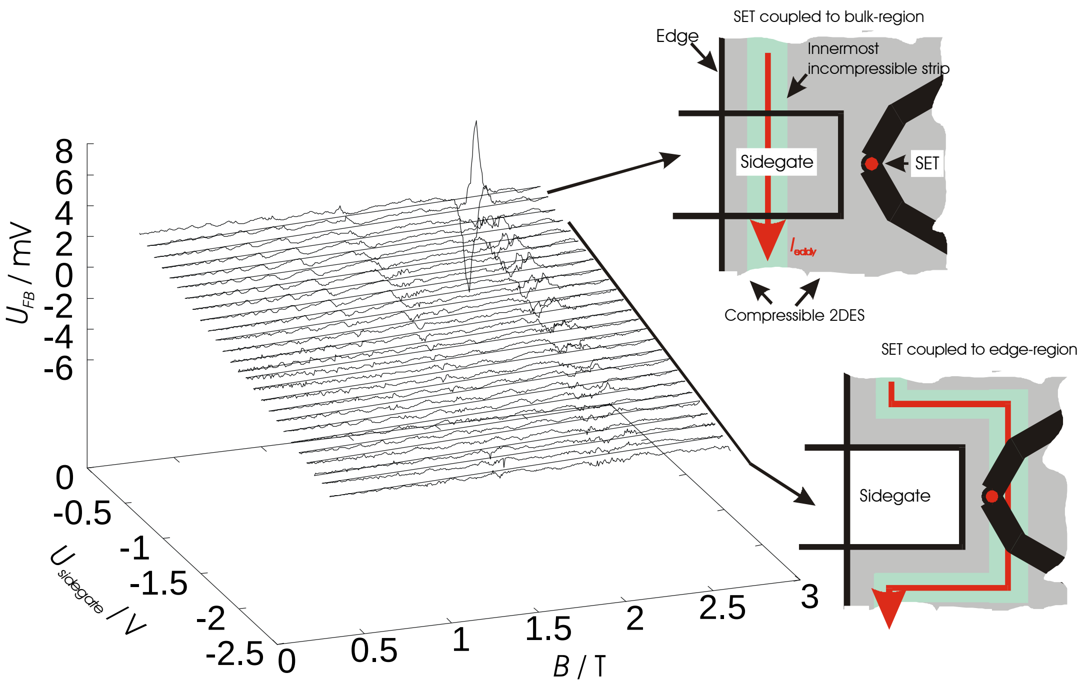

Figure 2: Feedback signal U_{FB} for various sidegate voltages $U_{sidegate}$. The observed phenomena can be explained within a model where an eddy current is induced in the innermost incompressible strip which separates the compressible bulk of the 2DES from its compressible edge.

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