Magnetotransport along a boundary: From coherent electron focusing to edge channel transport

Thomas Stegmann, Dietrich E. Wolf, and Axel Lorke

Department of Physics, University of Duisburg-Essen and CENIDE, 47048 Duisburg, Germany

We study theoretically how electrons, coherently injected at one point on the boundary of a two-dimensional electron system, are focused by a perpendicular magnetic field B onto another point on the boundary, see the inset of Fig. 1. Using the non-equilibrium Green's function approach, we calculate the generalized 4-point Hall resistance $R_{xy} = (U_{P_1} - U_{P_2})/I_{SD}$ as a function of B.

In weak fields, R_{xy} (solid curve in Fig. 1) shows the characteristic equidistant peaks, which are observed in the experiment and which can be explained by classical cyclotron orbits specularly reflected at the boundary. These classical trajectories can be clearly seen in the local current and the local DOS of the injected electrons (Fig. 2a). In strong fields, the Hall resistance shows a single extended plateau $R_{xy} = h/2e^2$ reflecting the quantum Hall effect. The current is carried by a single edge channel straight along the boundary (Fig. 2c).

In intermediate fields, instead of lower Hall plateaus as in the case of a diffusive boundary (dashed curve in Fig. 1), we find [1] *anomalous oscillations*, which are neither periodic in $1/B$ (quantum Hall effect) nor periodic in B (classical cyclotron motion). These oscillations can be explained by the interference of the occupied edge channels causing beatings in R_{xy}. The Fig. 2b shows this interference between two occupied edge channels, which resembles also to some extent a cyclotron motion. Moreover, in this regime of two occupied edge channels, the beatings constitute a new commensurability between the magnetic flux enclosed within the edge channels and the flux quantum h/e. Introducing decoherence and a partially diffusive boundary shows that this new effect is quite robust.

[1] T. Stegmann, D. E. Wolf, A. Lorke, submitted to Phys. Rev. B, arXiv:1302.6178