Fractional quasiparticles in the breakdown regime of a microscopic integer quantum Hall system

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Abstract

Integer quantum Hall (QH) effect breaks down in a high electric field. Although the mechanism of the breakdown has been intensively investigated, the state prepared by the breakdown might not have attracted much attention. Here we demonstrate that fractional quasiparticles emerge in the breakdown regime of a microscopic integer-QH system. First, we prepare a local QH region at $v$local $= 1$ in a point-like constriction in a macroscopic QH system at $v$bulk $= 2$, which is confirmed in the quantized conductance $G0 = e2/h$, the absence of shot noise, and a full Knight shift (full electron-spin polarization) of the resistively-detected nuclear magnetic resonance (NMR). When a large bias is applied, the conductance plateau breaks down. From the onset of the nonlinear behavior of the conductance, the shot noise starts to develop at a rate corresponding to the effective charge e^* _˜ $e/3$. This fractional-charge tunneling is observed over a wide parameter space (the bias voltage —Vbias— $>$ 500 μV and the differential conductance from $0.7e2/h$ to $1.1e2/h$ at various split-gate voltages). From the Knight shift of NMR, we find that the fractional-charge tunneling develops concomitant with the decrease in the spin polarization in the local region. These observations suggest the formation of a partially-polarized fractional QH liquid involving both spin-up and -down electrons in the non-equilibrium microscopic system. This work was supported by KAKENHI JP15H05854, JP26247051, JP16H06009, and Nanotechnology Platform Program (Tokyo Tech.).

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