Non-equilibrium edge-channel spectroscopy in the integer quantum Hall regime

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• What is the energy distribution $f(E)$ of 2DEG?
  – $f(E)$ can be fully extracted from tunnel current across QD
  • $f_{S,D}$ obtained independently for large S-D bias voltages

$$E_{lev} = E_0 - e\eta_G V_G$$
$$I_{QD} = I_{QD}^{\text{max}} (f_S(E_{lev}) - f_D(E_{lev}))$$
• What is the energy distribution $f(E)$ in QH edge channels?

$$f_D(E) = \tau f_{D1}(E) + (1 - \tau) f_{D2}(E)$$
• What is the energy distribution $f(E)$ in QH edge channels?
  – Non-Fermi distribution generated in edge channel with voltage-biased QPC
  – according to scattering approach

\[
f_D(E) = \tau f_{D1}(E) + (1 - \tau) f_{D2}(E)
\]

• $\tau =$ transmission probability
• applies to quasiparticles if internal modes are NOT excited at the QPC
• 1\textsuperscript{st}, standard nonlinear QD characterization
  – diamonds…
  – lever arm…
  – \( f_{S,D}(E) \)
  – \( T_{S,D} \sim T_{MC} \)
    +/- 10\%

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• 2\textsuperscript{nd}, drive drain current channel out of equilibrium with QPC
  - QPC conductance
• 2\textsuperscript{nd}, drive drain current channel out of equilibrium with QPC
  \[ \frac{\text{d}I_{QD}}{\text{d}V_G} / I_{QD}^{\text{max}} \]
• Fits to \( \frac{dI_{QD}}{dV_G}/I_{QD}^{max} \) … \( f_D(E) = \tau f_{D1}(E) + (1 - \tau)f_{D2}(E) \)
… yield \( \tau \) that agree well with 1DCF model.
• 3rd, extract quasiparticle heat current and compare with full edge-excitations’ heat current
  – \( J_{E_{qp}} \) versus \( J_E \)

\[
J_{E_{qp}} = vE_{qp} = \frac{\pi^2}{6h}(k_B T_{qp})^2 \quad \rightarrow \quad T_{qp} = \sqrt{6hJ_{E_{qp}}/\pi k_B}
\]

\[
J_E(T = 0) = \frac{(e\delta V_D)^2}{2h}\tau(1-\tau) \quad \rightarrow \quad T_{1DCF} = \sqrt{T^2 + \tau(1-\tau)3(e\delta V_D/\pi k_B)^2}
\]

“no fitting parameters”

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• Conclusion:
  – by
    [1] comparing $f(E)$ at a QPC output with scattering predictions and
    [2] showing that internal edge channel modes are not excited…

    …QPCs in the quantum Hall regime are tunable electrical beam splitters for one-dimensional fermions