Novel metallic and insulating states at a bent quantum Hall junction.

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Recommended with a Commentary by Bertrand I. Halperin, Harvard University

As is well known, disorder-induced scattering of quasiparticles between edge states on opposite sides of a narrow fractional quantized Hall system, or of electrons across a junction between two different quantized Hall systems, can lead to anomalous transport properties, with peculiar dependences on temperature and/or voltage, in the limit of low energies. The article by Grayson *et al*. reports such measurements in a fascinating geometry, where quantized Hall systems in quantum wells on two faces of a GaAs crystal, at right angles to each other, are joined along an edge of the crystal. A Hartree calculation of the self-consistent potential near the junction shows that the electron density is higher in the region where the two wells meet than it is on either face, so that there is effectively a one-dimensional wire of enhanced density separating the two quantum Hall states. The authors are able to measure, essentially, the two-terminal resistance of this wires, and they report results for two samples, having wire-lengths $L = 2$ mm and 4.5 mm.

Figure 1 shows a schematic of the "bent quantum well" structure employed, together with a schematic of the contacts and circuit provided by the edge states when a magnetic field is applied and the faces are each in a quantized Hall state of filling factor ν. By comparing voltages measured at different contacts, the author can deduce the current carried along the bent edge as well as the potential difference between the two ends.

Figure 2 shows the differential conductance dI/dV for the wire for various values of ν on the faces, as well as the temperature dependence of the low-voltage conductance G. For $\nu = 1$ and 2, the wire is strongly insulating at low temperatures and low voltages; apparently there is sufficiently strong backscattering scattering for electrons in the wire that the electron states are localized at T=0. (Alternatively, there could be a small gap at the Fermi energy due to band structure effects.) For $\nu = 3$ and 4, there is only a weak temperature and voltage dependence to the conductance, which might be consistent with weak localization, but this has not been analyzed in detail.

Most interesting is the data for $\nu = 1/3$. Here there is a strong conductance peak at low temperatures and low voltages, which the authors have fit to a power law: $dI/dV \propto V^{-0.4}$ at their lowest temperatures, and $G \propto T^{-0.4}$. This suggests a strong suppression of back scattering at low energies, and is consistent with a Luttinger liquid model for wire with interaction parameter g=1.2. [See, e.g., C. L. Kane and M. P. A. Fisher, Phys. Rev. B 56, 15231 (1997)]

The bent quantum wire geometry has properties, including sharp confinement and smoothness, which should make it very interesting for future investigations.

Figures from Grayson et al.

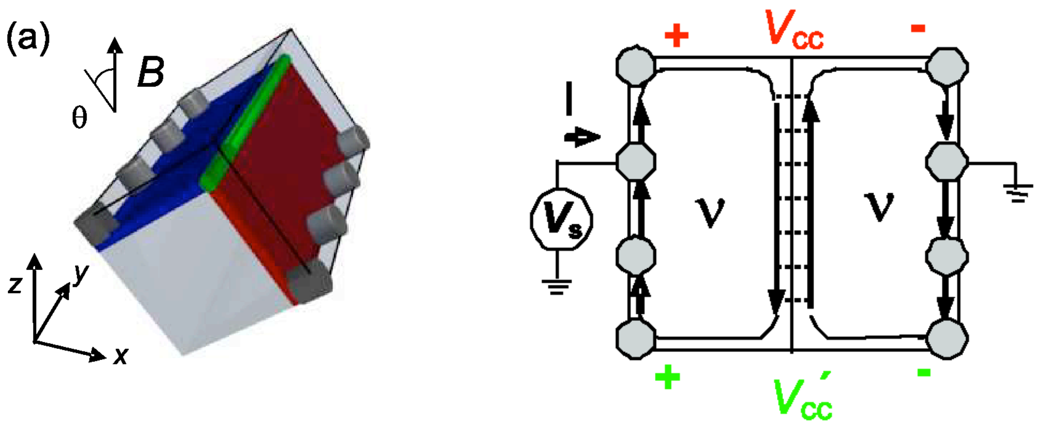

Figure 1: Left panel: Schematic view of bent quantum Hall junction, in three dimensions, showing four contacts on each face. Right panel: Schematic diagram of circuit used to measure conductance along the "wire" formed by junction. Arrows indicate direction of electron flow in quantized Hall edge states; dotted lines show backscattering across wire.

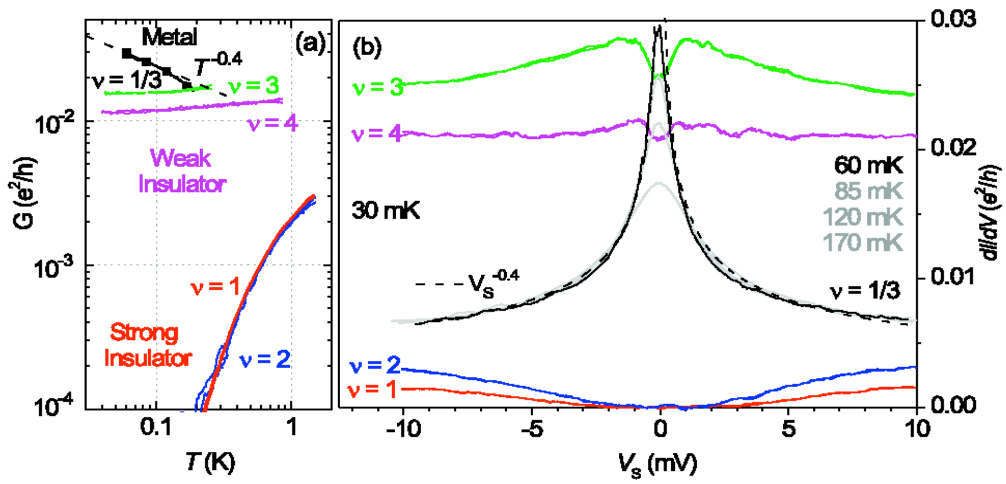

Figure 2. Experimental results. Left panel shows temperature dependence of low-voltage conductance G, for various values of ν, the filling factor for the quantized Hall states on the two faces of the structure. Right panel shows the differential conductance dI/dV as a function of voltage across the wire.