Switchable Transmission of Quantum Hall Edge States in Bilayer Graphene

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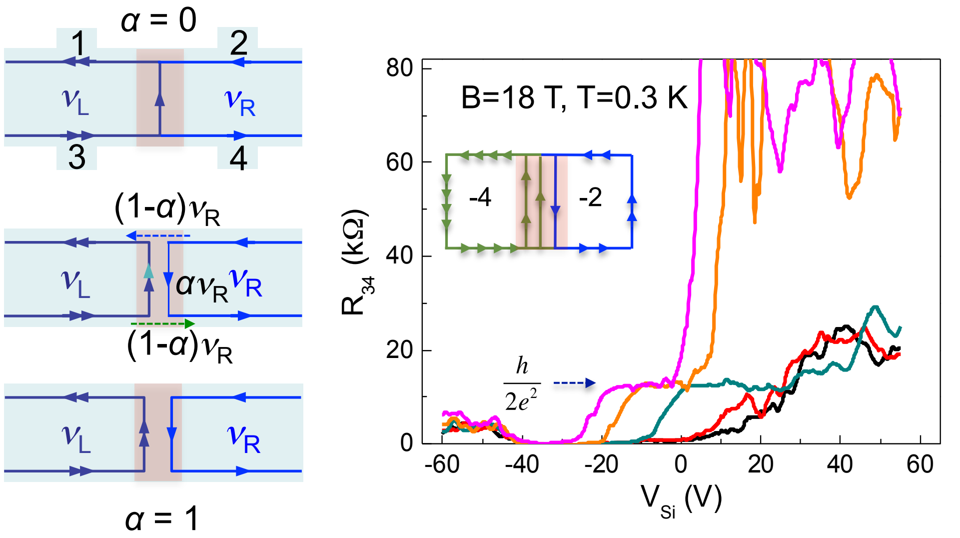
Bilayer graphene exhibits many fascinating fractional quantum Hall states in strong magnetic fields. The edge states carry important information about the low-energy, two-dimensional collective excitations in the bulk. Most notably, recently observed even-denominator fractional quantum Hall states may be non-Abelian in nature, such that they could potentially be used to carry out topological quantum computations. The experimental detection of these collective excitations requires the construction of an electron interferometer, which is a daunting challenge in bilayer graphene due to the gapless nature of the electron bands.

MagLab users have recently pioneered lithographic techniques to realize a bilayer graphene device in which electrons can tunnel between two regions exhibiting quantum Hall states (blue areas in the figure). This lateral quantum-Hall-to-quantum-Hall tunneling can be controlled electrically via a gate, where the height of the tunneling barrier is controlled by the gate voltage. By carrying out transport studies at the MagLab at fields up to 18T at 0.3K, *MagLab users demonstrated gate-controlled transmission and pinch-off of quantum Hall edge states. This control mimics the action of a quantum point contact, which is a key milestone toward the future development of edge state interferometers.*

The success of this experiment enables the building of more complex interferometer devices using bilayer graphene to probe the unusual behaviors of collective excitations in the fractional quantum hall regime.



Left: The variable coupling of edge states between two lateral quantum Hall states (blue regions). The backscattering rate α is controlled by the height of the tunneling barrier (gray region) which can be measured by longitudinal resistance across the barrier between contacts 3 and 4, denoted R_{34}. Three scenarios of α=0, 0<α<1, and α=1 are shown. (At right) R_{34} vs tunnel barrier gate voltage, which controls the barrier height. A vanishing R_{34} (as occurs around -35V) corresponds to perfect transmission of the edge states. A divergence (as occurs for pink and yellow traces for V>10V indicates no tunneling. *A plateau at $h/2e^2$, as seen around -10V, indicates one of the two edge states on the right is completely reflected while the other transmits through, as illustrated by the inset.*

Facilities and instrumentation: SCM2 18 T superconducting magnet, 3He cryostat

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