Coupled Luttinger Liquid State in Quantum Hall Line Junction

INSEOK YANG, University of Chicago, and Korea Research Institute of Standards and Science

We report on tunneling spectroscopy of quantum Hall tunnel junctions that juxtaposes two counterpropagating edge states across a high quality tunnel barrier. As the only current-carrying excitation of quantum Hall effect, edge states possess a unique ability to form robust one-dimensional electronic state along the perimeter of two-dimensional electron system. In our tunnel junctions, produced by cleaved edge overgrowth, the two edge states are laterally separated by an in-plane semiconductor barrier on the order of magnetic length and interact strongly over a junction that is \( \sim 100 \mu m \) long. Due to the quality of the tunnel barrier and the ballistic property of the edge states, inter-edge electron-electron interaction effects become predominant and disorder plays a negligible role to the leading order. Tunneling strongly mix the single particle states from two chiral one-dimensional systems, and the inter-edge correlation transforms the two counterpropagating edge states into a system of coupled, non-chiral Luttinger liquid whose Luttinger liquid properties are continuously tuned by magnetic field through the filling factor \( \nu \) of the bulk quantum Hall state. The tunneling density of states of this many-body state possesses a power-law dependence on energy with an exponent \( \alpha \), that is inversely proportional to the bulk filling factor, \( \alpha \sim 1/\nu \). Inter-edge correlation also manifests in a series of quantum critical points between successive strong and weak tunneling regimes that are reminiscent of the plateau-transitions in quantum Hall effect. Tunneling spectroscopy consequently provides a direct probe of the quantum order underlying within these highly correlated one-dimensional states.

\(^1\)This work was done in collaboration with P. Jiang, W. Kang (University of Chicago), L. Pfeiffer, K.W. Baldwin, and K.W. West (Lucent Technologies). The work at the University of Chicago was supported by NSF DMR-0203579.