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Coupled Luttinger Liquid State in Quantum Hall Line Junction[1]

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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 ν 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 α, 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.

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