MAR06-2005-001431

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

Localization Transition in a Ballistic Quantum Wire.

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We report measurements probing the many-body wave-function of localized states in one dimension. We utilize tunneling between two long, clean, parallel quantum wires in a GaAs/AlGaAs heterostructure, where one of the two wires is driven into the localized regime using a density tuning gate, and the other wire, still in the regime of extended electronic states, serves as a momentum spectrometer. Our measurements show that as the electron density is lowered to a critical value, the many-body state abruptly changes from an extended state with a well-defined momentum to a localized state with a wide range of momentum components. The signature of the localized states appears as discrete tunneling features at resonant gate-voltages, corresponding to the depletion of single electrons from the localized region and showing Coulomb-blockade behavior. Typically 5 - 10 such features appear, where the one-electron state has a single-lobed momentum distribution, and the few-electron states have double-lobed distributions with peaks at the Fermi momenta.