Energy relaxation in a quantum-Hall-based Luttinger liquid

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Single-channel one dimensional electronic systems with interactions between the particles are collective in nature. As first shown by Tomonaga [1], the elementary excitations of an interacting 1DES with a linearized spectrum are bosonic collective modes. Luttinger [1] introduced a model for two species of fermions (left and right movers) with an infinite linear dispersion. This model, referred to as a Tomonaga-Luttinger liquid (TLl) model, has an advantage of being exactly solvable. An arbitrary excited state of a spinless TLl is superposition of bosonic density excitations (plasmons). In a clean TLl, the plasmons are noninteracting and infinitely long-lived, in spite of the interaction between the original particles and a finite lifetime of fermionic excitations. Such a system exhibits no energy relaxation and never decays to a thermal equilibrium [2,3]. Any disorder or inhomogeneity result in backscattering of plasmons and allow energy relaxation, even in the absence of backscattering of the original particles [2,3].

I will review our recent experiments on the energy relaxation in a system of two identical counter-propagating edge channels (ECs) in a two-dimensional electron system (2DES) in GaAs in the $\nu=1$ quantum Hall regime. The ECs are separated by a potential barrier impenetrable for electrons with the help of a standard lateral gating technique. Two ECs defined on either side of the gate belong to separate pieces of the 2DES and propagate in opposite directions. A short segment of the gate is made narrow enough (150 nm) to bring the ECs nearby for interaction and mutual energy relaxation. This system is a close analogue of the weakly interacting TLl with suppressed electron backscattering and offers a unique possibility of independent control over the left and right species.

Excitation and probing of a nonequilibrium distribution function, respectively, in a hot-EC and a cold-EC is performed by use of quantum point contacts (QPCs). In particular, I will demonstrate the use of a QPC as a bolometer and a thermoelectric sensor. This enables to determine an effective excess temperature T^* of the cold-EC at the exit of the interaction region. The main observation is a nearly linear dependence of the T^* on a driving bias in the hot-EC over a few 100μV bias range. In the TLl framework this result can be interpreted in terms of the energy relaxation via a weak plasmon backscattering off disorder with a finite correlation radius [4,5]. The dependencies of the T^* on the bath temperature, the EC separation, the interaction length, as well as the origin of the interaction, will also be discussed.

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