Quasiparticle Tunneling between Fractional Quantum Hall Edges

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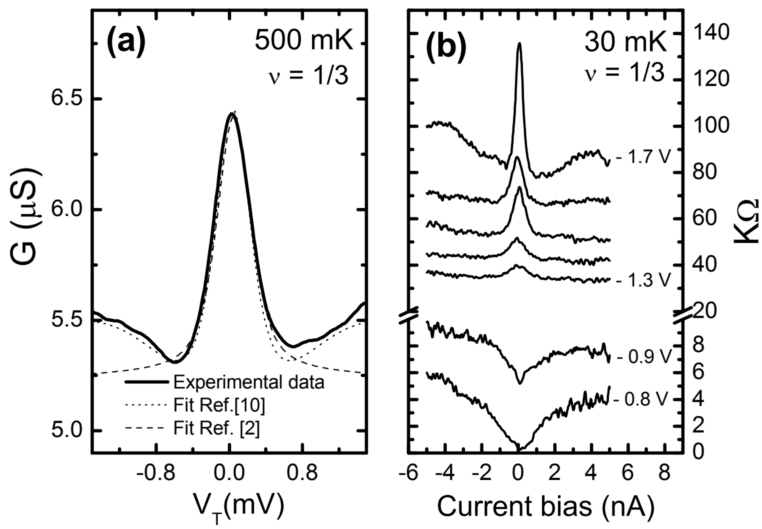
Two dimensional electron gases (2DEGs) in fractional quantum Hall (FQH) regime can gives rise to "exotic" phenomena driven by electron-electron interactions. The fundamental charged excitations of FQH liquids are predicted to display a fractional charge [1] and to obey fractional statistics. In addition, the one-dimensional (1D) edge states flowing at the border of incompressible FQH phases can form chiral Luttinger liquids [2].

Recent advances in nanofabrication and experimental techniques have opened the way to a higher level of understanding of FQH effect and to new research directions in condensed matter physics. In fact, mesoscopic systems are emerging as probes of the properties of correlated FQH states. Quantum point contacts (QPCs), for instance, can be adopted to induce a controllable inter-edge scattering and were exploited to measure line-shapes in resonant inter-edge tunneling [3] or to infer the charge of the quasiparticles [4]. Antidot configurations were also nanofabricated to investigate quasiparticle transport [5]. Alternative clean fabrication techniques, such as the cleaved-edge overgrowth, allowed the test of Luttinger-to-Fermi liquid tunneling characteristics with unprecedented accuracy [6]. In turns, these novel experimental findings are stimulating new efforts for a more accurate theoretical description of FQH systems.

Inter-edge tunneling provides a very useful test for the inner structure of the edge states. A controllable inter-edge tunneling of electrons or fractionally-charged quasiparticles in a FQH state can be obtained at a QPC depending on the tunneling strength. In the *strong-backscattering* regime one observes the tunneling of *electrons* between two quantum Hall fluids. For simple fractions (i.e. $\nu = 1/q$, where q is a odd integer), this leads to a dc tunneling current at temperature T = 0 given by $I_T \sim V_T^{2/\nu-1}$ [2,7]. Notably I_T vanishes when V_T, with V_T labeling the potential difference between the two edges, tends to zero. In the opposite limit of *weak-backscattering* the quantum Hall fluid is weakly perturbed by the QPC constriction. In this case the inter-edge current (again, at $\nu = 1/q$) consists of fractional quasiparticles of charge $e^* = e\nu$ that scatter between the edges through the quantum Hall fluid. At T = *0* the quasiparticles tunneling rate is predicted to grow at low voltages as $I_T \sim V_T^{2\nu-1}$ in contrast to the case discussed above [2,7]. At finite temperature, below a critical value $V_{T,max}$ of the order of K_BT/e^*, the tunneling current reverts to the linear Ohmic behavior. In the differential tunneling characteristics (dI_T/dV_T) this leads to a peak centered at $V_T = 0$ with a width $\Delta V_T \sim 2V_{T,max}$. Transitions from *weak-* to *strong-backscattering* regimes are an additional challenging problem [8] and can be driven by changes in temperatures, inter-edge voltage drop and QPC configuration.

In this work we will report a new set of tunneling data at a QPC constriction in the FQH regime. Measurements down to 30 mK on GaAs/AlGaAs samples were performed. Constrictions were realized by Al metallization and lift-off and different split-gate geometries were explored. We will discuss both the *weak-* and *strong-backscattering* limits and the transition between them. In the *weak-backscattering* regime at relatively high temperatures at $\nu = 1/3$ our data agree with available theory for quasiparticle tunneling [9]. Inclusion of non-uniform inter-edge coulomb repulsion [10] in the theory provides an even better description of the experimental data (see panel a in the figure). At temperatures below a critical value the tunneling displays an unexpected minimum (lower two curves in panel b). We shall show the evolution of the tunneling characteristics as a function of the magnetic field and split-gate voltage (panel b).



(a) Differential tunneling conductance in the *weak backscattering* regime at T=500 mK. Two fits are reported following references [2] and [10]; (b) evolution from the *weak-* to the *strong-backscattering* regime as a function of the QPC bias. The lowest two curves correspond to the *weak-backscattering* regime and are proportional to the conductance. The upper curves refer to the case of nearly pinched-off constriction (*strong-backscattering* regime) and are proportional to the resistance drop along the QPC. The current bias is proportional to V_T in the *weak-backscattering* regime and *is* the tunneling current in the *strong-backscattering* limit.

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