Detecting the energy spectrum of single electron emission in the quantum Hall regime

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The emission characteristics of a single-electron source [1,2] need to be understood if such device technologies [3,4] are to be used in quantum metrology and fermion quantum optics experiments. Particularly, when electrons are ejected at well above the Fermi energy [5], inelastic processes [6,7] can hamper the coherent transport of emitted electrons. Here, we investigate the emission characteristics of a tunable-barrier single-electron pump, using the energy-detection-barrier technique that has been developed in Ref. [7]. We place a tunnel barrier approximately 3 μm away from a single-electron pump [Fig. 1(a)]. In a perpendicular magnetic field B, the emitted electrons travel through edge states, well above the Fermi energy, before they reach the detector barrier. Depending on the barrier height relative to the electron energy, the electrons are transmitted through the barrier and appear as the collector current I_c, or are reflected by the barrier and appear as the side-contact current I_s. The calibration of detector barrier height is obtained by applying a bias across one of the pump gates. At very large magnetic field (B > 12 T), we find a sharp energy spectrum at E > 150 meV [Fig. 1(b)]. We find that the electron energy can be controlled linearly with the gate voltage on the exit barrier of the pump [Fig. 1(c)]. The inelastic scattering length is estimated to be over 40 μm. The second emission spectrum is observed when two electrons are pumped per cycle. At lower B, the phonon replica of spectrum lines are observed due to the emission of single/multiple LO phonon(s) per electron, resulting in a much shorter scattering length [Fig. 1(d) and (e)].

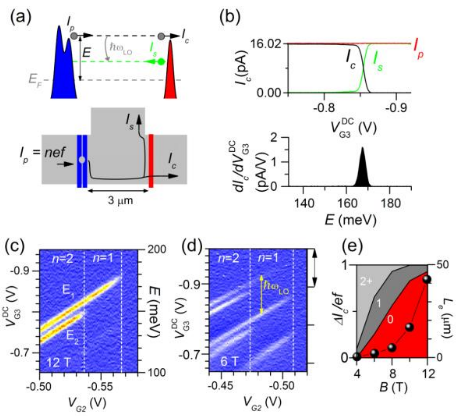

Fig. 1

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