Spin-resolved conductance quantization and evidence for zitterbewegung in InAs

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Spintronics envisions to carry and process information by both, the charge and the spin of the electrons. To this aim reliable generation, manipulation and detection of spin-polarized currents are mandatory. All-electric and all-semiconductor devices would be favorable, and that in the same semiconductor in order to prevent interface scattering and conductivity mismatch. Most appropriate and promising materials are InAlAs/InGaAs hetereostructures with narrow InAs quantum wells. They provide two-dimensional electron gases with high electron mobility and strong spin-orbit interaction of the Rashba type [1, 2]. The intrinsic spin Hall effect spatially separates the spins in quasi one-dimensional InAs quantum wires [3]. However, the electron density has to be reduced to the limit where only the lowest one-dimensional subband is occupied as otherwise intersubband scattering obscures the spin Hall information. This limit can be achieved either by side-gate electrodes that constrict the wires locally or by a top-gate electrode that depletes the whole device homogeneously. We study two-staged double-Y-shaped spin-filter cascades. The first stage acts as a polarizer, the second stage as an analyzer [4]. A straight central wire connects the two stages and allows for tuning the lateral separation of the spin probability density at the entrance of the second filter via the spin precession length. The precession length depends on the top-gate voltage and the strength of an in-plane magnetic field.

This contribution reports on measurements of spin-resolved conductance plateaus of quantum wires and quantum point contacts that our spin filters are composed of. These nanostructures have been prepared separately on the same InAs heterostructures. At a temperature of 5 K all integer and all spin-resolved half-integer plateaus of the conductance in units of $2e^2/h$ are observed up to the highest occupied mode ($N = 16$). Subsequently, we present results on the quantized conductance through top-gated spin-filter cascades that prove quasi-ballistic charge transport in these rather complex devices. Oscillations of the conductances of the second filter's outputs with the strength of an in-plane magnetic field perpendicular to the central wire provide evidence for the so-called zitterbewegung [5, 6]. At the same time they substantiate the interpretation of the conductance imbalance at the second filter's outputs as the consequence of a spin polarization. The period of the oscillations $\Delta B \approx 1$ T and the dependence of their amplitude on the occupation of subbands agree with simple theories [7].

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