All-electric Single Electron Spin Initialization

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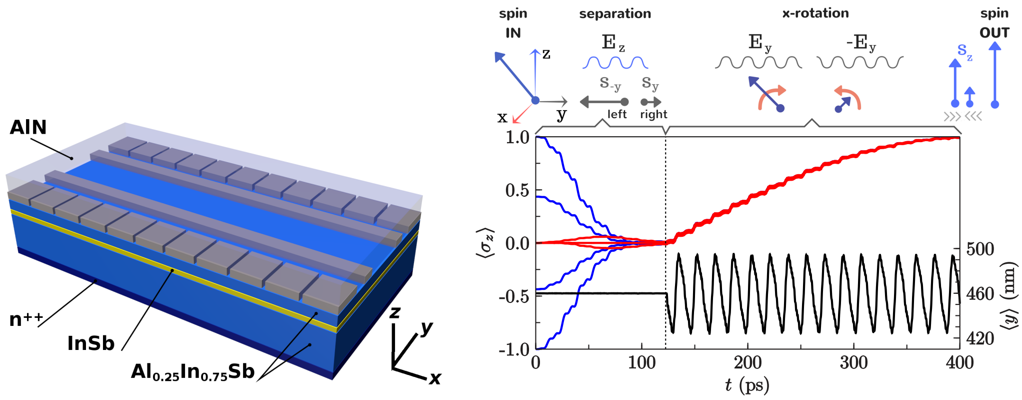
The qubit defined on spin of a single electron (or hole) is nowadays one of the most promising candidates for implementing quantum computers [1]. A natural place for creating electron confinement is the gated semiconductor nanostructure in which electrostatic quantum dots are easily formed, giving rise to localized electronic states [2]. Moreover, such qubits have a property, that they can be placed next to each other allowing for easy coupling between adjacent qubits, which is essential for two-qubit operations. To perform operations, the Rashba spin-orbit interaction is employed, where an electric field can be used to manipulate electron spin. Thus far, many single and two-qubit devices have been successfully realised [3], yet initialization and readout are still a challenge. Currently no fast and accurate spin initialization procedure exists, this is thus worthwhile to look for an efficient solution to this problem.

We propose a method of fast and accurate spin initialization of an electron trapped in an electrostatic quantum dot, generated in a planar nanostructure based on an InSb quantum well (a material featuring strong spin-orbit coupling) with gates, to which control voltages are applied. To manipulate spin, we use the electric control of the spin-orbit coupling. After the procedure, lasting about 400 ps, the electron spin becomes oriented in a definite direction with high precision, regardless of its initial orientation.



(a) Schematic view of the nanodevice

(b) Spin initialization

Figure 1: Schematic view of the nanodevice (a) showing the gate layout used and time courses of the Pauli z-matrix expectation value during the simulation (red and blue curves) for several different initial spin orientations.

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