Spin blockade lifting due to phonon mediated spin relaxation and electric dipole spin resonance in nanowire quantum dots

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Coherent electrical spin control is one of the prerequisites for creation of a solid-state quantum computer operating on spin qubits. Nanowire quantum dots have been demonstrated [1, 2, 4, 5, 6] as a good candidates to perform single spin rotations due to strong spin-orbit coupling that allows control the electron spin by electrical fields. The spin rotations are performed by electric dipole spin resonance where the electron is wiggled with frequency matching the Larmor frequency in a weak external magnetic field. The spin rotations allow for lifting the Pauli blockade of the single-electron current in the two-electron double-quantum dot. The electron-electron interaction leads to appearance of additional transitions due to exchange coupling between the adjacent spins [3, 7]. Lifting of the spin blockade is associated with phonon mediated relaxation from one of the spin antiparallel excited states in which electrons occupy separate dots to the singlet ground state with double occupancy of the single dot. However in the presence of spin-orbit coupling the spin-relaxation can occur as a concurrent process to electric dipole spin resonance lifting the blockade also from spin parallel states. We present theoretical description of the spin blockade lifting that incorporates both the electric dipole spin resonance and phonon mediated relaxation in two-electron coupled nanowire quantum dots. We find that the spin-nonconserving relaxation is possible provided the energy separation between initial and final states for the relaxation becomes small enough which leads to spontaneous lifting the blockade from one of the Zeeman split triplets. When the external magnetic field is increased the spin parallel triplet becomes the ground state which results in a restoration of the blockade from this state. This results in opening of an additional transition – related to the spin rotation accompanied by charge reconfiguration – which we identify in recent experimental results [4].

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