Phonon effects on the measurement of two-spin states in a double quantum dot

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Gate-defined double quantum dots (DQD) coupled to a quantum point contact (QPC) are proposed as a single shot measurement device of the spin configurations of two electrons confined in DQD[1-3]. The measurement is performed by monitoring QPC current which depends on the configurations of the charges in DQD due to Coulomb interaction between a DQD electrons and a QPC tunneling barrier. The access to a spin-configuration information is possible because transitions between different charge states are allowed for anti-symmetric spin configuration(singlet) and forbidden for symmetric configuration(triplet)[3]. Since in a lack of DQD-QPC interaction QPC current is Poissonian and DQD-QPC interaction depends on the charge distribution of the electrons in DQD, the QPC current fluctuations will be changed for a spin-singlet configuration in DQD as a consequence of transitions between different charge states. On the other hand there is a transfer of energy between QPC current and DQD electrons allowing the transitions between the singlet states. This leads to a different current noise characteristics for the singlet and triplet states. Furthermore readout of the information is not instantaneous since it is gradually inferred from the current fluctuations.

In this work we investigate phonon impact on the singlet-triplet measurement in a realistic model. We model a gate-defined lateral DQD formed on a GaAs/AlGaAs quantum well in the low temperature regime which is typical for spin experiments performed on such dots[4]. The electron-phonon interaction which is unavoidable in a solid state environment will suppress excitation to doubly occupied spin-singlet states in such systems. Hence, the fluctuations of the charge distribution are also suppressed and it will hinder distinguishability between the QPC current noise for the spin-singlet and spin-triplet states. The analysis of this effect allows us to find limitations for the applicability of the QPC current noise measurement of the DQD two-electron spin system.

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