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Modeling of charge noise in a double quantum dot semiconductor device

Presence of noise and dissipation in modern prototypes of quantum computer, prevent us from employing quantum advantage, which can be used in problems involving factorizing large numbers, database search or simulations of other quantum systems. In this project we concentrate on particular realization of quantum computer using Silicon nanostructure. In comparison to other systems it promises better scalability, due to small dimensions, long coherence time and inerrability with existing silicon industry. A building block of such quantum computer is a single spin-qubit, which can be realized by trapping a single electron inside the quantum dot, which is an attractive potential obtained using electrostatic gates.

In our project we model a double quantum dot in realistic device. In particular w model to what extent protocols needed for workings of future quantum computer could be affected by unwanted fluctuations of electric fields. In particular we consider a two-qubit gate, two-electron encoding of the qubit (singlet-triplet qubit) and two ways of realizing coherent link between quantum registers: spin-photon coupling and dot-to-dot adiabatic transitions, all of them utilizing double quantum dot system.

We concentrate on a popular model of charge noise according to which slow fluctuations of double quantum dot parameters comes from telegraph-like motion of electrons in the interface between semiconductor nanostructure and oxide, needed for creation of quantum dot. We attempt at reconstructing correlations between effective parameters of double quantum dot potential, energy detuning and tunnel coupling. Motivated by the literature, we plan to use charge traps in the interface, e.g. coming from dangling bonds to simulate their charging and discharging by the electron motion between the traps. In this way, using numerical methods we attempt at obtaining time-traces of detuning and tunnel coupling with possibility of looking at their correlations.

This project is believed to test hypothesis of relation between charge traps in the interface and 1/f noise, and should be considered as a first step towards more realistic modeling of charge noise.