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Simulation of Double Quantum Dots Charge Qubit Manipulation with Electric Field Pulses

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This study investigated the manipulation of a charge qubit by simulation for purpose of quantum computing. The charge qubit was constructed by modeling with InAs/GaAs double quantum dots (DQDs) based on sp3s* empirical tight-binding calculation. The manipulation concerned the evolution of the charge qubit, such as the state dynamics under the electric field pulses, and the leakage of probability to higher-order states of DQDs, called quantum leakage. The results demonstrated how the electric field pulses had influence on the state dynamics by determining the axes and frequency of rotation via specifying eigenstates and eigenenergies of the Hamiltonian. For quantum leakage, the pulse shapes with large changes and higher slope induce more quantum leakage than ones with smooth profiles. In addition, for the square electric field pulses, the simulations were also performed when the applied electric field pulses inherited uniform random fluctuation in amplitude and operating time. In this case, it was found that the precision of state measurement, quantified by the standard deviation (SD) of the occupancy probability in a dot, was proportional to the SD of the random fluctuation in amplitude. But for random fluctuation in operating time, such the proportionality does not exist. In both cases of random fluctuation, the accuracy of measurement, obtained by comparing the dynamics of the occupancy probability profile in a dot under pulses with no fluctuation, was shown to have non-monotonic relation with the fluctuation strength after some time.

Keywords: Double Quantum Dots; Gate Operation; Finite Electric Field Pulses, Quantum Leakage

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