Time evolution and pure dephasing of entangled states of two electrons in coupled quantum dots

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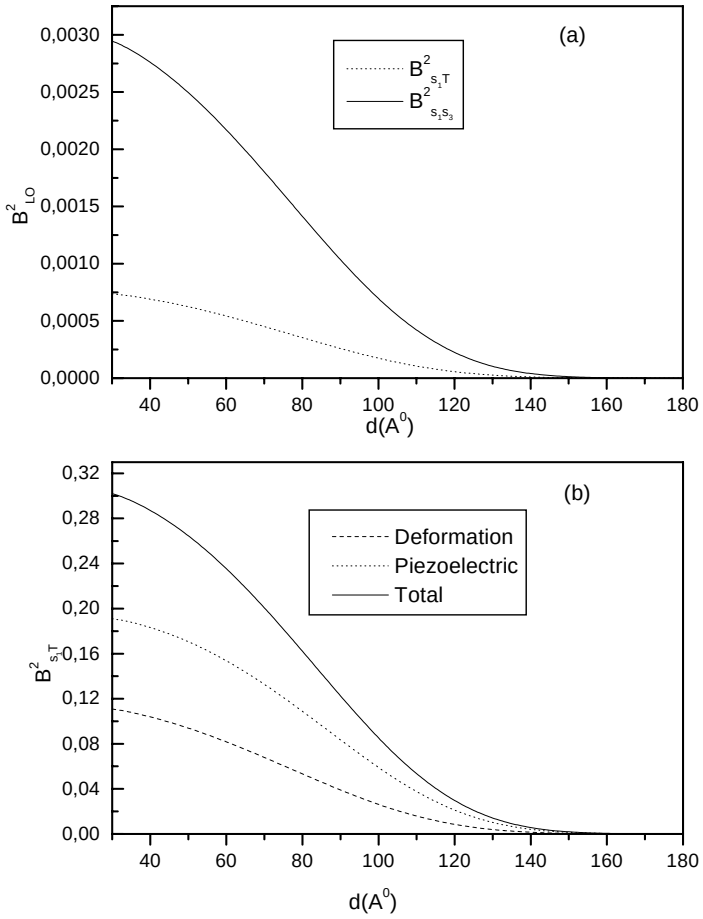
We theoretically study the pure dephasing dynamics of two charge qubits in double dot due to the interaction with acoustic and optical phonons. Semiconductor quantum dots (QDs) are often considered as candidate devices for a solid-state implementation of quantum information processing [1,2,3]. The implementation of charge states in quantum dot (QD) systems, recently supported by an experimental demonstration [4], has driven a lot of investigations on coherence properties of these systems. Coherent oscillations in double quantum –dot qubit are observed [5].

We consider the quantum dynamics of two interacting electrons in a vertically coupled quantum driven by external electric field, in terms of equations of motion for the density matrix, in which the presence of one electron confined in the double dot representes one qubit. The pure dephasing rates depend on the parameters of the double dot [6].

In order to study the pure dephasing effects on entangled states we adopt three possible measures. We adopt the concurrence C(ρ) in order to quantify the evolution of the degree of entanglement of two qubits in the presence of a bath of acoustic phonons. For second measure, we consider the fidelety F(t) in order to quantify the stability of the quantum system under the action of the phonon-electron interaction. Finally, we explore the linear entropy S(ρ) in order to study the mixed character of a system described by a density matrix ρ .

Keywords: decoherence, entanglement, double quantum dot



Dephasing rates as function of the half interdot separation d. The vertical confinement is $\hbar\omega_z$=16 meV and the time is chosen to be 40ps. (a) The total rates of B^2_{s1T} and B^2_{s1s3} due to the interaction with optical phonons, are represented by dotted and solid lines respectively. (b) The pure dephasing rate of B^2_{s1T} due to deformation potential, piezoelectric interaction and the total rates are represented by dashed, dotted and straight line respectively.

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