Non-adiabaticity of electron pick-up process by surface acoustic wave for qubit transport

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Surface acoustic waves have been suggested [1,2,3,4,5,6,7] as a carrier to enable remote transport of a single or multiple electrons from one quantum dot to another while maintaining quantum information encoded in the electron's spin or orbital degrees of freedom. It is widely believed [3,4] that the process where SAW picks up the electron from a fixed quantum dot is adiabatic, with the electron wavefunction following the instantaneous ground state centered at the collective potential minimum. In this work we explore the adiabaticity of this electron transfer from a static to a moving (or vice versa) dot as we vary system parameters such as relative dot sizes, bias potential, and speed of the moving dot. In particular, we showed that with parameters commonly seen in experiments, the electron pick-up process by SAW is non-adiabatic. The electron dynamics can be described by a highly excited "classical" wave packet. The high degree of excitation could negatively affect the electron spin decoherence, causing loss of quantum information encoded in the spin.

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