Two Qubit Manipulation with Driven Fields

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The effect of ac electric fields in the transport properties of low dimensional systems and nanodevices has been a topic of intense research in the last years. Applying ac electric fields to coupled quantum dots allows to control the tunneling between them and to transfer charge by means of photo-assisted transitions. Recent experiments in triple quantum dots unambiguously show direct electron transfer between the outer dots, without the participation of the intermediate region other than virtual, minimizing then decoherence and relaxation. This long range transfer mechanism is mediated by virtual transitions[1,2,3]. In the presence of ac driving the transfer of electrons between distant dots takes place by means of photo-assisted virtual transitions[2,4]. Interestingly, by means of this mechanism, direct transfer of heat and energy between outer dots in a quantum dot array has also been proposed [5].

In the present work we investigate how to manipulate two qubits located at the left and right edges of a triple quantum dot array with two interacting electrons by means of ac gate voltages. Our aim is to transfer a qubit state directly to another distant qubit by means of virtual photoassisted transitions. Our protocol consists first in isolating the two qubits, each in one of the outer dots. The two states of the qubit localized in the left side are connected by a virtual transition through an intermediate state. Once the left qubit is in the desired state, we apply ac gate voltages to the outer dots with amplitudes such that the left qubit state is fully transferred to the right qubit. Furthermore, by manipulating the intensities of the ac voltages we assure that the qubit state is not going to be corrupted by decoherence coming from the mixing of the initial quantum state with other accessible states. Importantly, this decoherence is avoided by the controlled generation of dark-states by the ac gate voltages[4,6]. Our proposal opens a way to transfer quantum states directly between distant regions in solid state devices by means of ac driving fields.

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