

Dynamics of single-electron charge and spin in semiconductor quantum dots

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The quantum dynamics in solid-state nanostructures has attracted much attention for building blocks of quantum computing. We present some recent results on coherency, dissipation and dephasing of charge and spin degrees of freedom in semiconductor quantum dots.

First, we discuss coherency of charge states in a double quantum dot. Consider a two-level system consisting of two charge state, in which an excess electron occupies an energy state in one or the other dot. When these two states are coupled by a tunneling barrier, one can induce coherent charge oscillations by means of non-adiabatic excitation with a high-speed voltage pulse. We have successfully observed clear coherent charge oscillations. The charge qubit can be manipulated arbitrarily by tailoring the pulse waveform. The experiments indicate the potential application for quantum information processing.

Second, we discuss about dissipation of spin degree of freedom in a quantum dot. Electron spin in quantum dots is expected to have a long decoherence time. We investigate the energy relaxation time from an excited state to the ground state in one- and two-electron quantum dots. We find that the relaxation time from spin-triplet state to spin-singlet state in a two-electron quantum dot can be longer than hundreds of microseconds. The long spin relaxation time is advantageous for spin based information storage.