RELAXATION OF ELECTRON-ENERGY IN POLAR SEMICONDUCTOR DOUBLE QUANTUM DOTS

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Various proposals of how to realize the quantum computation have been considered, including the scalable solid state nanostructures (see e.g. [1]). In these structures the basic element of the quantum computation - the quantum bit – can be represented by the states of a single-electron. In particular, the two basic states of the quantum bit can then be provided by the orbital motion of a single electron in a quasi-0D nanostructure.

The electronic effective masses in the polar semiconductors like GaAs and InAs are small enough to enable a fast electron dynamics, nevertheless, it appears that the relaxation rates of an electron from an excited state in a single quantum dot are considerably large (see e. g. [2]). The theoretical interpretation of this effect, in terms of multiple scattering of the electron on the polar modes of the optical phonons, was given recently [3-6]. Although the fast relaxation can be favourable for the quantum dot lasers, from the point of view of the quantum computation it is desirable to look for such nanostructure geometries, in which the relaxation of the energy of an excited electron is sufficiently slow, so that the unitary operations of the quantum gates can be performed in a safe manner.

We study theoretically the electron-energy relaxation process based on the multiple electron-LO-phonon scattering. The electronic relaxation rate is computed numerically for a realistic model consisting of a single electron in an asymmetric pair of tunneling-coupled quantum dots, each having a single orbital electronic state. The electron is assumed to be coupled to the LO optical phonons (bulk modes only). The dependence of the electron-energy relaxation rate on the magnitude of the inter-dot electronic tunneling parameter, on the electronic energy-level separation and on the lattice temperature, is computed in this GaAs-based double quantum dot structure. [&]

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