Influence of the Environment on Self-Interaction of Quantum Dot

R.Kh. Gainutdinov\textsuperscript{a}, M.A. Khamadeev, M.R. Mohebbifar, and A.A Mutygullina

Kazan Federal University, Institute of Physics, 18 Kremlevskaya Str. Kazan 420008, Russia

Abstract. The self-interaction of a quantum dot tunnel with Coulomb interaction coupled to two leads is investigated. We show that actually in the case of quantum dots the variations of the self-energy functions can be strong, and this can have a significant effect on the values of the tunneling-induced shifts of energy levels of quantum dots, that cannot be obtained in the standard way.

Quantum dots are nanometer-sized three-dimensional structures which confine electrons in all three directions. This confinement gives rise to a discrete energy spectrum. Quantum dots are of great interest both from a technological and a fundamental point of view. For example, experimental observations of resonance fluorescence from quantum dots showed an essential discrepancy with the predictions of quantum optics for two-level atomic systems [1]. This disagreement can originate from the fact that in the standard theory of resonance fluorescence from a two-level atom the non-radiative transitions caused by the self-interaction processes are not taken into account. In the case of quantum dots the role of the virtual photons in the self-interaction of ordinary atoms can be played by electrons which can leave the quantum dot and then come back. Such a self-interaction can be much more significant than the interaction of an atom with its own radiation field. In this work we investigate the effect of such a self-interaction on the tunneling-induced shift of energy levels of a quantum dot.

Using the generalized dynamical equation the self-energy functions for the states of the quantum dot with one, two electrons and for the state without electrons were derived [2]. With these functions the correction to the energies of the quantum dot that were derived previously [3] in the standard way were calculated. These corrections strongly depend on the variation of the self-energy functions for the corresponding states. If the variations of the self-energy functions were weak enough, then one could restrict oneself to this approximate solution. However [2], this is not the case, and this yields the significant shifts. Thus, by choosing parameters of a quantum dot coupled to leads, it is possible to intensify the self-interaction processes that open the way to increase the light-matter interaction.

References


\textsuperscript{a} Corresponding author: Renat.Gainutdinov@kpfu.ru

This is an Open Access article distributed under the terms of the Creative Commons Attribution License 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.