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Characterization of the optical line width in individual quantum dots

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Abstract

We study theoretically the width of the optical spectral lines in quantum dots using the electron coupling to optical phonons in polar semiconductors. Within the self-consistent Born approximation to the electronic self-energy we can reproduce the main experimental results on CdSe and CuBr quantum dots, namely the linear dependence of the optical line width on the inverse of the quantum dot diameter. The theory predicts certain resonance features on this linear dependence. Extensions of the present line width theory are considered to reach a better agreement with the experiments on the line width in CdSe and InAs quantum dots.

Key words: *Quantum dots, Electron-phonon interaction, Optical line-width, Green's function methods, Non-equilibrium thermodynamics and statistical mechanics*

1. Introduction

Individual quantum dots (QDs) are similar to single atoms or molecules. Despite the relative simplicity of such systems their behavior has not yet been satisfactorily understood. Because of the complete confinement of the charge carriers in all three dimensions, the energy spectrum of the stationary states of the charge carriers is nearly discrete. In some cases we like to reduce approximately the electronic system of a quantum dot to a two energy level system with two non-degenerate electronic states. Even such a simple model, with the inclusion of the electron-phonon interaction, is not regarded to be understood enough (Abbott *et al*., 2008).

The electron-phonon coupling of the electronic system of quantum dots, when included in the self-consistent Born approximation to the electronic self-energy, leads to a rapid relaxation of the electronic energy. Because of the nature of including this interaction the spectral lines of the optical transitions appear to show a finite width, and in certain cases the spectral line profiles display a special shape of a homogeneous spectral density (Kral, 2008). The present understanding of the processes within the individual quantum dots is currently led along several directions. For example, the rapidity of the electronic energy relaxation has been interpreted with the help of at least two mechanisms, one of them is

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