Polaron states in two coupled self-assembled quantum dots

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Self assembled quantum dots (QDs) are continuously attracting attention in fundamental research. From the theoretical point of view, one of the most interesting aspect is related to carrier-phonon coupling. The coupling can lead to the formation of polarons. Systems composed of coupled QDs offer reacher physical properties than a single QDs. In particular, a double quantum dot (DQD) supports also spatially indirect states with different dipole moments, the energy of which can be tuned by applying an axial electric field. Experimental and theoretical work on QD polarons is crucial e.g. for carrier relaxation in self-assembled QD systems, where typical energy separations are comparable with the LO phonon energy.

We study polaron states in two vertically stacked QDs[1]. The electron and hole states are found by applying the 8-band $\boldsymbol{k}\cdot\boldsymbol{p}$ model with strain distribution found within continuous elasticity approach. We calculate exciton states using the configuration interaction method, while polaron states are found by orthogonalization of the Fröhlich Hamiltonian in the basis of collective phonon modes[2]. We propose a numerically efficient mode orthogonalization scheme related to selection of effectively coupled modes. We investigate the dependence of polaron energy branches on axial electric field and also the dependence of the phonon-assisted tunnel coupling on the separation between dots.

In this presentation, we show that coupling between carriers and longitudinal optical phonons leads to the reconstruction of the optical spectra. In particular, we study resonances between the states belonging to different shells from different dots. We show that p-shell states are strongly coupled to the phonon replicas of s-shell states, while the direct s-p coupling is much weaker. We also show the exponential dependence of the strength of LO-phonon mediated coupling on the inter-dot distance.

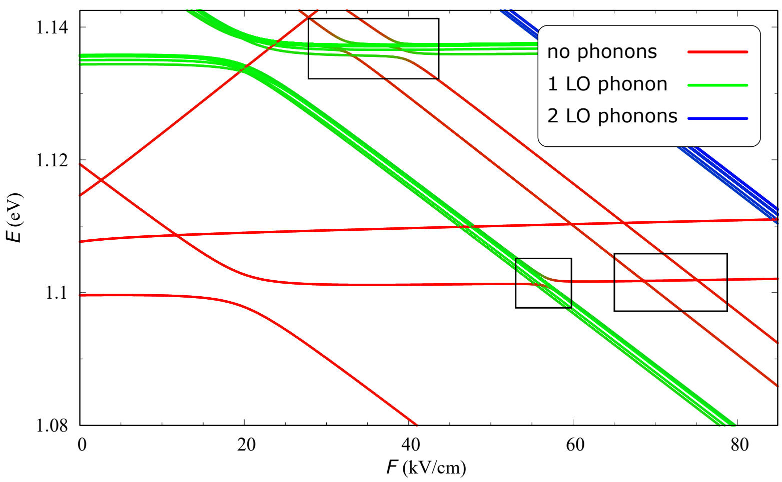

Figure 1: Polaron energy branches as a function of axial electric field.

[1] P. Karwat, K. Gawarecki, P. Machnikowski, arxiv: 1701.06613 (2017).

[2] T. Stauber, R. Zimmermann, H. Castella, *Phys. Rev. B* **62**, 7336 (2000).