# Phonon-induced transparency in quantum dot molecules

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Crystal lattice vibrations, i.e. phonons, have often been considered for the limitations they impose on quantum control and as sources of energy loss and noise in the crystalline-based components of modern technology. Here we report on the utilization of single phonons as a control parameter for the optical response of individual quantum dot molecules. As such, we demonstrate that phonons may enter the realm of mutual control of quantum states on the single particle level, which so far has been dominated by photons, electrons and spins.

Quantum dot molecules, i.e. coupled quantum dot pairs, provide an advantageous system as these individual particles can be made to interact and control each other. They possess highly tunable electronic, optical and spin properties [1]. We use quantum dot molecules to tune discrete optical transitions across tens of meV to enhance the interaction between excitonic states and optical phonons. In the presented case the interaction leads to an opto-mechanical mechanism by which the quantum dot molecule is rendered transparent by the quantized vibration of its own underlying lattice.

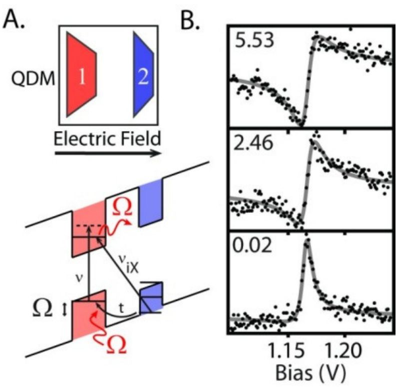


**Figure 1** (A) Schematic of the structure (top) and the band diagram (bottom) of a QDM. In the band diagram the processes that lead to the phonon-induced Fano effect are indicated: optical absorption into the intradot optical polaron state, ν, optical absorption into the interdot exciton state, $\nu_{iX}$, charge tunneling, t, with phonon emission and absorption, Ω. (B) Line scans of an interdot transition when it is in resonance with an intradot polaron at three different power levels (numbers in nW/μm$^2$).

We identify a Fano-effect as the physical mechanism behind this opto-mechanical transparency of the quantum dot molecule [2]. The Fano effect arises from quantum interference between two competing optical pathways, one associated with a discrete state and the other a continuum of states (Fig.1A). The result of this interference is a rapidly changing absorption lineshape verses the excitation energy. The Fano resonance is easily tunable (Fig.1B) and the consequent dips and peaks in absorption provide a switch to control quantum states. The universality of the Fano effect makes the concept of a vibration-induced decoupling from the environment transferable to a broad range of systems. We anticipate our results may provide an impetus for further investigations on the gainful use of phonons to provide greater control over individual quantum states, for example providing an on/off switch for optical state preparation and manipulation.

[1] Michael Scheibner, et al., "Essential concepts in the optical properties of quantum dot molecules" Solid State Comm. **149**, 1427-1435 (2009).
[2] Mark L. Kerfoot, et al., (manuscript in preparation).