DMR-1420541

2017

Microwave detection of electron-phonon interactions in semiconductor quantum dots

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Phonons, the quantized lattice vibrations in a crystalline solid, are ubiquitous in condensed matter systems and impact the properties of bulk and nanostructured materials. Hartke *et al*.* investigated the interplay of electrons, phonons, and photons in a cavity-coupled InAs nanowire DQD that is mechanically suspended in vacuum.

The dc current *I* was measured as a function of DQD energy level detuning e and shown to exhibit periodic oscillations that are consistent with the phonon spectral density in a confined nanostructure. Measurements of the cavity amplitude and phase response revealed the detailed energy dependence of the electron-phonon coupling and exhibited a response that was periodic in e. Hartke *et al.* employed a microscopic theoretical model of the device that suggests the dispersive cavity phase shift is due to a renormalization of the cavity center frequency by coupling to phonons.

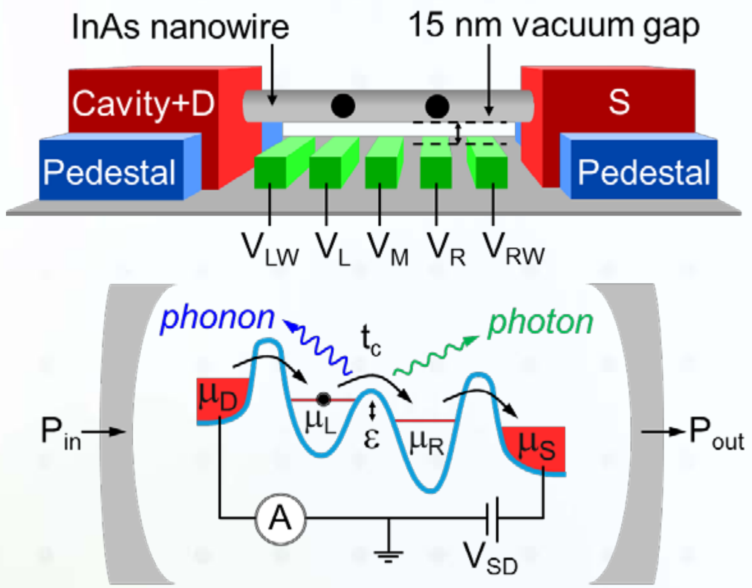

Fig. 1 A mechanically suspended InAs nanowire is placed inside of a high frequency microwave cavity. Inelastic charge transitions proceed via spontaneous emission of a phonon at a rate that is affected by the phonon confinement. Cavity photons are sensitive to the electronic occupation of the double dot and indirectly probe the electron-phonon coupling.

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References:

T. R. Hartke, Y.-Y. Liu, M. J. Gullans, and J. R. Petta, "Microwave Detection of Electron-Phonon Interactions in a Cavity-Coupled Double Quantum Dot," Phys. Rev. Lett. **120**, 097701 (2018).

M. J. Gullans, J. M. Taylor, and J. R. Petta, "Probing electron-phonon interactions in the charge-photon dynamics of cavity-coupled double quantum dots," Phys. Rev. B **97**, 035305 (2018).