Fano-interference in an optical transition from a neutral quantum dot to a correlated many-body state

F. Haupt[1], S. Smolka[1], M. Hanl[2], W. Wüster[1], J. Miguel-Sanchez[1], J. v. Delft[2] and A. Imamoglu[1]

[1] *Institute of Quantum Electronics - ETH Zürich, Wolfgang-Pauli-Strasse 16, 8093 Zürich, Switzerland*

[2] *Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität München, D-80333 München, Germany*

The interaction between a local energy level and a continuum of states leads to fascinating quantum phenomena such as the Kondo effect [1] or Fano-type quantum interference. Here, we demonstrate a quantum interference between a discrete quantum dot (QD) energy level and a nearby Fermi reservoir (FR), that is modified by the scattering potential of the QD. [2] This interference is detected with resonant absorption measurements by tuning the neutral exciton (X^0) energy level with respect to the FR. [Fig. 1a)] We observe - in addition to the QD transition - an indirect transition, i.e. the generation of a hole in the quantum dot and an absorption of an electron in the FR. The line shapes show a pronounced asymmetry as well as broadening originating from the tunnel-coupling between dot and the FR. [Fig. 1b)] When the energy of the X^0 excitation is in the vicinity of or above the Fermi energy ε_F, the charge of the photo-excited QD hole cannot be fully screened by the optically excited electron and generates a scattering potential for the free electrons of the FR. [Fig. 1c)] This scattering potential modifies the wave-function of the FR and leads to a quench dynamics after absorption - a Fermi edge singularity. The experimental data are found to be in good agreement with theory using a numeric renormalization group model allowing us to determine the scattering potential strength. [3] The quantum interference between a QD and the FR is an important step to study the interplay between coherent laser excitation and an interacting many-body system.

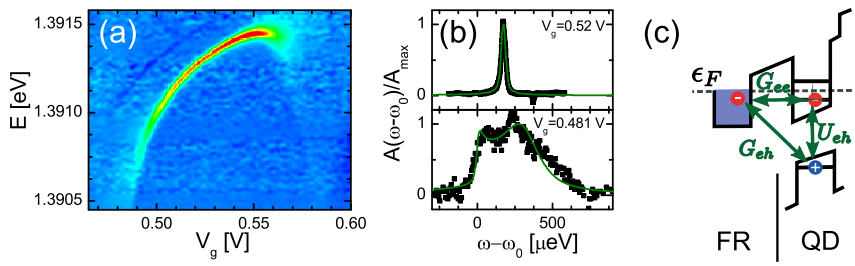

Figure 1: a) Absorption measurements as a function of applied gate voltage for the neutral exciton (X^0) transition from a strongly tunnel-coupled QD. [4] b) Representive absorption line shapes of the X^0 superimposed with our calculations (green curve). c) Schema depicts the effect of the scattering potentials in the sample structure (green arrows) between the QD and the FR electrons.

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