Light-matter interaction between a two-dimensional electron gas and a micro-cavity

S. Smolka[1], W. Wuester[1,2], S. Faelt[1,2], F. Haupt[1], W. Wegscheider[2], A. Imamoglu[1]

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

[2] *Laboratory for Solid State Physics – ETH Zürich, Wolfgang-Pauli-Strasse 16, 8093 Zürich, Switzerland*

We report quantum optical studies on a two dimensional electron gas embedded in a semiconductor cavity by positioning a remotely doped GaAs quantum well between two distributed Bragg reflectors that form a λ-cavity. The coherent coupling of a photonic resonator and semiconductor excitons results into polaritons that are the fundamental ingredients to study quantum optical phenomena in the realm of cavity quantum electrodynamics [1, 2]. In the presence of an electronic reservoir, one could expect the exciton binding energy to vanish due to the screening of the Coulomb potential while the interaction between a hole created by a single photon absorption event and the continuum of electronic states leads to intriguing many-body phenomena such as the Fermi edge singularity [3, 4]. Theoretical predictions show that the case of an electronic reservoir model of two coupled oscillators describing a confined photon and exciton forming a polariton breaks down and the interactions are strongly modified by the continuum of states [5].

High resolution laser spectroscopy as well as confocal photo luminescence measurements at cryogenic temperatures are conducted to optically probe correlated many-body states emerging from the interaction between the cavity photon, the electronic reservoir and the photo-excited hole. A spatial tuning of the cavity resonance frequency allows us to directly access the signatures of strong coupling between optical excitations from the two-dimensional electron gas and the photonic mode. By changing the electron density the electronic Bohr radius and the binding energies can be modified. This alters the coupling strength of the electronic reservoir to the photonic mode linking the otherwise remotely connected research areas of cavity quantum electrodynamics and many-body physics.

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