Exciton Tunnelling Between Quantum Wells in Optical Microcavity

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Quantum tunnelling is one of the core effects in quantum mechanics. Tunelling of excitons between semiconductor quantum wells (QW) has been demonstrated so far for distances of the order of single nanometers or tens of nanometers. With the present work we aim at extending this limit by at least an order of magnitude.

The sample contains a micro-cavity made of a wedge type (Cd,Zn,Mg)Te layer embedded between (Cd,Zn,Mg)Te based distributed Bragg reflectors. Two sets of (Cd,Zn)Te QWs, separated of each other by a distance of 125 nm are positioned at the antinodes of the electric field inside the microcavity. Each of the QW sets consists of 3 wells separated by 10 nm. Moreover, the QWs in one of the sets are doped with 0.8% of manganese, so their excitonic energy levels are slightly shifted towards higher energy and can be tuned by magnetic field.

Photoluminescence spectra acquired at 1.8 K as a function of the magnetic field for a place on the sample surface, where QW levels are in resonance with the mode of the microcavity show anti-crossing of levels of the Mn-doped and the non-magnetic QWs (see Fig. 1). This proves coupling of distant QWs that is mediated by the optical mode. Reference magneto-PL spectra taken for another place on the sample, where QW levels are detuned from the mode show no anti-crossing behavior. The experimental data are described with the Hamiltonian, taking into account strong light-matter coupling between the QWs and the mode of the microcavity. The value of the Rabi splitting is the same for the Mn-doped and the non-magnetic QWs and amounts to 6 meV. As seen in Fig. 1, polaritons populate mostly the lowest possible available state. This indicates photon assisted exciton tunnelling from the well of a higher exciton energy level to the one with lower exciton energy, since both QWs are equally populated by the excitation.

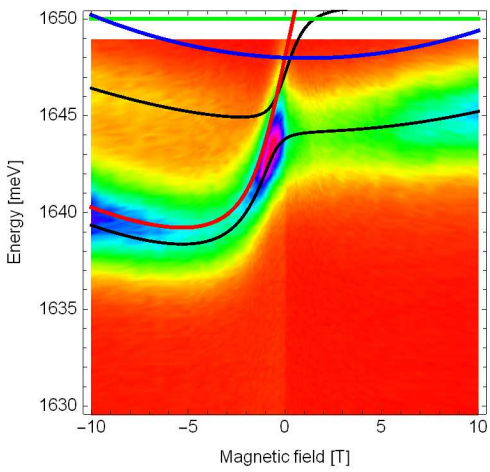

Figure 1: Anti-crossing of the Mn-doped and the non-magnetic QWs levels evidenced in photoluminescence at 1.8 K as a function of the magnetic field. Solid lines represent calculated levels of uncoupled excitons, mode, as well as (in black) polaritons. Negative field values correspond to σ^+ polarization and positive to σ^-.