

Giant Zeeman effect and non-equilibrium exciton-polariton condensation in microcavities with semi-magnetic quantum wells

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Despite the many interesting phenomena predicted theoretically [1] – like resonant Faraday rotation, Meissner effect or spin superfluidity – the experimental investigations of the magneto-optical properties of cavity polaritons are quite limited. For instance in the extensively studied GaAs-based microcavities the Zeeman splitting is of the order of polariton linewidth. Semimagnetic semiconductors offer the opportunity to enhance magneto-optical effects via the exchange interaction between the *d*-shell electrons of a magnetic ion and the *s*-shell electrons and *p*-shell holes of the conduction band of the host material. This *s,p-d* exchange interaction leads to enhanced magneto-optical effects like giant Faraday rotation or giant Zeeman splitting [2].

Our approach to semimagnetic cavity polaritons is based on redesigned structures where magnetic ions are inserted only in the quantum wells, while cavity and distributed Bragg reflectors are made of non-magnetic materials [3] (Fig. 1a). We show that the giant Zeeman effect of polaritons results only from the strong coupling of cavity photons with semimagnetic excitons confined in CdTe quantum wells containing manganese ions. Such a system exhibit strong magneto-optical properties related to the energy shift and polarization of exciton state therefore can be used for tuning exciton-photon energy and also for tuning of the frequency of the Rabi oscillations (Fig. 1b).

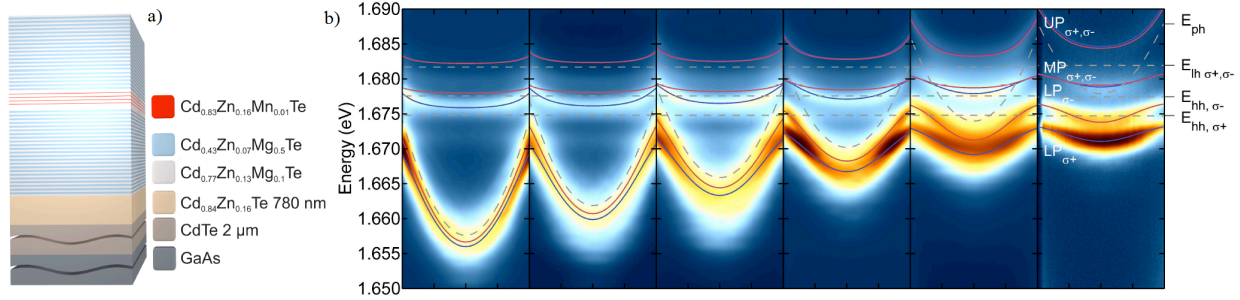


Figure 1. a) Concept of semimagnetic cavity polaritons and the structure of the sample. b) Set of angle resolved photoluminescence maps for various values of the detuning in magnetic field of 5 T. Gray dashed curves figure the calculated energies of uncoupled exciton and photon. Energies of polariton branches are marked by brown (σ^-) and purple (σ^+) curves.

These results pave the way to the study of polariton spinor condensates with enhanced magnetic properties. Under strong excitation we observe a non-linear transition to a non-equilibrium polariton condensate. We demonstrate that the condensation threshold strongly depends on magnetic field. Moreover, the onset of the condensation can be changed by the external magnetic field – with increasing magnetic field the emission from the condensate can be switched on and off, depending on the detuning and the excitation power. Magnetic field introduces the imbalance between spin-up and spin-down polariton densities by tending to align the spins. Therefore, it is an important parameter that allows tuning the interactions between polaritons and influences critical conditions for polariton condensation. This is particularly revealed by the polarization properties of the condensate, which are also strongly affected by magnetic field. At zero magnetic field we observe linearly polarized condensate. As magnetic field increase the condensate becomes elliptically polarized and it's energy is close to the dominant σ^+ circular polarization. Our results open now a wide possibility to experimentally study the magnetic interactions in exciton-polariton non-equilibrium condensates.

[1] A. V. Kavokin in *Exciton Polaritons in Microcavities* edited by D. Sanvitto and V. Timofeev, Springer Series in Solid-State Sciences (2012) [2] J. A. Gaj, R. Planel, G. Fishman, *Solid State Commun.* **29**, 435 (1979) [3] J.-G. Rousset *et al.*, *Appl. Phys. Lett.* **107**, 201109 (2015).