

# POLARITON STIMULATION AND ITS SPIN DYNAMICS IN SEMICONDUCTOR MICROCAVITIES

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Semiconductor microcavities have attracted increasing interest because they allow a precise control of the radiation-matter interaction. This interaction is strongest when the characteristic frequencies of photons (radiation) and excitons (matter) are brought into resonance.

Two different regimes can be established: the strong and weak coupling regimes. In the strong coupling regime (SCR) the eigenstates are no longer pure exciton or photon but a superposition of both, known as cavity-polaritons [1]. The existence, in the SCR, of a polariton-polariton scattering mechanism stimulated by the final state population has drawn a lot of attention. This mechanism is active in a bosonic system, such as cavity polaritons, when the final state population approaches unity. Experimental evidences of this stimulated scattering have been reported recently in the literature [2,3]. The result is a macroscopic polariton occupancy ("condensation") of the states at  $K \sim 0$  and  $K \sim 2k_{\text{pump}}$ , where  $k_{\text{pump}}$  is the incident pump wave vector.

We discuss how the polarization of the light emitted by a semiconductor microcavity can be controlled by varying the detuning between the cavity-mode and the exciton and/or the angle of the emission with respect to the cavity normal. Under high excitation conditions, when the cavity is in a non-linear regime, the emission originates from the cavity-like branch of the polaritons, i.e. the lower polariton branch (LPB) for negative detuning and the upper polaritons branch (UPB) for positive detuning. The time dependence of the polarization, which represents the spin dynamics of the polaritons, shows a very rich and novel behavior in this non-linear regime, as compared to that under low excitation conditions. In the latter case, the polarization decays exponentially to zero after a pulsed excitation, in a similar way to that known for bare excitons in quantum wells, while in the non-linear regime the polarization reaches its maximum at a finite time and furthermore, its sign is strongly dependent on the cavity-exciton detuning ( $\delta = E_C - E_X$ ): it is positive for  $\delta > 0$  and negative for  $\delta < 0$ . The negative polarization is directly related with an energy splitting between the  $\sigma^+$ - and  $\sigma^-$ -polarized components of the emission, which appears when the excitation density drives the cavity into the non-linear regime. In the non-linear regime, for  $\delta < 0$ , we have observed strong oscillations in the time-resolved emission. The period of the oscillations amounts to  $\sim 30$  ps independently of the angle of observation. The angular dependence of the emission, at a negative detuning of  $-13$  meV, shows that although the cavity starts emitting with maximum intensity at  $K \sim 0$ , the intensity is rapidly transferred to  $K \sim 2 \times 10^4 \text{ cm}^{-1}$ , close to the inflection point of the lower polariton branch, giving rise to a ring emission in a cone centered at  $\sim 15^\circ$ . Furthermore, at small angles the polarization of the emitted light reverses its sign with respect to that of the exciting pulses and steadily becomes positive for large angles.

The samples are  $\text{Cd}_{0.40}\text{Mg}_{0.60}\text{Te}$  microcavities of  $n\lambda/2$  thickness ( $n=1$  or  $2$ ), sandwiched between top (bottom) distributed Bragg reflectors (DBRs). Two 90-Å thick CdTe quantum wells are placed at the antinodes of the cavity to obtain the optimum radiation-matter interaction. A slight wedge in the cavity thickness allows tuning the cavity and the exciton into resonance. The samples are excited with 1.5 ps pulses at the first minimum above the stop-band of the DBRs. The emitted light is time- and spectrally-resolved either with an upconversion spectrometer or with a

streak camera, using  $\lambda/4$  plates to excite with  $\sigma^+$  +-polarized pulses and to analyze it into its  $\sigma^+$  - and  $\sigma^-$  -polarized components.

## References

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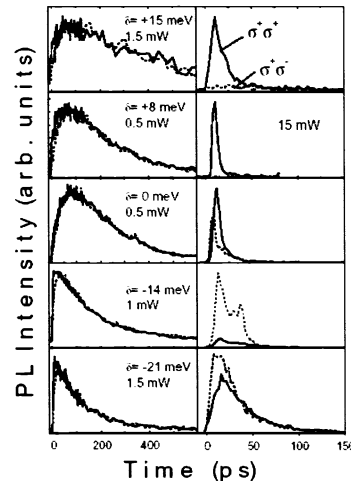


Figure 1. Time dependence of the  $\text{CdTe}/\text{Cd}_{0.4}\text{Mg}_{0.6}\text{Te}$  microcavity emission for different detunings. The left (right) panels correspond to conditions of weak (strong) excitation. Solid (dashed) lines represent co- (counter-) polarized circular emission with respect to that of the exciting pulses. Note that at negative detunings, in the non-linear regime, the  $\sigma^-$  emission is larger than the  $\sigma^+$  -polarized one.

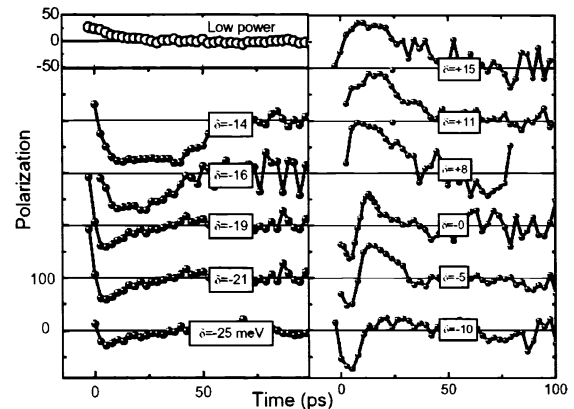


Figure 2. The open circles show the polarization for weak excitation conditions (practically independent of the detuning). Solid circles correspond to the polarization in the nonlinear regime (15 mW excitation power) for different detunings. The polarization reaches very large values and changes from negative to positive close to resonance (0 detuning).

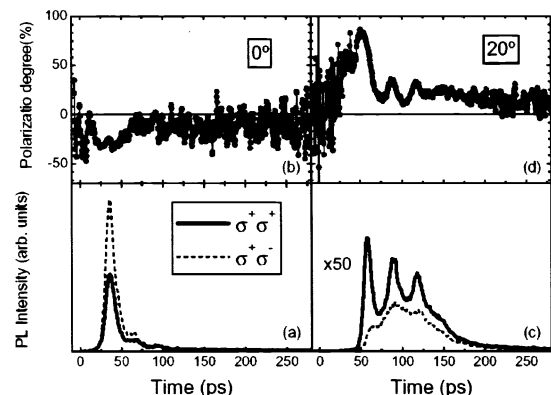


Figure 3. (a) Time evolution of the emission at  $0^\circ$ , analysed into its  $\sigma^+$ - (solid line) and  $\sigma^-$ -components (dotted line). (b) Time evolution of the degree of polarization for  $0^\circ$ . Panels (c) and (d) same as (a) and (b), respectively, detecting at  $20^\circ$ . The data are taken at a negative detuning of  $-13$  meV, exciting with  $\sigma^+$  - polarized pulses at the first minimum of the stop band with a power density of  $45 \text{ W cm}^{-2}$ .