Photon mediated valley depolarization in monolayer WSe_2 embedded in a microcavity

M. Król[1,*], K. Lekenta[1], R. Mirek[1], K. Łempicka[1], K. Polak[1], D. Stephan[1], K. Nogajewski[1,2], M.R. Molas[1,2], A. Babiński[1], M. Potemski[1,2], J. Szczytko[1] and B. Piętka[1]

[1] *Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Poland*
[2] *Laboratoire National des Champs Magnétiques Intenses, CNRS-UGA-UPS-INSA-EMFL, Grenoble, France*
*corresponding author: *mateusz.krol@fuw.edu.pl*

Thin layers of semiconducting transition metal dichalcogenides such as MoS_2, WS_2, $MoSe_2$ and WSe_2 have recently gained significant attention due to their exceptional optical properties, which for single layers of those materials are dominated by particularly strong exciton resonances. The lack of inversion symmetry in their crystal structure leads to two degenerate valleys in the band structure, which can be addressed with polarized light.

In this paper we present an observation of the strong coupling regime between excitons in monolayer tungsten diselenide (WSe_2) and the cavity photons. WSe_2 single-layers were incorporated into an optical cavity built from two SiO_2/TiO_2 dielectric mirrors. The tunability of the cavity (up to 100 meV) was realized by placing one of the mirrors on piezoelectric chip, which allowed for controlling the cavity resonance energy by applying external bias. Dispersion relations of polaritons in our system were measured in a wide temperature range by means of angle-resolved imaging.

An example of representative reflectance and photoluminescence data is shown in Fig. 1. In both cases two polariton branches: upper (UP) and lower (LP) can clearly be seen. They exhibit distinct anti-crossing behavior with the coupling energy of 28 meV. A combination of narrow resonances in high-quality exfoliated WSe_2 flakes and dedicated dielectric mirrors of special design allowed for achieving high splitting-to-linewidth ratio up to 5. The ability to tune the cavity during the experiment gave access to a wide range of exciton–photon energy detunings and to the resonant mixing of bright and dark excitons through the photonic mode.

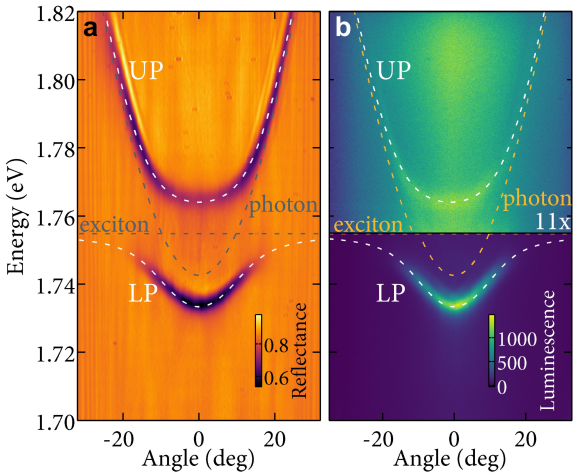

Fig. 1: Angle-resolved reflectance (**a**) and photoluminescence (**b**) spectra illustrating a strong coupling between excitons in a WSe_2 monolayer and the cavity photons.

Under quasi-resonant excitation up to 40% spin retention in the emitted light is observed. Additionally, the degree of circular polarization of luminescence is strongly dependent on the exciton–photon detuning. For energies resonant with the dark exciton, a considerable depolarization of emission is observed. This bright–dark state exchange demonstrates a significant valley depolarization process which is possible in a strongly coupled exciton–photon system.

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