Giant effective trion-polariton Zeeman splitting realized by spin-selective strong light-matter coupling

Thomas P. Lyons[1]
D. J. Gillard[1], C. LeBlanc[2], J. Puebla[3], D. D. Solnyshkov[2], C. Louca[1], P. Muduli[4], A. Genco[1], Y. Otani[3,4], G. Malpuech[2], A. I. Tartakovskii[1]
1. Department of Physics and Astronomy, The University of Sheffield, Sheffield, UK
2. Institut Pascal, PHOTON-N2, Université Clermont Auvergne, Clermont-Ferrand, France
3. CEMS, RIKEN, Wako, Japan
4. ISSP, The University of Tokyo, Kashiwa, Japan
t.lyons@sheffield.ac.uk

Atomically thin quantum materials present a varied ecosystem in which to study emergence in condensed matter, where strongly interacting mixtures of fermions and bosons play host to novel and often unexpected collective phenomena. Here we study the relationship between spin polarization of a two-dimensional electron gas (2DEG) in a monolayer semiconductor (molybdenum diselenide, $MoSe_2$) and light-matter interactions modified by a zero-dimensional optical microcavity [1,2]. We find robust paramagnetism of the 2DEG to simultaneously enhance and suppress trion-polariton formation in opposite photon helicities, leading to observation of a giant effective Zeeman splitting between +K or -K valley trion-polaritons (g-factor >20), exceeding the purely trionic splitting (g-factor =4) by five times. We demonstrate tuning of the 2DEG susceptibility by application of weak continuous-wave laser illumination, allowing optical control of the effective polaritonic Zeeman splitting, amplified by a highly nonlinear response of the valley-specific Rabi splitting. Our experiments achieve the often elusive large mode splitting necessary to support highly unidirectional edge modes in topological polaritonics.

REFERENCES

[1] M. Sidler, et al. *Nature Physics* **13**, 255-261 (2017)
[2] J. G. Roch, et al. *Nature Nanotechnology* **14**, 432-436 (2019)

FIGURES

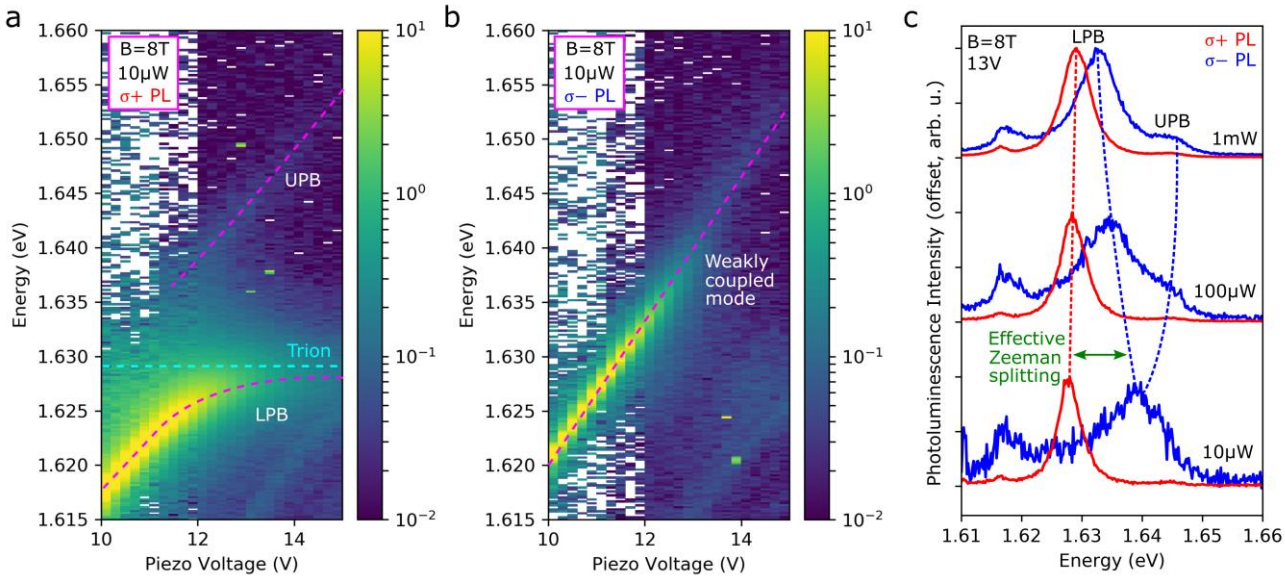

Figure 1: a,b Photoluminescence maps from monolayer $MoSe_2$ hosting a 2DEG embedded inside a tunable optical microcavity. Increasing the piezo voltage decreases the cavity length and tunes the 0-dimensional cavity mode through resonance with the trion state, forming trion-polaritons. At B = 8 T, the 2DEG is spin polarized, enhancing the Rabi splitting in σ^+ (**a**) while completely quenching strong coupling in σ^- (**b**). This leads to a giant effective Zeeman splitting (**c**) exceeding 10 meV. Applying higher laser powers depolarizes the 2DEG, allowing strong coupling in σ^- with associated tuning of the effective Zeeman splitting.