Electrical switching of spin-orbit coupled exciton-polariton condensates in liquid crystal microcavities

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Electrical control over the orientation of nematic liquid crystals in optical cavities allows for varying birefringence and synthetic spin-orbit coupling (SOC) of polaritons in a single compact device [1]. Such control holds promise to help interface strongly nonlinear polariton physics with spintronic and optoelectronic technologies. Recently, hybrid perovskite and liquid crystal microcavities were used to demonstrate electrical switching of a polariton laser (condensate) on-and-off while changing its polarization at the same time [2]. Here, we propose an alternative method to realize electric switching of a polariton condensate in liquid crystal cavities based on three ingredients: (i) strong repulsive polariton-exciton interactions, (ii) gain-selective formation of polariton vorticity, (iii) liquid crystal induced effective SOC of polaritons.

Our analysis is based on the open-dissipative Gross-Pitaevskii equation describing an optically trapped polariton condensate. The excitation scheme is an annular shaped spin-polarized ($\sigma^{\pm}$) nonresonant pump, known to produce stable condensate vorticity [3]. Because of the exciton optical-orientation effect, the pumped polariton spin component is more strongly confined than the opposite spin component. By increasing the strength of SOC, pumped polaritons are converted into the opposite lossy spin component. This eventually drives the system below threshold, switching off the polariton condensate (laser). Interestingly, the signal intensity revives as a function of SOC strength.

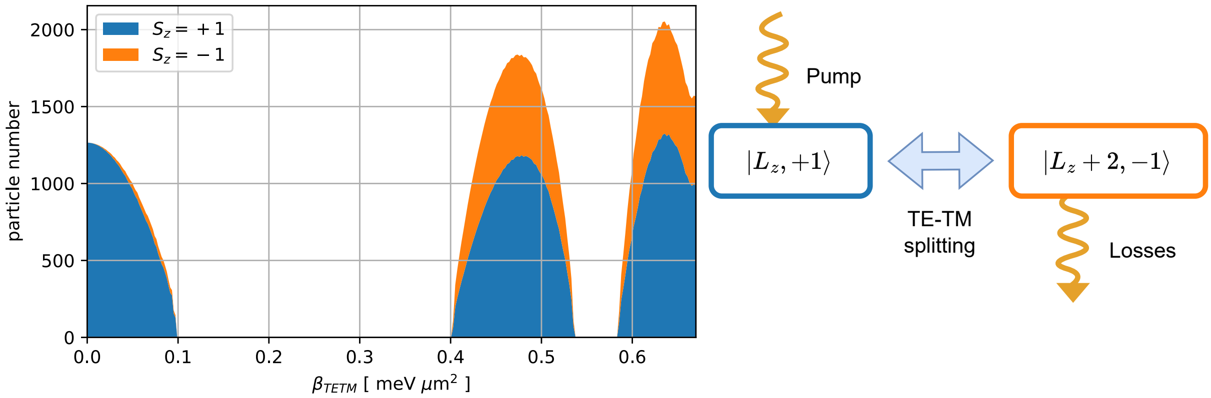

Figure 1: Spin resolved total particle number of the condensate. The condensation threshold shows revivals with increasing strength of SOC (β_{TETM}). A pumped vortex with charge L_z is converted into a leaking vortex with charge $L_z + 2$, conserving angular momentum.

[1] K. Lekenta et al., *Light: Science & Applications*, **7**, 74, (2018).
[2] K. Łempicka-Mirek et al., *Nanophotonics*, **7**, 74, (2024).
[3] X. Ma et al., *Nature Communications*, **11**, 897, (2020).