Occupancy-driven Zeeman suppression and inversion in trapped polariton condensates

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Polariton spin is a degree of freedom that can be used to manipulate the emission properties of polariton condensates. Our study addresses spin-related phenomena, which are difficult to observe due to the relatively weak Zeeman effect of exciton-polaritons in GaAs-based structures. Here, we overcome this limitation by generating optically trapped exciton-polariton condensates, which are known to possess extremely high condensate coherence time and, thus, ultra-narrow spectral linewidths (see Figure 1(a)). This makes it possible to resolve magnetically induced $\sim \mu$eV fine-energy shifts in the condensate, and identify unusual dynamical regions in its parameter space [1]. The continuous control over the polariton confinement allows exploration of two regimes of operation depending on the strength of the polariton-polariton interaction: (1) the full parametric screening of the Zeeman splitting, known as the spin-Meissner effect (see Figure 1(b)) and (2) Zeeman inversion regime, where, upon reaching the critical excitation pump power, the Zeeman splitting reverses (see Figure 1(c)). The transition between regimes occurs by adjusting the size of the optical trap, which controls the strength of the polariton-polariton and polariton-exciton reservoir interactions. We develop a mean field model based on a zero-dimensional generalized Gross-Pitaevskii equation coupled to a rate equation for the exciton reservoir, which qualitatively captures the observed effects.

Optical trapping offers a powerful tool for magneto-optical studies of polariton condensates. The magnetic control, tunability and reconfigurability, bring insights into the properties of the optically trapped polaritons and pave the way for the potential practical application of optically and magnetically controlled polariton systems.

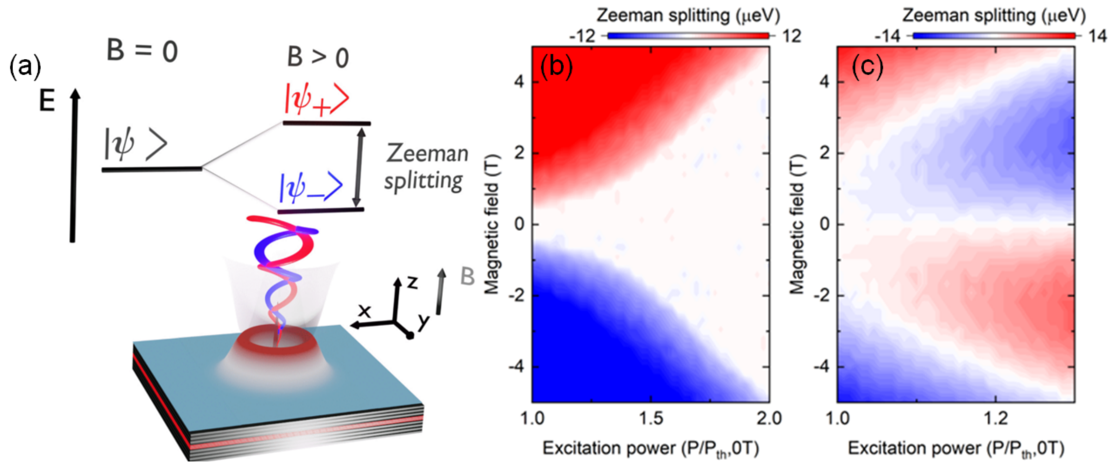

Figure 1: (a) The magnetic field lifts the degeneracy of the polariton spins, manifesting in a detectable energy difference between the emitted circularly polarized photons. Depending on the size of an optical trap, Zeeman splitting (b) vanishes at certain critical boundaries in the B-P plane, becoming parametrically screened by the condensate interactions or (c) reverses its sign after exceeding the critical value of the excitation power.

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