MEASUREMENTS OF POLARITON-POLARITON INTERACTION STRENGTH AND QUANTUM DEPLETION IN OPTICALLY TRAPPED EXCITON-POLARITON CONDENSATES

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Condensates of exciton polaritons in semiconductor microcavities typically coexist and interact with an incoherent excitonic reservoir injected by an optical pump. The reservoir serves both as the gain medium and as a repulsive potential for exciton polaritons, hence directly affecting the formation, coherence, and dynamics of the condensate. Measurements of the most fundamental properties of the exciton-polariton condensate, such as the strength of polariton-polariton interactions, have been hindered by the presence of the reservoir [1], with the reported values for GaAs and InGaAs quantum well microcavities differing by up to four orders of magnitude [3].

By realising a single-shot condensation [2] in an optically-induced “box” trap, our group has successfully created an exciton-polariton condensate in the high-density Thomas-Fermi regime, spatially separated from the incoherent reservoir. This has allowed us to perform a direct measurement of the polariton-polariton interaction strength by measuring the blueshift of the condensate mean-field energy as a function of the polariton density. This measurement, performed for a range of the excitonic fractions in the exciton-polariton quasiparticle, yields values in agreement with theoretical predictions [3].

Beyond this measurement, the high-density Thomas-Fermi regime of exciton-polariton condensation in an optically-induced trap offers a platform for fundamental studies of the non-equilibrium condensate without the influence of the reservoir. In particular, by reaching this regime under continuous wave (cw) optical excitation conditions, we have successfully imaged the so-called “ghost branch” of the dispersion of the elementary excitations, which is populated by the quantum depletion process. Since quantum depletion is a direct consequence of interactions, this observation provides an opportunity for another, independent measurement of the polariton-polariton interaction strength. Our measurement of the quantum depletion in momentum space demonstrates power-law decays of the occupation numbers [4], with a clear transition from equilibrium, Bogoliubov-like behavior for more exciton-like polaritons to a highly nonequilibrium behavior for photon-like polaritons [5]. Remarkably, the polariton-polariton interaction strengths extracted from these measurements [5] are in excellent agreement with our measurements performed in a single-shot regime. The two independent measurements serve to reduce the uncertainty in the values of the polariton-polariton interaction strengths.

References

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