Condensation of cavity exciton-polaritons in perovskite nanocrystals at room-temperature

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Strong light–matter coupling and exciton-polariton condensates have emerged as powerful means of integrating interactions and nonlinearities into a wide array of photonic systems, from low-threshold topological lasers to ultrafast all-optical logic circuits. Colloidal semiconductor quantum dots, featuring strong three-dimensional confinement, offer a particularly appealing active medium for such microcavities due to their tunable structural and compositional properties, straightforward wet-chemical synthesis, and potentially enhanced polaritonic interactions arising from confinement. However, cavity exciton-polariton condensation has not yet been reported in epitaxial or colloidal quantum dots.

In this work [1], we demonstrate room-temperature polariton condensation by embedding a thin film of monodisperse colloidal $CsPbBr_3$ quantum dots within a tunable optical resonator. This resonator incorporates a Gaussian-shaped deformation creating a wavelength-scale potential well for polaritons. Under pulsed optical excitation, we demonstrated the emergence of polariton condensation manifested by a superlinear increase in emission intensity, a narrowing of the emission linewidth, a blueshift (Fig. 1a), and an extension of temporal coherence (Fig. 1b). Our results highlight the potential of perovskite-based colloidal quantum dots, celebrated for their remarkable optical properties and high tunability, as a cutting-edge platform for next-generation polaritonic devices.

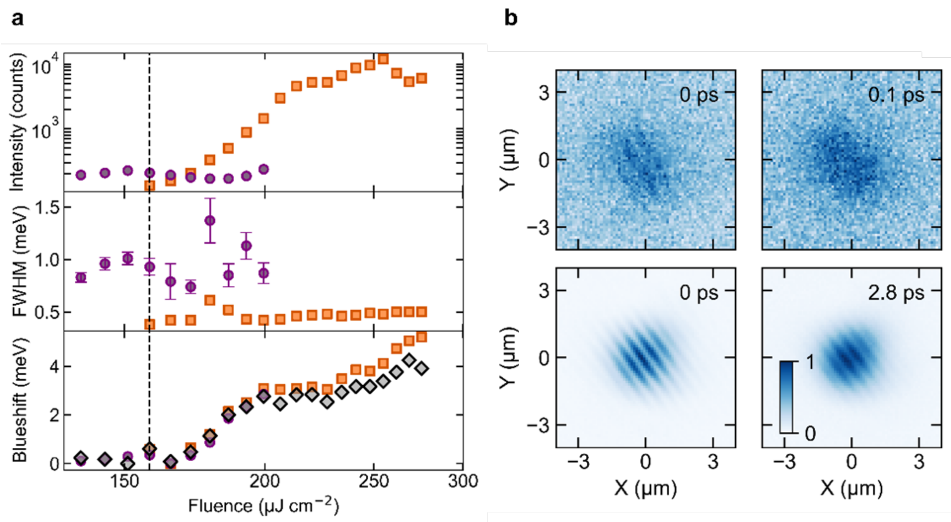

Figure 1: (a) Measurement of the condensation threshold, illustrating how emission intensity (top), emission linewidth (middle), and blueshift (bottom) evolve as excitation fluence increases. The uncondensed ground-state polariton emission is marked by purple circles, the ground-state condensate by orange squares, and the non-condensing first-excited state by gray diamonds. (b) Real-space interferograms of the emitted signal below (top panels) and above (bottom panels) threshold are shown. At $\Delta t = 0$ ps, interference fringes appear in both regimes. Below threshold, these fringes diminish within about 0.1 ps, whereas above threshold, they persist for as long as 2.8 ps.

References

[1] I. Georgakilas et al., *arXiv.2408.10667*, (2024).

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