Experimentelle Physik 2

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Exploring coherence properties of exciton-polariton condensates

Elena Rozas Jimenez

Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund Germany

Addressing the key challenge of engineering future quantum devices based on light-matter interaction involves achieving resourceful and long-term coherent quantum states. To address this challenge, we investigate the quantum features of light-matter interactions in semiconductor systems by engineering trapped coherent states. Thanks to the hybrid character of exciton-polaritons, they offer a broadly applicable framework for exploring time-dependent quantum phenomena. By employing multiport homodyne detection, we simultaneously measure the orthogonal quadratures of the polariton light field, providing comprehensive insight into the system's full-density matrix. Using this technique, we not only access the coherence properties of the system via the second-order correlation function $g^{(2)}(t)$, but also through the reconstruction of phase-space functions such as the Husimi-Q distribution. Intensity- and time-resolved reconstructions of these phase-space distributions allow us to probe the temporal stability of the polariton condensate and the system's potential for quantum information processing via the distribution's phase variance. Comparing our experimental measurements with the model of a displaced thermal state enables us to connect the distribution parameters to the quantum coherence of the system by calculating its coherent and thermal photon numbers. Our results reveal unstable fluctuations in the polariton system due to mode competition and intermittent transitions in and out of the condensate state. These findings pave the way for enhanced resourcefulness over long timescales in quantum information technologies.

[1] C. Lüders et al., Opt. Mater. Express **13**, 2997 (2023).
[2] C. Lüders et al., Phys. Rev. Lett. **130**, 113601 (2023)
[3] C. Lüders et al., PRX Quantum **2**, 030320 (2021)