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COLLOQUIUM „OPTICS AND CONDENSED MATTER“

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Revealing Spontaneous Ultrafast Dynamics in a Driven Polariton Condensate with Quantum-Optical Spectroscopy

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Exciton-polariton condensates are non-equilibrium quantum fluids of light that combine light mass, high propagation velocities and reasonable interaction strengths, which renders them interesting for potential ap- plications in realizing tailored on-chip light sources, neuromorphic computing and simulating complex physical problems. Monitoring polariton dynamics requires strong mode selectivity along with high temporal resolution on the scale of few picoseconds or below. Such measurements are challenging as most commonly available de- tectors do not have sufficient temporal resolution to directly resolve the dynamics arising. One workaround lies in deliberately driving the system to a non-stationary state and monitoring the relaxation towards the steady state using pump-probe spectroscopy or streak cameras and using the drive as trigger signal. However, as a driven-dissipative systems, polariton condensates may also show spontaneous dynamics in their steady state, which so far went unnoticed.

September 1st, starting with discussion at 17:00 h, talk at 17:15 h, live IAP lecture hall or via Zoom
https://uni-bonn.zoom.us/j/98441612025?pwd=a01SSjlkY1Q3SDFhL09JQk1qc1V6dz09
Meeting-ID: 984 4161 2025
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In the talk, I will discuss advanced continuous-variable quantum-optical spectroscopy techniques that hold great promise for applications in semiconductor physics [1] due to their high precision, excellent temporal resolution of about 100 fs and mode sensitivity. As an example, we utilize 16 port pulsed homodyne spectroscopy to iden- tify Josephson oscillations [2] in the steady state of a continuously driven polariton condensate in a photonic molecule consisting of two coupled micropillars. The individual light field quadratures of the emission from the individual pillars do not show any sign of Josephson oscillations, but the correlations between the quadratures show clear oscillations with a period of about 15 ps. Further, I will discuss how homodyne detection enables us to measure $g^{(2)}(0)$ of the polariton condensate within less than 1 ms. Our results demonstrate the enormous potential for continuous-variable quantum-optical approaches in in ultrafast semiconductor spectroscopy.

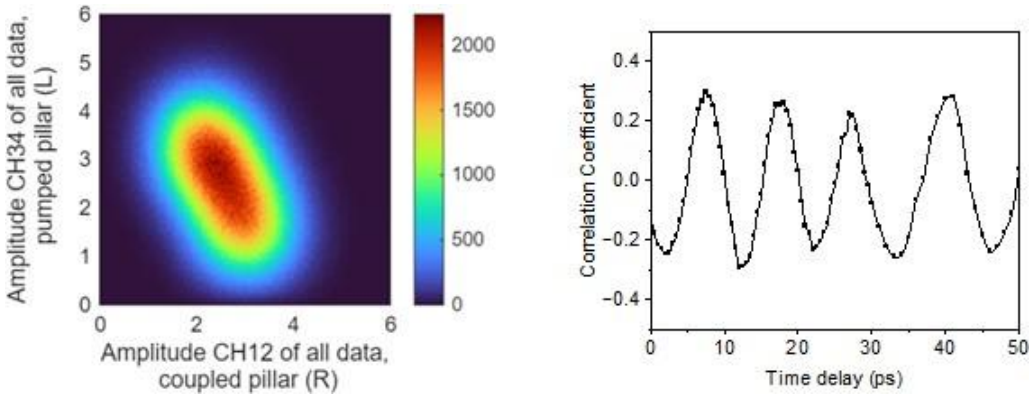

Figure 1: Left: Correlation map of the amplitudes in both pillars at $\tau = 0$. Right: Amplitude correlation coefficient versus delay τ , showing clear Josephson oscillations.

[1] C. Lüders et al., *Continuous-variable quantum optics and resource theory for ultrafast semiconductor spec- troscopy*, Optics Materials Express **13**, 2997 (2023).

[2] M. Abbarchi et al., *Macroscopic quantum self-trapping and Josephson oscillations of exciton polaritons*, Nature Physics **9**, 275 (2013).

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