Floquet optical lattices for exciton-polariton condensates

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Temporal modulation of microcavity exciton-polariton condensates – a macroscopically coherent, hybrid state of cavity photons and quantum well excitons - can be used to controllably drive condensate dynamics, enabling the study of open-dissipative superfluidity and the formation of topological phases. We have used off-resonant driving by the interference of two GHz frequency-offset, structured lasers to demonstrate both transverse [1] and longitudinal [2] dynamics.

In this presentation, I describe the creation of a one-dimensional optical lattice (Fig. 1b) by the angled interference of two quasi-1D beams (Fig. 1a) which drives the formation of tunable artificial bandstructures for polaritons (Fig. 1c). By further introducing a frequency-offset between the two lasers, the optical lattice becomes dynamical, leading to the formation of two-dimensional Floquet-Bloch bands where time plays the role of a synthetic second dimension. The temporal driving causes the bandstructure to become non-reciprocal and acquire a universal tilt connected to the non-trivial topology of the Floquet–Bloch bands.

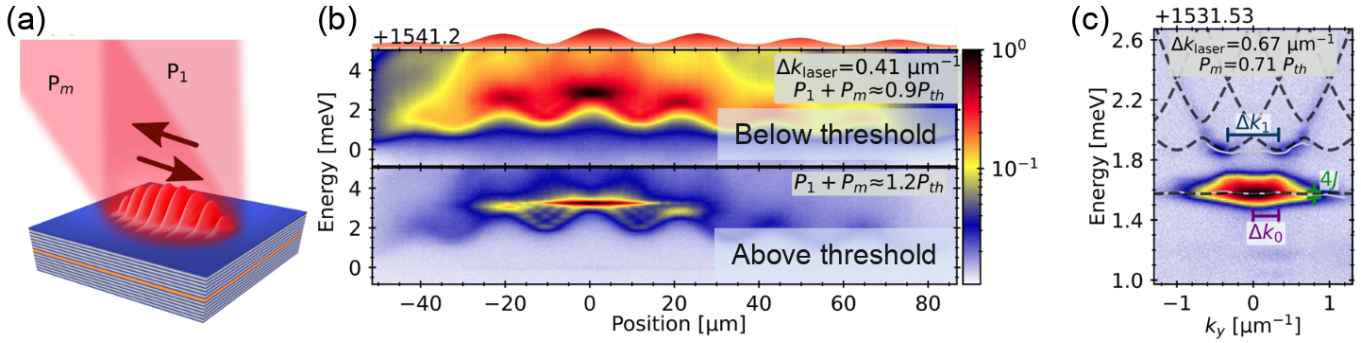

Figure 1: Pumping a polariton microcavity with two angled lasers (a) creates an optical lattice for polaritons (b) driving the formation of synthetic band-structures (c).

Dynamical, incoherent manipulation via pump-induced reservoirs is shown to be a versatile method for driving dynamical states of polariton condensates and holds promise for the engineering of robust non-linear, topological phases of light.

References

[1] Y. dV. I. Redondo *et al. Nano Letters* **23**, 4564 (2023).
[2] Y. dV. I. Redondo *et al. Nature Photonics* **18**, 548 (2024).

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