From Propagation and Coupling to Topological Effects of Exciton-Polariton Condensates in Waveguide Arrays

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After the first report of a phase transition in microcavity exciton-polaritons, numerous studies investigating a variety of fundamental properties arising from their light-matter nature followed: Bose-Einstein condensation, strong non-linearities, superfluidity and vorticity. This has led to the description of polaritons as quantum fluid of light.

While the research of free propagating polariton condensates [1] or in one-dimensional structures [2] has been ongoing, the deterministic coupling of polariton waveguides remained a challenge.

We start by studying the coupling of two waveguides in a co-directional coupler. Here, we use precise dry etching to create a controllable potential barrier between two waveguides. The condensate propagates in a Josephson-like oscillation, allowing us to tune the exit port by its energy or device coupling length [3]. Additionally, further experiments have been able to demonstrate strong polarization dependencies of the condensate when propagating through and out of the coupler system [4].

Continuing, we used a so called etch-and-overgrowth technique to create a tunable photonic potential landscape to design a multi-waveguide array. Here, discrete diffraction could be observed. By adding an energy gradient perpendicular to the propagation direction, the observation of pronounced Bloch oscillations was achieved [5]. Later, by alternating the coupling between waveguides in an array, a topological bandgap opening was observed, leading the way to a topologically-protected propagation of polaritons under resonant and non-resonant excitation [6].

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[2] E. Wertz et al., Nat. Phys. 6, 860–864 (2010)

[3] J. Beierlein et al., Phys. Rev. Lett 126, 075302 (2021)

[4] E. Rozas et al., ACS Photonics 8, 2489–2497 (2021)

[5] J. Beierlein et al., Adv. Opt. Mater 9, 2100126 (2021)

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