Acoustic Landau-Zener-like control of polariton ground-state condensation

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Bose-Einstein condensation (BEC) of microcavity exciton-polaritons requires an efficient process to transfer carriers from the pumped reservoir to the final state. In a typical setting, under non-resonant excitation the condensation pathways are fixed and the condensation process is governed by the incoherent scattering from the reservoir, which often leads to multimode BEC. In the light of recent advances in photonic ground-state (GS) BECs [1,2], it becomes important to realize control mechanisms that allow for the on-demand GS condensation of polaritons. The latter becomes particularly important in spatially confined polariton systems with multiple confined levels. Over the years, different schemes have been realized that allow to dynamically modify the relaxation pathways using, for example, short optical pulses [3] and Lotka-Volterra dynamics [4].

In this work, we demonstrate a concept for the selective condensation in the GS of a multilevel system based on the Landau-Zener-like periodic energy modulation enabled by the large-amplitude GHz-frequency acoustic wave. Phenomenologically, we exploit here the fact that a time-periodic energy modulation, with amplitude ΔE, coherently couples states displaced by the same amount (ΔE). The studies were carried out in microscopic polariton traps in a etch-and-overgrowth-patterned (Al,Ga)As microcavity. We use the strain of the piezoelectrically generated monochromatic 7 GHz BAW to coherently modulate the energy of the excitonic reservoir. For small BAW amplitudes, this leads to sidebands and even strong light-matter-phonon coupling [5]. For large BAW amplitudes, the reservoir undergoes periodic adiabatic avoided crossings through all of the confined levels. Close to the resonance with the levels, the transfer from the reservoir becomes governed by the Rabi-dynamics, which can lead to the predominant occupation of the GS. The time-dynamics of the coherent level population is captured by high-resolution emission spectroscopy, whose temporal autocorrelation reveals a pulsed coherent emission. These results demonstrate the feasibility of a BEC condensation in a chosen state and pulsed laser-like emission at GHz modulation frequencies, and highlight the potential for acoustically induced Floquet engineering of polariton lattices.

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