Experimentelle Physik 2

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Electrically driven polaromechanics: microcavity exciton-polaritons meet piezoelectrically generated GHz phonons

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Engineered coupling between optical, electronic and vibrational degrees of freedom opens a pathway to manipulate light-matter interactions at the nanoscale. On the one hand, excitons can couple strongly to resonant photons, resulting in light-matter exciton-polariton quasiparticles. On the other hand, lattice phonons can couple efficiently to excitons via the deformation potential mechanism. Moreover, interactions between phonons, excitons and photons can be enhanced in semiconductor microcavities (MCs). Such hybrid systems allow to explore rich physics of coherent optomechanical interactions in non-linear driven-dissipative systems. In this talk, I will introduce the emerging field of polaromechanics [1], which studies interactions between non-equilibrium exciton-polariton Bose-Einstein-like condensates [2] and GHz phonons in hybrid phonon-photon (Al,Ga)As MCs [3]. I will describe, how we engineer MCs to enhance the coupling between polaritons and monochromatic GHz phonons that we can inject using piezoelectric transducers [4]. Then, I will discuss the adiabatic interaction between polaritons and phonons, i.e., when the polariton decoherence rate exceeds the phonon frequency, $\gamma pol >> \Omega M$ [5]. I will then show that under strong optical pumping (large polariton populations), polaritons condense and obtain ns-long coherence leading to $\gamma pol << \Omega M$. Following this, I will focus on the experimental phenomena related to this non-adiabatic interaction regime, such as tunable phonon sidebands in the emission. I will show that polariton-phonon interaction rate can be controlled by tuning the phonon population by transducers. Polaromechanical MCs are a powerful platform to study phonon lasing [6], strong polariton-phonon coupling [7], locking of polariton lasers by phonons [8], time crystals [9] as well as applications in microwave-to-optical conversion.

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