Experimentelle Physik 2

Seminar Festkörperphysik (CMP Seminar)

Aktuelle Probleme der Festkörperphysik für Studenten und Mitarbeiter
020236 Kolloquium/Seminar SS 24
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Exciton-Polariton Continuous Time Crystal with an Optomechanical Clock

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Time crystals (TCs) broadly refer to the spontaneous breaking of time translation symmetry in quantum systems paralleling the similar concept of spatial symmetry breaking evidenced in crystalline matter. In this context, so-called discrete time crystals (DTCs) have been demonstrated in diverse physical systems including cold atoms, magnons in superfluid 3He, nuclear spins, photonic devices, and quantum computer qubits. DTC behavior is typically evidenced by the emergence of period doubling upon a time-dependent external drive. Very recently also continuous time crystals (CTCs) have been proposed in dissipative quantum systems perturbed from their equilibrium with a time-independent drive. Here, we reveal, through both ultra-high resolution spectroscopy and time-resolved spatial first-order coherence function g(1)(r,t) experiments, that the exciton-polariton ground state in a trap can develop a non-linear self-sustained dynamics, intimately affected by mechanics in ways that expose characteristics of both CTCs and DTCs. In contrast to other realizations, here the TC phases can be controlled by the power of continuous-wave non-resonant optical drive exciting the condensate and the optomechanical interactions with phonons. Those phases are, for increasing power, (i) Larmor precession of pseudo-spins - a signature of continuous TC, (ii) locking of the frequency of precession to self-sustained coherent phonons - stabilized TC, (iii) doubling of TC's period by phonons - a discrete TC with continuous excitation. Non-Hermiticity, non-linearity, and dissipative coupling between the polariton pseudo-spin states are shown to be critical ingredients for the observation of the spontaneous breaking of time-symmetry in such a many-body quantum system.