Polariton cascade phonon laser

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Phonon lasers, as their photon counterparts, rely on the physics of stimulated emission. Despite their conceptual origin alongside optical lasers in the 1960s, achieving stimulated phonon emission across diverse platforms has faced significant challenges. Recent advances in hybrid quantum systems integrating exciton-polaritons and optomechanics [1] represent a new approach for coherent phonon generation at ultra-high frequencies (20–300 GHz) [2]. We describe laser-like phonon emission in a system that couples exciton-polariton Bose-Einstein condensates (BECs) with phonons in a semiconductor microcavity. The system studied consists of GaAs/AlAs quantum wells embedded in microstructured traps, enabling interaction between cavity-confined optical and vibrational modes. Inspired by the concept of quantum cascade lasers (QCLs), and by theoretical proposals of THz photon bosonic cascade lasers [3], we demonstrate phonon-stimulated emission driven by a polariton condensate cascading down a series of engineered energy levels. Crucially, double phonon and polariton stimulation, strong exciton-mediated optomechanical coupling, and the synchronization dynamics—governed by dissipation and exciton-exciton nonlinearities—are identified as key factors enabling this phenomenon in such a many-body quantum system.

References

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