Coherent manipulation and phonon lasing in electromechanical resonators

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The periodic oscillation of mechanical elements can be regarded as an ensemble of acoustic phonons, described as a phonon coherent state in quantum mechanics. An electromechanical resonator is one of the most ideal phonon cavities, where the phonon ensemble survives much longer than the oscillation period provided that the frequency matches with one of the resonances. The long-lived phonons at different resonance frequencies have much larger probability for mutual nonlinear interaction and novel peculiar dynamics of mechanical oscillation can be activated. GaAs/AlGaAs parametric resonators allow us to electrically control the nonlinear phonon dynamics [1] and provide an excellent platform for the nonlinear phonon interaction. In this talk, we will present our two recent approaches to control the nonlinear dynamics using the semiconductor-based electromechanical resonators. One is to realize all-mechanical phonon lasing using a mechanical three-level system [2]. Highly coherent mechanical oscillation can be generated from incoherent electrical input and this scheme can provide a novel technique to generate highly periodic mechanical oscillation. The other is the coherent phonon manipulation in coupled mechanical resonators [3]. The oscillation in one beam resonator can be quickly annihilated by transferring the energy to the other resonator. This technique can be applied for the rapid manipulation of resonator-based sensors and processors [4]. The highly controllable mechanical devices open up a new direction in the study of the fundamental phonon dynamics, as well as the realization of novel kind of electromechanical systems, including high-speed sensors and actuators, high-frequency filters, and ultra-high energy-efficient phonon processors [5,6].

References

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