Virtual and real dynamical Casimir effects in optomechanical systems

Vincenzo Macrì

RIKEN Theoretical Quantum Physics Laboratory, 2-1 Hirosawa, 351-0198, Wako, Japan

Here we summarize recent theoretical studies on the dynamical Casimir effects (DCEs) in optomechanical systems. We studied the DCE using a fully quantum-mechanical description and without linearizing the dynamics [1]. We have shown that the resonant generation of photons from the vacuum is determined by a ladder of mirror-field vacuum Rabi splitting. We find that vacuum emission can originate from the free evolution of an initial pure mechanical excited state, in analogy with the spontaneous emission from excited atoms. We also show that the DCE can also be driven by incoherent mechanical pumping [2]. We then applied this framework to study the interaction of two mechanical oscillators mediated by the exchange of virtual photon pairs. Specifically, we demonstrated that mechanical quantum excitations can be coherently transferred among spatially separated mechanical oscillators, through a dissipationless quantum bus, due to the exchange of virtual photon pairs [3]. This system can also operate as a mechanical parametric downconverter.

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[3] O. Di Stefano, A. Settineri, V. Macrì, A. Ridolfo, R. Stassi, A. F. Kockum, S. Savasta, F. Nori, "Interaction of mechanical oscillators mediated by the exchange of virtual photon pairs" Phys. Rev. Lett. 122 (3), 030402