Mechanical oscillators coupled to light: Interaction and Cooling

Marc Bienert
Universität des Saarlandes
Germany

Abstract

The technological progress in microfabrication allowed to introduce a new species to the zoo of quantum mechanically controllable systems: Optomechanical devices, whose paradigmatic representative is a Fabry-Perot resonator with an oscillating end-mirror, where the optical and mechanical degree of freedom is coupled by light pressure. Such devices are useful for high precision measurements at the quantum level, as a building block for quantum hybrid systems, and for the construction of "quantum machines". Moreover, they allow to tackle fundamental questions concerning the quantum behavior of mesoscopic bodies.

For the usage of the mechanical element in the quantum realm, it is first necessary to prepare it in a defined quantum state. To accomplish this, techniques similar to laser cooling known from atomic physics can be applied: The radiative coupling between the light field and the mechanical object allows for the reduction of the motional energy and entropy of the oscillator in such an open quantum system.

In this lecture, two fundamental topics of the theoretical description of optomechanical systems will be discussed, namely:

1. How the coupled system of cavity and moving mirror can be quantized in order to find the basic Hamiltonian for optomechanical devices.

2. How the methods from laser cooling can be transferred to optomechanical systems to cool a certain motional mode of the mechanical element down to its quantum ground state.