Q 50: Micromechanical Oscillators I

Time: Thursday 15:15–16:15 Location: A 320

Q 50.1 Th 15:15 A 320

Coupling of ultracold atoms and a mechanical oscillator via an optical lattice — •Stephan Camerer, Maria Korppi, David Hunger, Theodor W. Hänsch und Philipp Treutlein — LMU München und MPQ Garching

We report on the status of an experiment which aims at coupling a single mode of a mechanical oscillator to the motion of trapped atoms. The atoms are trapped in a red detuned 1D optical lattice provided by a laser beam, which is retroreflected at the mechanical oscillators' surface. Motion of the mechanical oscillator causes shaking of the lattice and thus couples to the atomic motion. On the other hand, the motion of the atoms leads to a redistribution of photons between the two running waves forming the lattice and is thus imprinted on the power of the laser beam that is retroreflected at the oscillator. The resulting modulation of the radiation pressure constitutes a backaction of the atoms onto the mechanical oscillator. The goal is to study the dynamics of the coupled system that may be employed to cool a single mode of the mechanical oscillator.

Q 50.2 Th 15:30 A 320

Cooling of nanomechanical resonator via coupling to flux qubits — •Keyu Xia and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

In recent years, the idea of observing quantum phenomena in macroscopic objects raised considerable effort to achieve the mechanical ground state of a micro- or nanomechanical resonator (NAMR). One obstacle is that ground state cooling in most schemes can only be achieved in the so-called resolved or strong-confinement regime [1].

Here, we discuss cooling of a NAMR to its ground state in the weak-confinement regime by coupling it to flux qubits. Our first approach [2] is based on electromagnetically induced transparency (EIT) cooling which was already successfully proposed and implemented for trapped ions [3]. EIT cooling relies on favorable modification of the cooling field absorption spectrum by quantum interference. We show that our scheme has several advantages over previously known cooling mechanisms for NAMRs. Our second approach [4] does not have a straightforward analogy in trapped atoms in ions. It is based on the coupling of two interacting flux qubits to a single NAMR. We demonstrate that collective effects lead to an efficient ground state cooling of the NAMR in the weak-confinement regime.

[1] F. Elste et al., Phys. Rev. Lett., **102**, 207209 (2009)
[2] K. Xia and J. Evers, Phys. Rev. Lett. **103**, 227203 (2009)
[3] G. Morigi et al., Phys. Rev. Lett. **85**, 4458 (2000); F. Schmidt-Kaler et al., Appl. Phys. B **73**, 807 (2001)
[4] K. Xia and J. Evers, arXiv:0912.1990[quant-ph]

Q 50.3 Th 15:45 A 320

Quantum state tomography and squeezed state preparation of a mechanical oscillator — Michael R Vanner[1], •Igor Pikovski[1], Myung S Kim[2], Nikolai Kiesel[1], Klemens Hammerer[3], Caslav Brukner[1], Gerard J Milburn[4], and Markus Aspelmeyer[1] — [1]University of Vienna, Vienna, Austria — [2]Queen's University Belfast, Belfast, United Kingdom — [3]Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, Innsbruck, Austria — [4]The University of Queensland, Brisbane, Australia

We propose a short pulsing scheme which allows squeezed state generation of a mechanical oscillator via projective measurements and complete quantum state tomography. Despite initial thermal occupation, we show that squeezing of the mechanical mode can be observed and low entropy states can be prepared.

Q 50.4 Th 16:00 A 320

Minimizing phonon tunneling losses in optomechanical resonators — •Garrett D. Cole[1], Ignacio Wilson-Rae[2], Michael R. Vanner[1], Simon Gröblacher[1], Johannes Pohl[3], Martin Zorn[3], Markus Weyers[3], Achim Peters[4], and Markus Aspelmeyer[1] — [1]Faculty of Physics, University of Vienna — [2]Department of Physics, Technical University Munich — [3]Ferdinand-Braun-Institute, Berlin — [4]Institute of Physics, Humboldt University Berlin

Micromechanical resonators are a promising means to observe quantum phenomena in macroscopic bodies. Within this emerging field of quantum Optomechanics, the overarching goal is to combine the concepts of quantum optics cavity with radiation-pressure coupling in order to generate and detect quantum states of optomechanical systems. In this regime, resonators of exceptional mechanical and optical quality are required, specifically, these devices must combine both high reflectivity and low mechanical dissipation (high Q) for the vibrational mode of interest. A major challenge in this endeavor is the coupling of the resonator with the external environment. Here, we present experimental and theoretical results for high-performance megahertz resonator based on freestanding epitaxial AlxGa1-xAs Bragg reflectors in which the anchoring to the supports has been engineered to minimize phonon tunneling losses. Compared with dielectric reflectors, the use of a monocrystalline heterostructure gives rise to significant improvements in the achievable Q while simultaneously exhibiting comparably low optical absorption and transmission losses.