Q 1: Mikromechanische Oszillatoren

Zeit: Montag 10:45–12:00 Raum: ESA-A

Q 1.1 Mo 10:45 ESA-A

Ultralow-dissipation optomechanical resonators on a chip — •Georg Anetsberger[1], Rémi Rivière[1], Albert Schliesser[1], Olivier Arcizet[1] und Tobias Kippenberg[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str.1, 85748, Garching, Germany — [2]EPFL Lausanne, 1015, Lausanne, Switzerland

Cavity-enhanced radiation-pressure coupling of optical and mechanical degrees of freedom gives rise to a range of optomechanical phenomena, in particular providing a route to the quantum regime of mesoscopic mechanical oscillators. A prime challenge in cavity optomechanics[1] has been to realize systems that simultaneously maximize optical finesse and mechanical quality. Here we demonstrate, for the first time, independent control over both mechanical and optical degrees of freedom within the same on-chip resonator[2]. The first direct observation of mechanical normal mode coupling in a micromechanical system allows for a quantitative understanding of mechanical dissipation. Subsequent optimization of the resonator geometry enables intrinsic material loss limited mechanical Q-factors, rivalling the best values reported in the high megahertz frequency range, while simultaneously preserving the resonators' ultrahigh optical finesse. As well as providing a complete understanding of mechanical dissipation in microresonator-based optomechanical systems, our results provide a promising setting for cavity optomechanics[1].

[1] T.J. Kippenberg, K.J. Vahala. Science 321, 1172-1176 (2008).

[2] G. Anetsberger, R. Rivière, A. Schliesser, O. Arcizet, T. J. Kippenberg. Nature Photonics 2, 627-633 (2008)

Q 1.2 Mo 11:00 ESA-A

Resolved-sideband laser cooling and measurement of a micromechanical oscillator close to the quantum limit — •Albert Schliesser[1], Remi Riviere[1], Georg Anetsberger[1], Olivier Arcizet[1], and Tobias Kippenberg[1,2] — [1]Max-Planck-Institute of Quantum Optics, Garching, Germany — [2]Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland

The observation of quantum effects in the mechanics of mesoscale objects has been of interest since the inception of quantum mechanics. It would provide new insights in the quantum-classical boundary, opportunities for experimental investigation of the postulates of quantum theory of measurements, and access to the regime of nonclassical states of mechanical motion. Here we closely approach the quantum regime of a mechanical oscillator, discernable by bare eye, and more than three orders of magnitude more massive than typical nanomechanical resonators used in prior work: A silica toroidal optical microcavity, which simultaneously supports a high-quality mechanical radial breathing mode (RBM). Using modest cryogenic pre-cooling to 1.65K, we apply resolved-sideband laser cooling to the RBM and reduce its thermal occupation to 63 ± 20 quanta. Simultaneously, highly sensitive optical interferometric measurements allow approaching the standard quantum limit to within a factor of 5 ± 1.5. Taking measurement backaction into account, this represents the closest approach to the Heisenberg uncertainty relation for continuous position measurements yet demonstrated for mesoscopic oscillators.

Q 1.3 Mo 11:15 ESA-A

Coupling of laser-cooled atoms to a mechanical resonator via an optical lattice — •Stephan Camerer[1], David Hunger[1], Margareta Wallquist[2], Claudiu Genes[2], Klemens Hammerer[2], Peter Zoller[2], Theodor W. Hänsch[1], and Philipp Treutlein[1] — [1]MPQ Garching und LMU München — [2]Universität Innsbruck, Österreich

We investigate ultracold atoms in a 1D optical lattice that is formed by a laser beam retroreflected from a mechanical resonator. The optical lattice serves as a transfer rod which couples vibrations of the cantilever to the atoms and vice versa. As the mechanical resonator oscillates, the center of mass mode of the atoms in the lattice is excited. By applying laser cooling to the atoms, the motion of the mechanical resonator can be sympathetically cooled. We present theoretical investigations of this system and the current status of our experiment.

In combination with cryogenic precooling our system can provide ground state cooling of a single mode of the mechanical resonator. In this limit, the system is an example of a hybrid quantum system. A hybrid quantum system is composed of individual quantum subsystems which are coupled in the sense that information is transferred in both directions. Our system would provide a coherent link between the mechanical motion of ultracold atomic gases and the motion of a massive solid-state object.

Q 1.4 Mo 11:30 ESA-A

Coupling of Bose-Einstein condensates to a micromechanical cantilever via atom-surface forces — •David Hunger[1,2], Stephan Camerer[1,2], Daniel König[2], Jörg P. Kotthaus[2], Jakob Reichel[3], Theodor W. Hänsch[1,2], and Philipp Treutlein[1,2] — [1]Max-Planck-Institut für Quantenoptik, Garching — [2]Ludwig-Maximilians-Universität München — [3]Laboratoire Kastler Brossel, E.N.S., Paris

Micro- and nanostructured mechanical oscillators are presently approaching the quantum regime, driven by the continuous improvement of techniques to read out and cool mechanical motion. By coupling mechanical oscillators to ultracold atoms, hybrid quantum systems could be formed, in which the atoms are used to cool, read out, and coherently manipulate the oscillators' state. For the experimental realization of such systems it is important to investigate different coupling mechanisms.

Here we report experiments in which the vibrations of a classically driven micromechanical oscillator are coupled to the motion of a Bose-Einstein condensate in a magnetic microtrap on a chip. The coupling relies on surface forces experienced by atoms at (sub-) micrometer distance from the mechanical structure. We observe parametric resonances induced by the coupling, corresponding to different mechanical modes of the atoms. Coupling via surface forces does not require functionalization of the oscillator with magnets, electrodes, or mirrors, and could thus be employed to strongly couple atoms to carbon nanotubes or other molecular-scale oscillators.

Q 1.5 Mo 11:45 ESA-A

Cavity optomechanics with a Bose-Einstein condensate — •Christine Guerlin, Ferdinand Brennecke, Stephan Ritter, Kristian Baumann, Tobias Donner, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zürich, CH-8093, Switzerland

In our experiment we study the coupling between a Bose-Einstein condensate and an ultrahigh-finesse optical cavity. The tremendous degree of control over atomic gases achieved in Bose-Einstein condensates combined with the rich field of cavity quantum electrodynamics opens access to a wealth of new physics, ranging from studies of the coupling between quantized light and coherent matter to the implementation of tools for quantum communication.

In the dispersive regime, our system realizes a model of cavity optomechanics. This research field typically studies the coupling of the mechanical degree of freedom of one of the cavity mirrors to the light field via radiation pressure. In our case, the mechanical oscillation is given by a coherent and periodic density modulation of the atomic cloud driven by dipole forces due to the cavity light field. We have observed this density modulation and very strong optical nonlinearities, present even at the single photon level. Furthermore our micromechanical oscillator naturally starts in its ground state, from which a single motional excitation can cause a shift of the cavity resonance on the order of the cavity linewidth. Our system is therefore promising to study the quantum regime of cavity optomechanics. We hope to reveal signatures of the quantum nature of the light and matter fields in further experiments.