HL 32: Focused Session: Quantum optomechanics

Time: Wednesday 14:00–15:30 Location: HSZ 01

Topical Talk HL 32.1 Wed 14:00 HSZ 01

Cavity Optomechanics using Optical Microresonators — •Tobias Kippenberg[1,2], Albert Schliesser[2], Remi Riviere[2], and Olivier Arcizet[2] — [1]Ecole Polytechnique Federale de Lausanne (EPFL) — [2]Max Planck Institut fuer Quantentoptik (MPQ)

In this talk I will describe the advances the Max Planck Institute of Quantum Optics has made in the field of cavity optomechanics. Using on chip micro-cavities that combine both optical and mechanical degrees of freedom in one and the same device(2), we have been able to show that the radiation pressure back-action of photons can be used to passively cool3 the mechanical oscillator, akin to Doppler Cooling of Atoms. Furthermore, we have been able to demonstrate for the first time resolved sideband cooling(4) by using optical microresonators whose mechanical oscillator frequency exceeds the cavity decay rate. This technique is well known in Atomic Physics to provide ground state cooling. Moreover the ability to monitor the motion of the oscillator with a quantum limited sensitivity attometer will be discussed and a description of our quest to ever lower phonon occupancies using cryogenic exchange gas cooling to 1.6 K will be described, which has allowed to reach a final occupancy of only 68 +/- 20 phonons. (1) Kippenberg, T. J. & Vahala, K. J. Science 321, 1172 (2008). (2)Kippenberg, T. J., Rokhsari, H., Carmon, T., Scherer, A. & Vahala, K. J. Physical Review Letters 95, 033901 (2005). (3) Schliesser, A., Del'Haye, P., Nooshi, N., Vahala, K. J. & Kippenberg, T. J. Physical Review Letters 97, 243905 (2006). (4) Schliesser, A., Riviere, R., Anetsberger, G., Arcizet, O. & Kippenberg, T. J. Nature Physics 2008 (2008).

Topical Talk HL 32.2 Wed 14:30 HSZ 01

Experimental quantum optical control of micromechanical resonators — •Markus Aspelmeyer — Institute for Quantum Optics and Quantum Information (IQOQI), Austrian Academy of Sciences, Vienna, Austria

Experiments on massive mechanical resonators are now approaching the quantum regime. This opens up not only a spectrum of new applications but it also promises access to a previously inaccessible parameter range for macroscopic quantum experiments.

Quantum optics provides a rich toolbox to prepare and detect quantum states of mechanical systems, in particular by combining nano- and micromechanical resonators with high-finesse cavities. I will review our recent experiments in Vienna on laser cooling micromechanical systems towards the quantum ground state by using radiation pressure. I will also discuss the prospects and experimental challenges of generating optomechanical entanglement, which is at the heart of Schrödinger's cat paradox and which is also essential for future quantum hybrid architectures.

Topical Talk HL 32.3 Wed 15:00 HSZ 01

Optomechanical correlations between light and mirrors — •Antoine Heidmann, Pierre-Francois Cohadon, and Tristan Briant — Laboratoire Kastler Brossel, Paris, France

Recent progress in high-finesse optical cavities and mechanical resonators allows one to reach a new regime in which the dynamical properties of an optomechanical system are governed by the radiation pressure exerted by light on mirrors. This optomechanical coupling leads to quantum limits in ultra-sensitive interferometric measurements such as gravitational-wave detectors, but also to very efficient laser-cooling mechanisms. This may help to reach the quantum fundamental state of a macroscopic mechanical resonator, by cooling a micromirror down to a temperature unreachable by other conventional techniques.

To experimentally study this optomechanical coupling, we monitor in a very high-finesse cavity the displacements of moving mirrors, either coated on a cm-size silica substrate or on a silicon micro-resonator. We have recently observed the optomechanical correlations induced by radiation pressure between a tiny classical intensity noise of a light beam and the resulting mirror displacements. This scheme can be extended down to the quantum level and has applications both in high-sensitivity measurements and in quantum optics.