Q 56: Optomechanics II

Time: Friday 14:30–15:45 Location: P 4

Q 56.1 Fri 14:30 P 4

Stable Zerodur optical benches for space applications — •Ioannis Drougkakis[1,2], Konstantinos Mavrakis[1,2], Konstantinos Poulios[1], Dimitris G Papazoglou[1,2], and Wolf von Klitzing[1] — [1]Institute of Electronic Structure and Laser, Foundation for Research and Technology-Hellas, P.O. Box 1527, 71110, Heraklion, Greece — [2]Department of Material Science and Technology, University of Crete, P.O. Box 2208, 71003, Heraklion, Greece

A large number of optical systems used in space applications, require stable optical benches that are extremely robust, reliable and efficient. A major challenge in these applications is coupling light into single mode optical fibers after having traversed a number of active and passive optical elements. This leads to high level of complexity for the benches and for the subcomponents used. As a consequence of trade-offs between robustness, complexity, reliability and constrains in manufacturing, coupling efficiencies lie typically from 50% to 80% at the cost of an increased complexity of their sub-components and procedures. Here we report a novel scheme, which allows precise beam-steering for fiber-free space-fiber systems on a Zerodur breadboard using optical wedges and flats. Our approach greatly reduces the precision required for the sub-components as well as the complexity of the fiber couplers used. We present an in-depth theoretical treatment of the optical scheme, using both analytical and numerical simulations. We corroborate the results of the simulations with preliminary tests performed.

Q 56.2 Fri 14:45 P 4

THz radiation emission by phonon-polariton coupling in a semiconductor microcavity — •Katharina Rojan[1,2,3], Giovanna Morigi[3], Maxime Richard[4,5], and Anna Minguzzi[1,2] — [1]Université Grenoble Alpes, LPMMC, Grenoble, France — [2]CNRS, LPMMC, Grenoble, France — [3]Theoretische Physik, Universität des Saarlandes, Saarbrücken, Germany — [4]Université Grenoble Alpes, Institut Néel, Grenoble, France — [5]Université Grenoble Alpes, Institut Néel, Grenoble, France

We suggest a scheme to generate THz radiation emission out of a semiconductor microcavity in the strong coupling regime. For this purpose we consider a model of interacting excitons, photons, and phonons which we describe by coupled Heisenberg-Langevin equations. We investigate the conditions necessary to achieve and optimize the THz emission and analyse the characteristics of the emitted photons. Furthermore we discuss a possible experimental realization using state-of-the-art semiconductor microcavities.

Q 56.3 Fri 15:00 P 4

Two dimensional optomechanical crystals for quantum optomechanics — •Hannes Pfeifer[1], Greg MacCabe[2,3], Hengjiang Ren[2,3], and Oskar Painter[2,3] — [1]MPI for the Science of Light, Erlangen, Germany — [2]Kavli Nanoscience Institute, California Institute of Technology, Pasadena, USA — [3]Institute for Quantum Information and Matter and Thomas J. Watson, Sr., Laboratory of Applied Physics, California Institute of Technology, Pasadena, USA

Cooling of nanomechanical resonators to their motional ground state triggered recent achievements like non-classical mechanical state preparation or coherent optical to microwave photon conversion. Implementations through optomechanical crystal (OMC) resonators use co-localization of optical and acoustic modes in a patterned device layer of a silicon-on-insulator (SOI) chip. Their operation at small thermal mechanical mode occupations and mechanical Q-factors $\gtrsim 10^6$ requires pre-cooling to millikelvin temperatures, where even weak optical absorption induces unfavorable local heating. Commonly used one-dimensional nanobeam OMC resonators have significantly smaller thermal connectivity to the cool environment and reduced robustness against undesired heating than their two-dimensional counterparts. A drawback of 2D OMCs were their complex fabrication and weaker interaction of acoustic and optical modes. Here, we present a modified 2D OMC cavity that exhibits coupling strengths comparable to the previous nanobeams and reduces the complexity for nanofabrication compared to other 2D OMCs. It uses a mechanical mode at 11 GHz and creates a high Q optical cavity at telecom wavelengths.

Q 56.4 Fri 15:15 P 4

Novel approaches to optomechanical transduction — •Ondrej Cernotik and Klemens Hammerer — Institute for Theoretical Physics, Institute for Gravitational Physics (Albert Einstein Institute), Leibniz University Hannover

In recent years, mechanical oscillators received attention as a promising tool for frequency conversion between microwaves and light. A general, bidirectional transducer with high efficiency is still far from reach of current technology; finding new strategies for optomechanical transduction allows us to relax the requirements and bring these systems closer to an experimental realization. An interesting example is generation of entanglement between two superconducting qubits using measurement and postselection. Here, the mechanical oscillators interacts directly with the superconducting transmon qubit in such a way that it feels a qubit-state dependent force. This force can then be read out using a cavity field; reading out two such systems sequentially realizes an effective total spin measurement. Starting from a suitable initial state and employing postselection, entanglement can be generated. Another interesting approach is to use an array of optomechanical transducers in which the output fields of one transducer are fed into the input of the next. The periodicity of the array results in a joint dispersion relation for the propagating microwave and optical fields. The resulting structure can be used to control the conversion bandwidth and forward and backward scattering.

Q 56.5 Fri 15:30 P 4

Collective atom-light interactions in an atom-optomechanical system — •Aline Faber[1], Tobias Kampschulte[2], Niels Lörch[1], Klemens Hammerer[3], and Philipp Treutlein[1] — [1]Universität Basel, Departement Physik — [2]Universität Ulm, Institut für Quantenmaterie — [3]Universität Hannover, Institut für theoretische Physik

Collective effects in atomic ensembles originating from the dispersive atom-light interaction have been observed in optical cavities but are not well studied in free space systems.

Here we report on an experiment with our hybrid atom-membrane system in which light-mediated atom-atom interactions in a free space ensemble strongly influence the atom-membrane dynamics. In our system the fundamental vibration of a Si_3N_4 membrane is coupled to the motion of atoms in an optical lattice over a macroscopic distance via the lattice light itself. Collective effects between the atoms lead to a significant phase delay in the atomic back-action onto the lattice light which induces an instability in the coupled system if the coupling is large enough. The latter can be observed by probing the membrane displacement. In this experiment the membrane thus acts as a sensitive detector for the collective atomic-light interactions, demonstrating the possibilities of the hybrid system for sensing and signal transduction.