TT 32: Transport: Nanomechanics and Optomechanics (jointly with CPP, DY, BP, DF)

Time: Tuesday 14:00–15:15 Location: HSZ 201

TT 32.1 Tue 14:00 HSZ 201

Classical Stückelberg interferometry of a nanomechanical two-mode system — •Maximilian Seitner[1,2], Hugo Ribeiro[3], Johannes Kölbl[1], Thomas Faust[2], Jörg Kotthaus[2], and Eva Weig[1,2] — [1]Departement of Physics, University of Konstanz, 78457 Konstanz, Germany — [2]Center for NanoScience (CeNS) and Fakultät für Physik, Ludwig-Maximilians-Universität, Geschwister-Scholl-Platz 1, München 80539, Germany — [3]Department of Physics, McGill University, Montreal, Quebec, H3A 2T8, Canada

Stückelberg interferometry is a phenomenon well established for quantum mechanical two-level systems. Here, we present classical two mode interference of a nanomechanical two-mode system, realizing a classical analog of Stückelberg interferometry. Our experiment relies on the coherent energy exchange between two strongly coupled, high quality factor nanomechanical resonator modes. Furthermore, we discuss an exact theoretical solution for the double passage Stückelberg problem by expanding the established finite time Landau-Zener single passage solution. For the parameter regime explored in the experiment, we find the Stückelberg return probability in the classical version of the problem to formally coincide with the quantum case which reveals the analogy of the return probabilities in the quantum mechanical and the classical version of the problem. This result qualifies classical two-mode systems at large to simulate quantum mechanical interferometry.

TT 32.2 Tue 14:15 HSZ 201

Transmon qubits meet cavity electromechanics — •P. Schmidt[1,2,3], D. Schwienbacher[1,2,3], M. Pernpeintner[1,2,3], F. Wulschner[1,2,3], F. Deppe[1,2,3], A. Marx[1,2], R. Gross[1,2,3], and H. Huebl[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Germany — [2]Physik-Department, TUM, Germany — [3]Nanosystems Initiative Munich, Germany

In cavity electromechanics, quantum mechanical phenomena can be studied in the literal sense. For the preparation of mechanical (phonon) Fock states, the integration of a sufficiently nonlinear circuit element is of key importance. Here, we present a hybrid system consisting of a superconducting coplanar microwave resonator coupled to a nanomechanical beam and a transmon qubit acting as nonlinear circuit element. In this way circuit QED is combined with the world of circuit electronanomechanics. We show continuous wave spectroscopy data for the transmon qubit as well as the nano-mechanical beam. The ac-Stark shift of the transmon qubit as well as electromechanically induced absorption measurements allow us to determine the microwave photon number in the microwave resonator for two opposite power regimes, differing by ten orders of magnitude. In both regimes we find qualitatively the same dependence of the photon number on the power applied to the microwave resonator. Our experiments demonstrate the successful combination of circuit QED and nanomechanics.

TT 32.3 Tue 14:30 HSZ 201

Frequency tuning and coherent dynamics of two nanostring resonators in the strong coupling regime — Matthias Pernpeintner[1,3], •Daniel Schwienbacher[1,2,3], Philip Schmidt[1,2,3], Rudolf Gross[1,2,3], and Hans Huebl[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Germany — [2]Physik-Department, Technische Universität München, Germany — [3]Nanosystems Initiative Munich (NIM), Germany

Coupled nanomechanical resonators are prime examples for studying synchronization effects and nonlinear dynamics. Additionally, high-quality resonators are considered as building blocks for all-mechanical information processing platforms [1,2].This, however, requires the possibility to tune the relevant mode frequencies independently and to operate the resonators in the strong coupling regime. Here, we present a possible realization consisting of two high-quality ($Q \approx 10^5$) SiN nanostring resonators in the MHz regime, coupled mechanically by a shared support. We demonstrate that the fundamental mode frequencies of both nanostrings can be tuned independently by a strong drive tone resonant with one of the higher harmonic modes. We investigate the coherent dynamics of the two strongly-coupled nanostring resonators acting as an effective classical two-level system. We discuss the observation of classical Rabi oscillations and classical Landau-Zener dynamics indicating coherent and selective phonon transfer between two spatially separated mechanical resonators.

[1] Hatanaka et al., Appl. Phys. Lett. **102**, 213102 (2013)
[2] Mahboob et al., Sci. Rep. **4**, 4448 (2014).

TT 32.4 Tue 14:45 HSZ 201

High Quality Factor Mechanical Resonator based on encapsulated $NbSe_2$ Membranes — •Markus Müller[1], Marco Will[1], Matthew Hamer[2], Roman Gorbachev[2], Adrian Bachtold[3], Christoph Stampfer[1], and Johannes Güttinger[1] — [1]JARA-FIT and 2nd Institute of Physics, RWTH Aachen University, 52074 Aachen — [2]School of Physics and Astronomy and Manchester Centre for Mesoscience and Nanotechnology, University of Manchester, Oxford Road, Manchester M13 9PL — [3]ICFO-Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels, Barcelona

Nanomechanical resonators based on 2d materials show high mechanical quality factors and extraordinary force sensitivities. A common problem limiting graphene based resonators are electronical losses due to charge movements induced by mechanical motion or the electrical readout. One promising way to overcome this issue are superconducting 2d membranes potentially suppressing electrical losses. Here we demonstrate a hybrid membrane composed of superconducting three layer thick $NbSe_2$ encapsulated in 1-2 layers of graphene. The resonator is probed by means of capacitive coupling to a superconducting microwave cavity enabling high precision readout of the resonance frequency. We measure a mechanical quality factor of over 200,000 showing the general applicability of such heterostructures in resonators. Additionally, the quality factor is more stable in comparison to graphene only resonators when varying the gate voltage, which can be attributed to a reduced electrical resistance.

TT 32.5 Tue 15:00 HSZ 201

Hypersound spacerless cavities — •M. Esmann[1], F. Lamberti[1], O. Krebs[1], L. Lanco[1], I. Favero[2], P. Senellart[1], A. Lemaître[1], C. Gomez[1], and N.D. Lanzillotti-Kimura[1] — [1]Centre de Nanosciences et des Nanotechnologies, CNRS, Université Paris-Sud, Université Paris-Saclay, 91460 Marcoussis, France — [2]Université Paris Diderot, Sorbonne Paris Cité, Laboratoire Matériaux et Phénoménes Quantiques, CNRS-UMR 7162, 75013 Paris, France

We introduce new strategies to engineer and study semiconductor nanostructures capable of confining, controlling the propagation, and manipulating acoustic phonons in the GHz-THz frequency range. Superlattices work as high reflectance phononic mirrors and constitute a fundamental building block for the conception of more complex devices. Acoustic cavities are capable of confining and amplifying the hypersound field both spatially and in the spectral domains. Usually, an acoustic cavity is formed by two identical distributed Bragg reflectors embedding an acoustic spacer, acting in a similar way to a Fabry-Perot resonator. We design a novel kind of phononic cavities where no spacer is needed, based on the engineering of the phonon phase in the interface between two superlattices. Such kind of resonators can be combined in coupled-acoustic cavity structures such as molecules and coupled-resonator waveguides able to evidence novel physical phenomena such as acoustic Bloch oscillations.

[1] A. Fainstein et al. PRL 110, 037403 (2013)
[2] M. Xiao et al. Nature Physics 11, 240 (2015)