TT 18: Nano- and Optomechanics

Time: Monday 17:15–18:30 Location: HSZ 201

TT 18.1 Mon 17:15 HSZ 201

Microwave optomechanics of the transversal carbon nanotube vibration — •Akong Loh, Fabian Stadler, Furkan Özyigit, Nicole Kellner, Niklas Hüttner, and Andreas K. Hüttel — Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany

Recently, optomechanical coupling of a carbon nanotube and a coplanar microwave resonator has been achieved[1,2]. In this case, the nanotube acts as a mechanical resonator as well as a quantum dot. The coupling is enhanced by several order of magnitude by via the nonlinearity of Coulomb blockade. This novel optomechanical system presents several interesting features. For optimized paramters, e.g., strong optomechanical coupling (with hybridization of vibrons and photons) and the quantum coherent limit (where manipulation is faster than thermal decoherence) could be reached. Significant improvements of our microwave resonators have recently been achieved. Ongoing work aims to optimize the mechanical resonator, via improving the nanotube growth and the transfer of the nanotubes onto the resonator chip, as well as the cryogenic millikelvin setup for the measurements.

[1] S. Blien *et al.*, Nat. Comm. 11, 1636 (2020)
[2] N. Hüttner *et al.*, in preparation.

TT 18.2 Mon 17:30 HSZ 201

Squeezed mechanical states in nano-electromechanical systems — •Korbinian Rubenbauer[1,2,3], Thomas Luschmann[1,2,3], Rudolf Gross[1,2,3], and Hans Huebl[1,2,3] — [1]Walther-Meißner-Institut, Bayrische Akademie der Wissenschaften, Garching, Germany — [2]Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — [3]Munich Center for Quantum Science and Technologies, Munich, Germany

The generation of nonclassical quantum states in a mechanical system such as squeezed states is not only an essential milestone for quantum-enhanced sensing of ultra-small forces and accelerations, but will also enhance our understanding of the foundations of quantum theory. Optomechanical systems coupling a mechanical displacement to a microwave resonator represent one way to implement protocols resulting in squeezed mechanical states and their readout. Here, we experimentally explore a scheme for the generation and detection of squeezed mechanical states using microwave control and spectroscopy of a nanoelectromechanical system. In detail, we investigate a system based on a nanomechanical string resonator inductively coupled via a SQUID to a superconducting microwave resonator. Within this presentation, we discuss the challenges regarding the experimental implementation and the required parameter regime, and present preliminary experimental data.

TT 18.3 Mon 17:45 HSZ 201

Nanowire deflection detection based on a coupled mechanical oscillator — Maneesha Sharma, Aniruddha Satyadharma Prasad, Norbert H. Freitag, Bernd Büchner, and •Thomas Mühl — Leibniz Institute for Solid State and Materials Research IFW Dresden, 01069 Dresden, Germany

The field of nanowire (NW) technology represents an exciting and steadily growing research area with applications in ultra-sensitive mass and force sensing. Existing detection methods for NW deflection and oscillation include optical and field emission approaches. However, they are challenging for detecting small diameter NWs because of heating produced by the laser beam and the impact of the high electric field. Alternatively, the deflection of a NW can be detected indirectly by co-resonantly coupling the NW to a cantilever and measuring it using a scanning probe microscope. Here, we prove experimentally that co-resonantly coupled devices are sensitive to small force derivatives in a similar way as standalone NWs do. We detect force derivatives as small as 10^{-9} N/m with a bandwidth of 1 Hz at room temperature. The detection technique presented in this work verifies a major step in boosting NW-based force and mass sensing.

TT 18.4 Mon 18:00 HSZ 201

Symmetry breaking in a parametrically modulated quantum oscillator — •Daniel Boness[1], Mark Dykman[2], and Wolfgang Belzig[1] — [1]Department of Physics, University of Konstanz, 78457 Konstanz, Germany — [2]Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824, USA

A weakly damped nonlinear oscillator modulated close to twice its eigenfrequency has two stable states, which have the same vibration amplitudes but opposite phases. The states are equally populated due to classical or quantum fluctuations.

An extra force at half the modulation frequency lifts the symmetry of the states, generally. We study how the symmetry breaking occurs in the quantum regime.

As we show, a significant change of the state populations can take place already for a weak extra force. The mechanism is the force-induced change of the rates of interstate switching. The change is exponential in the ratio of the force amplitude to the appropriately scaled quantum length. It is large even where the effect of the force on the mean-field oscillator dynamics is small.

TT 18.5 Mon 18:15 HSZ 201

Quantum friction between metals in the hydrodynamic — •Kunmin Wu, Thomas Schmidt, and Maria Belén Farias — Faculty of Science, Technology and Medicine, 162 A, avenue de la Faïencerie, L-1511 Luxembourg

In this work, we study the phenomenon of quantum friction in a system consisting on a moving atom at a constant speed parallel to a metallic slab. We use a hydrodynamic model to describe the degrees of freedom of a clean metal without internal dissipation. The moving and polarizable atom is modeled as a two-level system with a unique $(l = 0)$ ground state and a three-fold degenerate $(l = 1)$ excited state. We show that a quantum frictional force is present even in the absence of intrinsic damping in the metal, but that there is a velocity threshold giving rise to such a force. In particular, to have non-vanishing friction demands that the atom must move at a velocity larger than the effective speed of sound in the material. We provide analytical arguments to show that this result holds at all orders in perturbation theory. Besides, we also explore how the spatial dispersion, which is determined by the sound speed in the hydrodynamic regime, affects the friction. Our numerical results show that the spatial dispersion has less effect on the friction when the speed of atom is much higher than the sound speed.