TT 45: Nano- and Optomechanics

Time: Tuesday 11:45–13:00 Location: H 0110

TT 45.1 Tue 11:45 H 0110

Nanomechanical characterization of the Kondo charge dynamics in a carbon nanotube — Karl J. G. Götz, Daniel R. Schmid, Felix J. Schupp, Peter L. Stiller, Christoph Strunk, and •Andreas K. Hüttel — Institute for Experimental and Applied Physics, University of Regensburg, 93053 Regensburg, Germany

Suspended single wall carbon nanotubes are at cryogenic temperatures both extraordinary nanomechanical systems and clean and defect-free single electron devices. By measuring the gate voltage dependence of the transversal vibration frequency, the evolution of the charge on a quantum dot embedded in the nanotube can be evaluated.

We apply this technique to the limit of strong Kondo correlations between a nanotube quantum dot and its contacts. The current through the nanotube displays a clear odd-even pattern, with a zero-bias conductance anomaly at odd electron number. The charge on the quantum dot, however, shows no such odd-even pattern, and can be well modeled via sequential tunneling only. We conclude that the Kondo current is carried via virtual occupation of the quantum dot alone, without impact on the vibration. This is in excellent agreement with recent results coupling a nanotube to a coplanar waveguide resonator.

In addition, the simultaneous detection of charge and current signal allows us to compare the gate potentials where on one hand the current is maximal and on the other hand the charge in the quantum dot increases. Here, a distinct relative shift is observed, which decreases logarithmically with temperature, displaying the typical scaling of the Kondo effect.

TT 45.2 Tue 12:00 H 0110

Nano-electromechanics with High Impedance Superconducting Microwave Resonators and Aluminum Strings — •L. Rosenzweig[1,2], D. Schwienbacher[1,2,3], P. Schmidt[1,2,3], M. Pernpeintner[1,2,3], C. Utschick[1,2], R. Gross[1,2,3], and H. Huebl[1,2,3] — [1]Walther-Meißner-Insitut, Garching, Germany — [2]Physik-Departement, Technische Universität München, Garching, Germany — [3]Nanosystems Initiative Munich, München, Germany

In optomechanics the interaction of light with a tailored phononic state is studied. Replacing optical cavities by superconducting microwave resonators defines the subfield of nano-electromechanics. These circuits benefit from high-Q microwave resonators and nanometer-sized mechanical resonators. A key challenge is the realization of a large electromechanical coupling exceeding the damping rate of the microwave cavity.

We present a hybrid system consisting of a high impedance superconducting microwave and a mechanical string resonator. Using finite element modeling, we discuss how the capacative electromechanical coupling rate (g_0) scales with the system geometry and how high impedance resonators allow to enhance g_0 compared to $50\,\Omega$ resonators. We show experimental data and compare the results to simulations. Moreover, high impedance resonators are compatible with superconducting qubits and provide hereby a pathway towards the preparation of quantum states in mechnical resonators.

TT 45.3 Tue 12:15 H 0110

Inductively Coupled Nano-Electromechanics in Flux Tunable Superconducting Resonators — •C. Utschick[1,2], P. Schmidt[1,2,3], D. Schwienbacher[1,2,3], L. Rosenzweig[1,2], N. Segercrantz[1,2], F. Deppe[1,2,3], A. Marx[1,2], R. Gross[1,2,3], and H. Huebl[1,2,3] — [1]Walther-Meißner-Insitut, Garching, Germany — [2]Physik-Department, Technische Universität München, Garching, Germany — [3]Nanosystems Initiative Munich, München, Germany

The field of cavity electromechanics provides a platform to study the light matter interaction on a quantum level. To observe quantum mechanical effects a strong photon-phonon coupling is desired, preferably exceeding the microwave (MW) resonator decay.

In this talk we present a hybrid system consisting of a magnetic field tunable superconducting MW resonator based on a dc-SQUID, where the latter encloses a nanomechanical string resonator. Here, the nanomechanical string displacement couples inductively to the MW resonator by changing the area of the dc-SQUID loop. The parameters of the system offer an inherently large photon-phonon coupling on the single excitation level and estimates for optimized parameters suggest a coupling rate on par with the decay rate of the MW resonator. We discuss the optomechanical coupling strength, present the device layout including its fabrication and show experimental data of the mechanical element and the superconducting circuit.

TT 45.4 Tue 12:30 H 0110

Magnetoelasticity of CoFe thin films — •Daniel Schwienbacher[1,2,3], Matthias Pernpeintner[1,2,3], Mathias Weiler[1,2], Eric R.J Edwards[4], Hans Nembach[4,5], Justin M. Shaw[4], 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 — [4]National Institute for Standards and Technology, Boulder, CO, USA — [5]JILA,University of Colorado, CO, USA

Ultra-low magnetic damping materials are essential for spintronic applications. Schoen *et al.* [1] recently discovered ultra-low magnetic damping in a metallic CoFe thin film. Magnetoelastic properties are known to critically affect spintronic devices, however, they are difficult to quantify in thin films. Here, we use SiN nanostring resonators loaded with CoFe thin films for measuring the magnetoelastic properties and find a saturation magnetostriction coefficient of $\lambda = (-27.2 \pm 4.1) \times 10^{-6}$ for 10 nm thick $Co_{25}Fe_{75}$ films. This opens exciting perspectives for combining magnetoelastics with ultralow damping materials.

[1] Schoen et al., Nature Physics **12**, 839 (2016)

TT 45.5 Tue 12:45 H 0110

Multistability in vibrational lasing of a nanomechanical resonator — •Mattia Mantovani[1], Andrew Armour[2], Wolfgang Belzig[1], and Gianluca Rastelli[1] — [1]Fachbereich Physik, Universität Konstanz, D-78457 Konstanz, Germany — [2]School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, United Kingdom

We study the nonequilibrium dynamics of a nanomechanical resonator, realized by a suspended carbon nanotube in contact with two ferromagnetic leads. The nanotube hosts a quantum dot with two spin levels, which are coupled to the vibrational flexural modes via spin-vibration interaction [1-3]. We show that the system encodes a single-atom laser [4] in which the mechanical vibration plays the role of the cavity with frequency equal to the Zeeman splitting of the two levels. The lasing state can be achieved in the experimental range of the parameters for the spin-vibration coupling strength and magnetic polarization of the leads. Moreover, such a system has unique features which distinguish it from the single-atom model. In particular, we find regions with multistability of the resonator that are reflected in the zero-frequency current noise through the quantum dot.

[1] P. Stadler et al., Phys. Rev. Lett. 113, 047201 (2014).
[2] P. Stadler et al., Phys. Rev. B 91, 085432 (2015).
[3] A. Pályi et al., Phys. Rev. Lett. 108, 206811 (2012).
[4] Y. Mu, M. Savage, Phys. Rev. A 46, 5944 (1992).