TT 24 Symposium Nanomechanics

Zeit: Dienstag 10:15–12:50 Raum: TU H104

Hauptvortrag TT 24.1 Di 10:15 TU H104

Single-Electron Transport in Nano-Electromechanical Devices — •Yaroslav M. Blanter — Kavli Institute of NanoScience, Delft University of Technology, 2628 CJ Delft, The Netherlands

We first review existing experimental and theoretical developments in nanoelectromechanical systems (NEMS) in the single-tunneling regime. Next, we discuss effect of electric degrees of freedom on the mechanical properties and show that eigenfrequencies of suspended beams can be tuned by the gate voltage (as confirmed recently by the Cornell group). Then, we consider the situation of a strong mechanical feedback and discuss the modification of transport properties by mechanical motion.

Hauptvortrag TT 24.2 Di 10:50 TU H104

Nano-Electromechanical Systems with Carbon Nanotubes — •Yuval Yaish, Vera Sazonova, Ethan D. Minot, Hande Üstünel, David Roundy, Tomas A. Arias, and Paul L. McEuen — Laboratory of Atomic and Solid-State Physics, Cornell University, Ithaca, NY 14853, USA

Carbon nanotubes (NTs) offer a unique opportunity to scale down Nano Electro Mechanical Systems (NEMS) to the nanometer scale. Here we present our recent results in which guitar-string-like oscillation modes of doubly clamped nanotube oscillators were found. These resonance frequencies can be widely tuned electrostatically and their quality factor increases as temperature decreases. The static behavior of suspended NTs is intriguing as well. We will discuss their electrical response to mechanical perturbations and magnetic fields.

Fachvortrag TT 24.3 Di 11:25 TU H104

Some Quantum Phenomena in Nanoelectromechanical Systems — •Jörg P. Kotthaus — Department für Physik and Center for NanoScience, LMU München

In an effort to create a single electron shuttle we study a nanoelectromechanical system (NEMS) etched out of Si and containing a metallic island which driven by Coulomb forces mechanically oscillates and transfers charge between two contacts. With increasing ac bias we find in the dc current a transition from charge transport via normal tunneling to transport via field emission from the isolated nanoscale island. It deviates in a characteristic fashion from the usual Fowler Nordheim description of field emission [1]. GaAs-based NEMS containing a low-dimensional electron gas are fabricated suitably to enable the definition of an individual quantum dot within a suspended beam. The low temperature electron transport through such a suspended quantum dot is found to exhibit a new characteristic gap in the diamond-like conductance spectra caused by Coulomb blockade. It is interpreted as a phonon blockade [2] caused by coherent transfer of electronic energy to a quantized thickness vibration of the thin suspended cavity, in analogy to the Franck-Condon principle in molecular systems [3].

[1] A. D. V. Scheible, C. Weiss, J. P. Kotthaus, and R. H. Blick, Phys. Rev. Lett. 93, 186801 (2004)

[2] E. M. Weig, R. H. Blick, T. Brandes, J. Kirschbaum, W. Wegscheider, M. Bichler, and J. P. Kotthaus, Phys. Rev. Lett. 92, 046804 (2004)

[3] J. Koch and F. von Oppen, cond-mat/0409667

Fachvortrag TT 24.4 Di 12:00 TU H104

Cooling and squeezing nanomechanical resonators with Josephson qubits — •Alexander Shnirman[1], Peter Rabl[2], Ivar Martin[3], Lin Tian[1,2], and Peter Zoller[2] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, D-76128 Karlsruhe — [2]Institute for Theoretical Physics, University of Innsbruck, A-6020 Austria — [3]Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545, USA

We propose an application of a single Cooper pair box (Josephson qubit) for active cooling of nanomechanical resonators. Latest experiments with Josephson qubits demonstrated that long coherence time of the order of microsecond can be achieved in special symmetry points. Here we show that this level of coherence is sufficient to perform an analog of the well known in quantum optics "laser" cooling of a nanomechanical resonator capacitively coupled to the qubit. By applying an AC driving to the qubit or the resonator, resonators with frequency of order 100 MHz and quality factors higher than 10^3 can be efficiently cooled down to their ground state, while lower frequency resonators can be cooled down to micro-Kelvin temperatures.

In addition we show how the resonator can be driven into a squeezed state by choosing the appropriate coupling to a Josephson charge qubit. The stationary squeezed state of the resonator exhibits a reduced noise in one of the quatrature components by a factor of 0.5 - 0.2. These values are obtained for a 100 MHz resonator with a Q-value of 10^4 to 10^5 and for T≈25 mK. We show that the coupling to the charge qubit can be used to detect the squeezed state via measurements of the excited state population. Furthermore, by extending this measurment procedure a complete quantum state tomography of the resonator state can be performed. This provides a universal tool to detect a large variety of different states and to proove the quantum nature of a nanomechanical oscillator.

TT 24.5 Di 12:35 TU H104

Charge transport through a SET with a mechanically oscillating island — •Wolfgang Belzig[1], Nikolai M. Chtchelkatchev[2], and Christoph Bruder[1] — [1]Department of Physics and Astronomy, University of Basel, Klingelbergstr. 82, 4056 Basel, Switzerland — [2]L.D. Landau Institute for Theoretical Physics, Russian Academy of Sciences, 117940 Moscow, Russia

We consider a single-electron transistor (SET) whose central island is a nanomechanical oscillator. The gate capacitance of the SET depends on the mechanical displacement, thus, the vibrations of the island may influence the transport properties. Harmonic oscillations of the island and thermal vibrations change the transport characteristics in different ways. The changes in the Coulomb blockade oscillations and in the current noise spectral density help to determine in what way the island oscillates, and allow to estimate the amplitude and the frequency of the oscillations.