SYSD 1: SKM Dissertation-Prize 2018

Time: Monday 11:00–12:40 Location: HE 101

Invited Talk SYSD 1.1 Mon 11:00 HE 101

Optical detection of charge carrier dynamics in a self-assembled quantum dot — •Annika Kurzmann — Faculty of Physics and CENIDE, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany

One of the central visions in quantum information processing is the realization of a quantum network, where information exchange is based on the storage and transfer of quantum states (QuBits). Self-assembled quantum dots (QDs) allow both, the storage of QuBits as charge- or spin states and their transfer via single photons. Therefore, quantum dots are one promising candidate as nodes in a quantum network.

In this work, resonance fluorescence on a single self-assembled dot was used to investigate three important aspects for QDs as quantum nodes: (i) Single photon generation with narrow linewidth, using a feedback loop, where tunneling of resonantly generated holes lead to a stabilization of the QDs emission [1]. (ii) The coupling mechanism of the QD to the charge reservoir, that is important for the electrical control of the dots states. In real-time measurements [2] quantum jumps of electron tunneling were measured, that give access to the statistics of the fluctuations, i.e. shot noise and Fano factor. (iii) The non-radiative Auger recombination, an important detrimental mechanism inside an optically-excited dot, that leads to linewidth broadening and intensity quenching of the excitonic resonances [3].

[1] B. Merkel et al., Phys. Rev. B **95**, 115305 (2017). [2] A. Kurzmann et al., Phys. Rev. Lett. **117**, 017401 (2016). [3] A. Kurzmann et al., Nano Lett. **16**, 3367 (2016).

Invited Talk SYSD 1.2 Mon 11:20 HE 101

Carbon nanotubes as electrically driven on-chip light sources — •Felix Pyatkov — Institute of Nanotechnology, Karlsruhe Institute of Technology, Germany — Department of Materials and Earth Sciences, TU Darmstadt, Germany

Light emitting carbon nanotubes can be envisioned as waveguide-integrated emitters for future on-chip data communication due to their unique structural, electrical and optical properties. Progress in the field of nanotube sorting, site-selective deposition and efficient light coupling into underlying substrate has made nanotubes suitable for wafer-scale fabrication of active hybrid nanophotonic devices. Here, various devices with versatile functionalities were fabricated and equipped with nanotubes by means of dielectrophoresis. The realized electrically driven nanotube-based light emitters integrated with nanophotonic circuits allow for efficient coupling and propagation of light in waveguides over centimeter distances. It was demonstrated how spectral properties of a nanotube emitter can be controlled directly on a chip. In combination with a one-dimensional photonic crystal cavity nanotube becomes an emitter with exceptionally narrow linewidths at desired adjustable wavelength. Finally, the usage of electrically driven nanotubes as fast waveguide-integrated light emitters with Gbit/s response speed was shown.

Therefore direct, near-field coupling of electrically generated nanotube-emitted light into a waveguide opens new avenues for scalable nanoscale optoelectronic systems in a CMOS compatible framework.

Invited Talk SYSD 1.3 Mon 11:40 HE 101

Surely you're joking, Mr. Feynman? The breakdown of diagrammatic perturbation theory — •Thomas Schäfer[1,2,3], Alessandro Toschi[1], and Karsten Held[1] — [1]TU Wien, Vienna, Austria — [2]Collège de France, Paris, France — [3]École polytechnique, CNRS, Palaiseau, France

Strongly correlated electron systems exhibit some of the most fascinating phenomena of condensed matter physics. Beyond the famous example of the Mott-Hubbard metal-to-insulator transition and the occurrence of classical phase transitions like magnetic and charge ordering as well as superconductivity, quantum phase transitions in strongly correlated systems are currently under intense research. While Feynman diagrammatic-based techniques are successfully exploited in the forefront method developments for the description of these phenomena in correlated materials, only very recently theoretical manifestations of the breakdown of diagrammatic expansions have been unveiled and analyzed.

In this talk, I will take you on a journey through the highly dangerous regions of one of the most important and fundamental model systems in condensed matter physics, the Hubbard model. Together, by applying cutting edge field theoretical methods, we will experience the consequences of Kohn anomalies in three dimensions on quantum criticality, witness the murder of the Mott-Hubbard transition in two dimensions and look directly into the watchful eyes of the dragons guarding the gates to strong electronic correlations.

Invited Talk SYSD 1.4 Mon 12:00 HE 101

Ground-state cooling of a mechanical oscillator in hybrid nano-conductors — •Pascal Stadler, Gianluca Rastelli, and Wolfgang Belzig — Universität Konstanz, Konstanz, Germany

Nanoelectromechanics paves the way to the formidable task of observing quantum effects in large mechanical systems formed by millions of atoms. To achieve this goal, a crucial requirement is cooling the mechanical resonator to very low temperatures. We show that ground-state cooling of a mechanical oscillator can be achieved via coupling of the resonator with the charge or the spin of a quantum dot inserted between (i) spin-polarized contacts [1] or (ii) a normal metal and a superconducting contact [2]. Such a system can be realized e.g. by a suspended carbon nanotube quantum dot with a suitable interaction between a vibrational mode and the charge or spin. We show that ground-state cooling of the mechanical oscillator can be achieved for many oscillator modes simultaneously [2] as well as selectively for single modes [1]. Furthermore, the nonequilibrium state of the oscillator can be detected in the current-voltage characteristics and the current noise. Our method allows a more sophisticated quantum manipulation of carbon nanotube oscillators like a coherent superposition of modes which might be used as quantum limited sensor of weight or motion.

[1] P. Stadler et. al., Phys. Rev. Lett. 113, 047201 (2014).
[2] P. Stadler et. al., Phys. Rev. Lett. 117, 197202 (2016).

Invited Talk SYSD 1.5 Mon 12:20 HE 101

Electron-phonon interactions beyond the two-temperature approximation — •Lutz Waldecker — Stanford University, Stanford, CA 94305, USA — Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin, Deutschland

The coupling between electrons and phonons is central to solid state physics as it determines fundamental effects ranging from transport phenomena to many-body effects like superconductivity. Despite the complexity of the problem on the microscopic level, the energy exchange between electronic and vibrational degrees of freedom is typically approximated by simple models assuming thermal distribution functions of the populations in both subsystems.

In this talk, I will present measurements of the electron-phonon coupling strength in simple metals, semimetals and semiconductors employing femtosecond electron diffraction. This technique allows following the thermal relaxation dynamics after photoexcitation of a material's electrons by measurement of its phonon populations with time- and momentum-resolution, therefore providing a picture beyond ensemble averages near- as well as far out of equilibrium. I will discuss the limits of the two-temperature model for the interpretation of these measurements and present easy to solve models that can significantly improve the microscopic description of electron-phonon scattering.