TT 88: Transport: Carbon Nanotubes

Time: Thursday 9:30–10:45 Location: A 053

TT 88.1 Thu 9:30 A 053

The excitation spectrum of a carbon nanotube — from 0 to 2 electrons — Daniel Schmid[1], Magdalena Marganska[2], Siddharth Buddhiraju[2], Peter Stiller[1], Alois Dirnaichner[1], Milena Grifoni[2], •Andreas K. Hüttel[1], and Christoph Strunk[1] — [1]Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany

Defect- and contamination free, suspended single wall carbon nanotubes (CNTs) display a highly regular transport spectrum. The spectral features directly reflect the properties of the underlying graphene lattice, modified by curvature and finite length effects as well as the cylindrical topology of the nanotube.

We present and analyze data on the first two Coulomb blockade oscillations ($0 \leq N_{\rm el} \leq 2$) of such a system. Sharp differential conductance features enable the observation of multiple excited states of the trapped electronic system in variable angle magnetic fields. The analysis of the $N_{\rm el} = 1$ data provides us with direct knowledge of the single particle level spectrum. In contrast, the $N_{\rm el} = 2$ spectrum is dominated by the electron-electron interactions. In both regimes, the spectra are governed by the underlying symmetries of the CNT Hamiltonian.

Our model is based on a minimal one-shell Hamiltonian of a CNT with spin-orbit coupling and valley mixing and taking into account a magnetic field, extended to include two shells and the exchange interaction.

TT 88.2 Thu 9:45 A 053

Influence of spin-orbit interaction and chirality on Fabry-Perot interference in carbon nanotubes — •Alois Dirnaichner[1], Miriam del Valle[2], Karl Götz[1], Felix Schupp[1], Andreas K. Hüttel[1], Christoph Strunk[1], and Milena Grifoni[2] — [1]Institute of Experimental and Applied Physics, University of Regensburg — [2]Institute for Theoretical Physics, University of Regensburg

For highly transparent contact interfaces a carbon nanotube can be described as an electronic Fabry-Perot interferometer combining weak scattering at the contacts with a one-dimensional ballistic waveguide. In experiments on clean single wall carbon nanotubes we observe complex gate and bias voltage dependent interference patterns in conductance. This includes slow envelope beats as well as an apparent frequency doubling. Using an analytical scattering matrix model as well as numerical tight-binding calculations we show that such complex interference patterns can arise from the chirality and the spin-orbit interaction of a nanotube. Theoretical expectations for different types of nanotubes are compared with the experiment.

TT 88.3 Thu 10:00 A 053

Thermally induced subgap features in the cotunneling spectroscopy of a carbon nanotube — Sascha Ratz[1], •Andrea Donarini[1], Daniel Steininger[2], Thomas Geiger[2], Amit Kumar[2], Andreas Huettel[2], Christoph Strunk[2], and Milena Grifoni[1] — [1]Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany

We report on the nonlinear cotunneling spectroscopy of a carbon nanotube quantum dot coupled to Nb superconducting contacts [1]. Our measurements show rich subgap features in the stability diagram which become more pronounced as the temperature is increased. Subgap features in the tunnelling spectroscopy of hybrid superconductor-quantum dot structures are commonly attributed to Andreev reflection processes. However, applying a transport theory based on the Liouville-von Neumann equation for the density matrix, we show that, in the parameter range of our experiments, the subgap transport properties can be attributed solely to processes involving sequential as well as elastic and inelastic cotunneling of quasiparticles thermally excited across the gap. In particular, we predict thermal replicas of the elastic and inelastic cotunneling peaks, in agreement with our experimental results.

[1] S. Ratz, A. Donarini, D. Steininger et al. accepted by NJP, arXiv:1408.5000v2.

TT 88.4 Thu 10:15 A 053

Strong localization in defective carbon nanotubes — •Fabian Teichert[1,2], Andreas Zienert[2], Jörg Schuster[3], and Michael Schreiber[1] — [1]Institute of Physics, Technische Universität Chemnitz, Chemnitz, Germany — [2]Center for Microtechnologies, Technische Universität Chemnitz, Chemnitz, Germany — [3]Fraunhofer Institute for Electronic Nano Systems, Chemnitz, Germany

Carbon nanotubes (CNTs) are a prominent example for new materials in microelectronics, overcoming the miniaturization problem. So far CNTs cannot be grown or deposited in an ideal and reproducible way inside a device. As one consequence they contain defects.

The present work describes the transport properties of armchair CNTs with randomly positioned realistic defects, namely monovacancies and divacancies. The calculations are based on a fast, linearly scaling recursive Green's function formalism, allowing to treat large systems quantum-mechanically. The electronic structure is described by a density-functional-based tight-binding model.

The transmission spectrum of CNTs with single / many defects is studied. The influence of certain defect densities, the diameter of the CNT, and the temperature is investigated within a statistical analysis. It is shown that the system is in the regime of strong localization (i.e. Anderson localization), where the conductivity scales exponentially with the number of defects. This allows us to extract localization lengths, which depend on defect density, CNT diameter, and temperature. Finally, the correlation between the localization length and the single-defect conductance is shown.

TT 88.5 Thu 10:30 A 053

Random Telegraph Noise in Carbon Nanotubes — •Sung ho Jhang[1], Hyun-jong Chung[1], and Yung woo Park[2] — [1]Konkuk University, Seoul, Korea — [2]Seoul National University, Seoul, Korea

We have investigated random telegraph noise (RTN) observed in individual carbon nanotubes (CNTs). By analyzing the statistics and features of the RTN,we suggest that this noise originates from two different mechanisms; from the charge traps surrounding CNTs or from the random transition of defects within CNTs, activated by inelastic scattering with conduction electrons. The magnitude of resistance fluctuation is giant up to 60% of total resistance, much larger than inevitable thermal Nyquist noise. Due to the large RTN amplitude, the RTN approach could be developed into an effective probe to characterize single defects in CNTs. In addition, we show the RTN is sensitive to the encapsulated molecules inside CNTs, and report interacting noise behaviors.