TT 51: TR: Nanoelectronics I - Quantum Dots, Wires, Point Contacts 2

Time: Thursday 14:00–15:30 Location: HSZ 304

TT 51.1 Thu 14:00 HSZ 304

Correlation of quantum transport and tip-enhanced Raman spectroscopy on carbon nanotubes — •Karin Goss[1], Niculina Peica[2], Sebastian Smerat[3], Martin Leijnse[4], Maarten R. Wegewijs[1,5], Christian Thomsen[2], Janina Maultzsch[2], Claus M. Schneider[1], and Carola Meyer[1] — [1]Peter Grünberg Institut, Forschungszentrum Jülich & JARA Jülich Aachen Research Alliance, Jülich, Germany — [2]Institut für Festkörperphysik, TU Berlin, Germany — [3]Physics Department, Arnold Sommerfeld Center for Theoretical Physics, LMU München, Germany — [4]Niels Bohr Institute & Nano-Science Center, University of Copenhagen, Denmark — [5]Institut für Theoretische Physik A, RWTH Aachen, Germany

Carbon nanotube (CNT) ropes offer a generic system to study the interactions of molecules with their environment. We show quantum transport spectra of a contacted rope, which consists of several CNT strands forming parallel quantum dots at low temperature. From their distinct interaction properties, we count at least five parallel dots. In order to attribute these to the different strands within the rope, it is characterized using tip-enhanced Raman spectroscopy. This method offers both an increased spatial resolution and a high signal enhancement. From the diameter dependent Raman modes in combination with a tentative chiral assignment, we identify several CNTs with different diameters and electronic properties. This correlation of transport with Raman spectroscopy illustrates a useful principle for molecular electronics, where an understanding of strong perturbations by environmental effects is required for the interpretation of transport data.

TT 51.2 Thu 14:15 HSZ 304

Spin current polarization due to spin orbit interaction in carbon nanotubes — •Miriam del Valle, Magdalena Margańska, and Milena Grifoni — Institute for Theoretical Physics, University of Regensburg, Germany

Finite carbon nanotubes placed in a magnetic field parallel to their axes develop localized states and an associated suppression of current. The current is completely blocked for magnetic fields beyond a certain value which depends on the length and chirality of the tube. We will focus on the interplay of this blocking mechanism with the spin orbit interaction and the Zeeman effect. We observe in particular reversible spin polarization of the current, controlled by the bias applied to the tube. The analytical results are supported by numerical simulations for different lengths and chiralities.

TT 51.3 Thu 14:30 HSZ 304

Magnetic field-induced localization in carbon nanotubes — •Magdalena Marganska, Miriam del Valle, Sung Ho Jhang, Christoph Strunk, and Milena Grifoni — University of Regensburg, Regensburg, Germany

The electronic spectra of long carbon nanotubes (CNTs) can, to a very good approximation, be obtained using the dispersion relation of graphene with both angular and axial periodic boundary conditions. In short CNTs one must account for the presence of open ends, which in some CNTs may give rise to states localized at the edges. We show that when a magnetic field is applied parallel to the tube axis, it modifies both momentum quantization conditions, causing hitherto extended states to localize near the ends. The localization is gradual and at low magnetic fields the involved states are still extended. This effect occurs in nanotubes of any size and chirality except armchair. We derive our results using the tight-binding model including the nanotube curvature.

TT 51.4 Thu 14:45 HSZ 304

Pseudo-spin-dependent scattering in carbon nanotubes — •Leonhard Mayrhofer[1] and Dario Bercioux[2,3] — [1]Fraunhofer IWM, Wöhlerstrasse 11, D-79108 Freiburg, Germany — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, D-79104 Freiburg, Germany — [3]Physikalisches Institut, Albert-Ludwigs- Universität, D-79104 Freiburg, Germany

We investigate the electronic scattering properties of defected armchair single-walled carbon nanotubes with analytical and numerical methods [1]. By analyzing the local density of states and its Fourier transform we show that electron scattering at defects in carbon nanotubes is strongly affected by the pseudo-spin of the electrons. Depending on the defect symmetry pseudo-spin is conserved or not. In addition, the investigation reveals that the lattice reconstruction of the energetically favored 5-8-5 di-vacancy defects, breaking particle-hole symmetry, is responsible for the pseudo-spin selection rules observed in the experiments by Ouyang *et al.* [2]. Comparison with other experiments is also reported [3,4].

[1] L. Mayrhofer and D. Bercioux, arXiv:1009.4839.
[2] M. Ouyang *et al.*, Phys. Rev. Lett. **88**, 066804 (2002).
[3] J. Lee *et al.*, Phys Rev Lett. **93**, 166403 (2004).
[4] G. Buchs *et al.*, Phys. Rev. Lett. **102**, 245505 (2009).

TT 51.5 Thu 15:00 HSZ 304

Defect-Induced Electron Scattering in Single-Walled Carbon Nanotubes — •Dario Bercioux[1,2], Gilles Buchs[3], Hermann Grabert[1,2], and Oliver Groening[4] — [1]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, D-79104 Freiburg, Germany — [2]Physikalisches Institut, Albert-Ludwigs-Universitat, D-79104 Freiburg, Germany — [3]Kavli Institute of Nanoscience, TU-Delft, P.O. Box 5046, 2600 GA Delft, The Netherlands — [4]EMPA Swiss Federal Laboratories for Materials Testing and Research, nanotech@surfaces, Feuerwerkerstr. 39, CH-3602 Thun, Switzerland

We present a detailed comparison between theoretical predictions on electron scattering processes in metallic single-walled carbon nanotubes with defects and experimental data obtained by scanning tunneling spectroscopy of Ar^+ irradiated nanotubes [1,2]. To this purpose we first develop a formalism for studying quantum transport properties of defected nanotubes in presence of source and drain contacts and an STM tip. The formalism is based on a field theoretical approach describing low-energy electrons. We account for the lack of translational invariance induced by defects within the so called extended $\mathbf{k}\cdot\mathbf{p}$ approximation. The theoretical model reproduces the features of the particle-in-a-box-like states observed experimentally. Further, the comparison between theoretical and experimental Fourier-transformed local density of state maps yields clear signatures for inter- and intravalley electron scattering processes depending on the tube chirality.

[1] D. Bercioux *et al.*, arXiv:1011.1423.
[2] G. Buchs *et al.*, Phys. Rev. Lett. **102**, 245505 (2009).

TT 51.6 Thu 15:15 HSZ 304

Multi-level carbon nanotube quantum dots: reservoir-coupling induced renormalization effects — •Stephan Grap[1], Sabine Andergassen[1], Volker Meden[1], Kasper Grove-Rasmussen[2], Jens Paaske[2], Karsten Flensberg[2], Henrik Jørgensen[2], Poul Lindelof[2], Koji Muraki[3], and Toshimasa Fujisawa[4] — [1]RWTH Aachen and JARA-Fundamentals of Future Information Technology, Germany — [2]Niels Bohr Institute, Copenhagen, Denmark — [3]NTT Basic Research Laboratories, Japan — [4]Tokyo Insitute of Technology, Japan

In carbon nanotube dots the fourfold level degeneracy with respect to the spin and valley index K, K' is lifted by intervalley coupling, resulting from disorder, the confining potential, spin-orbit interactions due to the tube curvature, or a magnetic field. In the basis of single-particle eigenstates of the isolated dot the inner four levels lead to pairs of strongly and weakly coupled levels in absence of magnetic field. In addition to the Kondo ridges at zero field, the crossings of levels originating from different shells give rise to Kondo ridges at finite magnetic field. The observed bending with respect to the Kondo ridges at zero field turns out be a consequence of the magnetic-field dependence of the level-reservoir coupling strengths. Theoretical understanding is provided by using the functional renormalization-group approach, which reproduces the features of the linear conductance measurements as a function of the applied gate voltage and magnetic field. In particular the bending of the Kondo ridges at finite magnetic field is traced back to the renormalization of the couplings.