HL 84: Quantum Dots and Wires: Transport Properties III (mainly Thermal Gradients)

Time: Thursday 15:00–16:15 Location: EW 202

HL 84.1 Thu 15:00 EW 202

Nanocaloritronics of thermoelectric transport across interacting quantum dots. — •Bhaskaran Muralidharan and Milena Grifoni — Institut I - Theoretische Physik Universität Regensburg D-93040 Regensburg

By subjecting a weakly coupled quantum dot system to an applied voltage and temperature gradient, we present notable subtleties involved in its thermoelectric energy conversion efficiency. First, is the well known, but non-intuitive aspect in the non-interacting case, of achieving a reversible operation with Carnot efficiency. Second, is the rather surprising result in the presence of Coulomb interactions that similar operating conditions lead to zero efficiency [1]. It is then shown that even in this case, operating efficiencies close to the Carnot value may be attained, but, under non-equilibrium conditions [1]. Consequently, the inadequacies of traditionally employed performance metric zT in capturing the aforementioned non-equilibrium conditions are pointed out.

Reference:

[1]"Nanocaloritronic performance analysis of an interacting quantum dot thermoelectric", B. Muralidharan and M. Grifoni, cond-mat/1110.4357 (2011).

HL 84.2 Thu 15:15 EW 202

Noise-induced currents in open quantum dots — •Björn Sothmann[1], Rafael Sánchez[2], Andrew N. Jordan[3], and Markus Büttiker[1] — [1]Département de Physique Théorique, Université de Genève — [2]Consejo Superior de Investigaciones Científicas — [3]Department of Physics and Astronomy, University of Rochester

Recently, the influence of fluctuations on transport through quantum dots has generated quite some interest. In Ref. [1], it was shown how a double dot in a three-terminal device can convert a heat current into a charge current. This converter is optimal in the sense that it transfers one electron for every heat quantum delivered by the hot dot. However, the currents generated are very small. Of interest is the scaling of this effect as the system size increases.

Here, we consider transport through two open quantum dots coupled to leads via quantum-point contacts with energy-dependent transmissions. We, additionally, take into account fluctuations of the cavity potentials. Using a semiclassical analysis, we calculate the charge current through one cavity as a response to a heat gradient between the reservoirs of the two cavities. We, furthermore, evaluate the heat currents in the system to discuss its thermodynamic efficiency.

[1] R. Sánchez and M. Büttiker, Phys. Rev. B **83**, 085428 (2011).

HL 84.3 Thu 15:30 EW 202

Thermal gradients and noise thermometry in 2D and 1D electron systems — •S.S. Buchholz[1], E. Sternemann[1], P. Miechowski[1], D. Reuter[2], A.D. Wieck[2], and S.F. Fischer[1] — [1]Neue Materialien, Humboldt-Universität zu Berlin, D-10099 Berlin — [2]Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44801 Bochum

Thermoelectric (TE) and out-of-equilibrium thermal properties of nanostructured semiconductors are of increasing research interest with respect to the improvement of the TE efficiency. A particular challenge is the determination of the charge carrier temperature at the nano-scale.

Here, we performed cross-correlated thermal voltage noise measurements under applied dc current heating in nanopatterned (2D and 1D) channels of a GaAs/AlGaAs heterostructure at bath temperatures of 1.4 K and above.

Via the current heating technique, we heat the electron system up to several K above the lattice temperature and measure the electron temperature by Nyquist-noise thermometry. In narrow 2D channels, the temperature dependence of the electron energy-loss rate is reduced compared to wider 2D systems [1], which may be attributed to the strong lateral confinement of the etched channels. In a 1D quantum interferometer sandwiched between a hot and a cold electron reservoir, we show the decoherence due to the diffusion of hot electrons by the thermal gradient.

[1] S.S. Buchholz et al., arXiv:1111.1591 (2011).

HL 84.4 Thu 15:45 EW 202

Thermopower of a Coupled Quantum Dot System — •Holger Thierschmann[1], Michael Henke[1], Johannes Knorr[1], Wolfgang Hansen[2], Hartmut Buhmann[1], and Laurens W. Molenkamp[1] — [1]Physikalisches Institut (Experimentelle Physik III), Universität Würzburg, Germany — [2]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Germany

We perform electrical characterization and thermopower measurements on lateral gate patterned coupled quantum dot systems based on a GaAs/AlGaAs HEMT structure. The two quantum dots are connected in series and are tuned into the strong coupling regime. A temperature difference of a few 10mK is established using the current heating technique [1]. We observe strong asymmetries in the thermovoltage signal around the tripel points, which we can explain within an electrostatic capacitance model and also between two tripel points, which we believe are caused by molecular-like electron states. Due to strong interdot tunnel coupling we find thermovoltages in regions with finite conductance, which is in strong contrast to the thermopower of a single quantum dot [2]. [1] R. Scheibner, H. Buhmann, D. Reuter, M. N. Kiselev and L.W. Molenkamp, PRL 95, 176602 (2005). [2] R. Scheibner, E.G. Novik, T. Borzenko, M. König, D. Reuter, A.D. Wieck, H. Buhmann and L.W. Molenkamp, Phys. Rev. B 75, 041301(R) (2007).

HL 84.5 Thu 16:00 EW 202

Phonon-drag thermopower of a Si/SiGe quantum point contact — •Joeren von Pock[1], Daniel Salloch[1], Ulrich Wieser[1], Ulrich Kunze[1], and Thomas Hackbarth[2] — [1]Lehrstuhl für Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]DaimlerChrysler Forschungszentrum Ulm, D-89081 Ulm

We investigate the influence of phonon-drag thermopower on a gate-modulated inertial ballistic rectifier. Our devices are fabricated from a high mobility Si/SiGe heterostructure with an electron mobility of $\mu_{2D} = 18.3$ m^{2}V^{-1}s^{-1} and a density of $n_{2D} = 6.3 \cdot 10^{15}$ m^{-2} at 1.4 K. The confinement is realized by low damage CF_4/O_2 plasma etching. Two quantum point contacts (QPCs) are directed parallel and perpendicular to a heating wire and are electrically isolated from it. A gradient of temperature from the heating wire generates phonons which drag electrons through QPC constriction. In case of the perpendicular QPC the electrons relax behind the constriction and create a measurable thermopower signal of about 10^{-3} times smaller magnitude than hot-electron thermopower. Because of the absence of a gradient of temperature on each side of the constriction, the QPC parallel to the heating wire shows no signal. The measured phonon-drag thermopower is strongly dependent on the phonon priority direction [100] in Si/SiGe. The temperature dependence shows a decrease of the phonon-drag induced thermopower in the region of $4.2K \leq T \leq 30$ K which is not yet understood. At 1.5 K no phonon-drag effect is observed as in [1].

[1] W. E. Chickering *et al.*, PRL **103**, 046807 (2009).