TT 12: Fluctuations and Noise

Time: Monday 15:00–16:30 Location: H 3007

TT 12.1 Mon 15:00 H 3007

Full counting statistics of ultrafast quantum transport — •Matthias Hübler and Wolfgang Belzig — Universität Konstanz, D-78457 Konstanz, Germany

Quantum transport in the presence of time-dependent drives is dominated by quantum interference and many-body effects at low temperatures. For a periodic driving, the analysis of the full counting statistics revealed the elementary events that determine the statistical properties of the charge transport. However, so far only continuous wave excitations were considered, but recently transport by few-cycle light pulses were investigated [1] and the need for a statistical interpretation became eminent. We investigate the temporal dynamics of single- or few-cycle light pulses leaving traces in the charge transfer. The fingerprints of these time-dependent voltage pulses are imprinted in the full counting statistics of a coherent mesoscopic conductor at zero temperature. In addition, we identify the elementary processes that occur in the form of electron-hole pair creations, which can be investigated by the excess noise. We study the differential noise quantum oscillations induced by a wave packet consisting of an oscillating carrier modulated by a Gaussian- or a box-shaped envelope. As expected, the differential noise exhibits an oscillatory behavior with increasing amplitude. We find clear signature of the so-called carrier-envelope phase in the peak heights and positions of these quantum oscillations.

[1] T. Rybka, M. Ludwig, M. F. Schmalz, V. Knittel, D. Brida, A. Leitenstorfer, Nat. Photonics 10 (2016) 667.
[2] M. Hübler, W. Belzig; Appl. Phys. Lett. 17 (2023) 123 (3): 034006.

TT 12.2 Mon 15:15 H 3007

Noise calculations for transport through quantum dot systems and applications in charge sensing and nano thermodynamics — •Simon Wozny and Martin Leijnse — Division of Solid State Physics and NanoLund, Lund University, Box 118, S-22100 Lund, Sweden

Using full counting statistics we calculate the current and current noise through quantum dot (QD) systems. With this general framework making use of master equations we can investigate many different systems including electron-electron interactions and focus on different aspects. We have, for example, investigated the use of a parallel double QD as a charge sensor and show that it can outperform a single-dot charge sensor. We also explore the connection between the current noise and other thermodynamic quantities. Here relevant relations are for example fluctuation dissipation bounds or thermodynamic uncertainty relations.

TT 12.3 Mon 15:30 H 3007

Dark states versus blocking states in electronic transport: a Lee-Yang zero analysis of full counting statistics — •Johann Zöllner[1], Eric Kleinherbers[2], Philipp Stegmann[3], and Jürgen König[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, 47057 Duisburg, Germany — [2]Department of Physics and Astronomy, University of California, Los Angeles, California 90095, USA — [3]Department of Chemistry, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

Electronic transport through nanostructures can be suppressed by coherent population trapping, in which quantum coherence leads to a dark state that decouples from the drain electrode. Finite transport, then, relies on decoherence of the dark state [1]. An alternative scenario for reduced transport is weak coupling of a state, referred to as a blocking state, to the drain [2]. This raises the question of whether and how these two scenarios can be distinguished in the transport features. For the example of electron transport through a carbon nanotube, we identify regimes, in which this distinction is possible by analyzing the full counting statistics in terms of Lee-Yang zeros and factorial cumulants [3].

[1] A. Donarini et al., Nat. Commun. 10 (2019) 381
[2] M.-C. Harabula et al., Phys. Rev. B 97 (2018) 115403.
[3] P. Stegmann et al., Phys. Rev. B 92 (2015) 155413

TT 12.4 Mon 15:45 H 3007

Strongly correlated radiation of a tunnel junction due to charge quantization — •Steven Kim and Fabian Hassler — Institute for Quantum Information, RWTH Aachen University, 52056 Aachen, Germany

A chaotic light source is characterized by the fact that many independent, identical emitters radiate with a random optical phase. For such light sources, the correlation of the photons, characterized by the second-order coherence, is always given by $g^{(2)}(0) = 2$. One might expect that a tunnel junction with many channels produces chaotic light as many independent channels contribute to the radiation. We study the radiation emitted by a tunnel junction embedded in a cavity at low temperatures. Surprisingly, we find that the radiation deviates from the prediction of chaotic light. In particular, we find strong correlations of the photons. These correlations originate from shot-noise, where a single electron traversing the junction emits multiple photons.

TT 12.5 Mon 16:00 H 3007

Heat Pulses in Electron Quantum Optics — •Pedro Vinicius de Castro Portugal, Fredrik Brange, and Christian Flindt — Department of Applied Physics, Aalto University, 00076, Finland

Electron quantum optics aims to realize ideas from the quantum theory of light with the role of photons being played by charge pulses in electronic conductors. Experimentally, the charge pulses are excited by time-dependent voltages, however, one could also generate heat pulses by heating and cooling an electrode [1,2]. Here, we explore this intriguing idea by formulating a Floquet scattering theory of heat pulses in mesoscopic conductors [3]. The adiabatic emission of heat pulses leads to a heat current that in linear response is given by the thermal conductance quantum. However, we also find a high-frequency component, which ensures that the fluctuation-dissipation theorem for heat currents, whose validity has been debated, is fulfilled. The heat pulses are uncharged, and we probe their electron-hole content by evaluating the partition noise in the outputs of a quantum point contact. We also employ a Hong–Ou–Mandel setup to examine if the pulses bunch or antibunch. Finally, to generate an electric current, we use a Mach–Zehnder interferometer that breaks the electron-hole symmetry and thereby enables a thermoelectric effect.

[1] P. Portugal, C. Flindt, N. Lo Gullo, Phys. Rev. B **104** (2021) 205420.
[2] P. Portugal, F. Brange, C. Flindt, Phys. Rev. Res. **4** (2022) 043112.
[3] P. Portugal, F. Brange, C. Flindt, arXiv:2311.16748

TT 12.6 Mon 16:15 H 3007

Noise measurements in four-terminal quantum wire interferometer — •Birkan Düzel[1], Olivio Chiatti[1], Christian Riha[1], Sven S. Buchholz[1], Dirk Reuter[2], Andreas D. Wieck[3], and Saskia F. Fischer[1,4] — [1]Novel Materials Group,Humboldt-Universität zu Berlin,10099 Berlin, Germany — [2]Optoelektronische Materialien undBauelemente, Universität Paderborn,33098 Paderborn, Germany — [3]Angewandte Festkörperphysik,Ruhr-Universität Bochum,44780 Bochum, Germany — [4]Center for the Science of Materials Berlin, 12489 Berlin, Germany

Quantum ring structures can be used to investigate interference effects of electrons as a result of phase-coherent transport. Voltage noise measurements are performed using the cross-correlation technique in an etched quantum ring structure based on $Al_{0.35}Ga_{0.65}As/GaAs$ at temperatures of 4.2 K. In thermal equilibrium the measured two-terminal voltage noise depends on the detail of the contact configuration in these multiply-connected quantum wire ring structures [1,2]. Here, we investigate and discuss all noise contributions in various contact configurations and compare these with the calculated thermal noise according to the Johnson-Nyquist formula $S_{\mathrm{V}} = 4k_{\mathrm{B}}TR$, as determined from the four-terminal conductance measurements of the respective contact configuration. Aharonov-Bohm magneto-resistance oscillations observed at 15 mK prove quantum interference in the ring structure.

[1] C. Riha *et al.*, Appl. Phys. Lett. **117**, 063102 (2020).
[2] B. Düzel *et al.*, accepted/to be published in 2023 International Conference on Noise and Fluctuations (ICNF), IEEE.