TT 84: Fluctuations and Noise

Time: Thursday 9:30–11:15 Location: HFT-FT 131

TT 84.1 Thu 9:30 HFT-FT 131

Thermodynamic Bounds on Dissipation in Open Quantum Systems — •Paul Menczel, Christian Flindt, and Kay Brandner — Department of Applied Physics, Aalto University, 00076 Aalto, Finland

Given today's rapid experimental advances in quantum engineering, it becomes increasingly important to understand the laws that govern thermodynamic processes far from equilibrium in nano-scale devices. For an open quantum system under weak coupling conditions, we derive universal lower bounds on the total dissipation accompanying such a process. Going beyond the second law, our bounds are expressed in terms of the photon exchange between the system and its environment. As a key application of our approach, we obtain a new trade-off relation between power and efficiency of periodically driven quantum heat engines. This bound becomes weakest for semi-classical engine cycles that do not involve superpositions between the energy levels of the working substance. Showing that cycles with coherence inevitably come at the price of increased dissipation, our results are relevant for current experimental efforts to realize thermal machines in the quantum realm.

TT 84.2 Thu 9:45 HFT-FT 131

Electron waiting times of a periodically driven single-electron turnstile — •Elina Potanina and Christian Flindt — Department of Applied Physics, Aalto University, 00076 Aalto, Finland

We investigate the distribution of waiting times between electrons emitted from a periodically driven single-electron turnstile [1]. To this end, we develop a scheme for analytic calculations of the waiting time distributions for arbitrary periodic driving protocols. We illustrate the general framework by considering a driven tunnel junction before moving on to the more involved single-electron turnstile. The waiting time distributions are evaluated at low temperatures for square-wave and harmonic driving protocols. In the adiabatic regime, the dynamics of the turnstile is synchronized with the external drive. As the nonadiabatic regime is approached, the waiting time distribution becomes dominated by cycle-missing events in which the turnstile fails to emit within one or several periods. We also discuss the influence of finite electronic temperatures. The waiting time distributions provide a useful characterization of the driven single-electron turnstile with complementary information compared to what can be learned from conventional current measurements.

[1] E. Potanina and C. Flindt, Phys. Rev. B **96**, 045420 (2017)

TT 84.3 Thu 10:00 HFT-FT 131

Hierarchical quantum master equation approach to current fluctuations in vibrationally coupled charge transport through nanosytems — •Christian Schinabeck[1] and Michael Thoss[1,2] — [1]Institut für Theoretische Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany. — [2]Physikalisches Institut, Universität Freiburg, Freiburg, Germany.

We investigate vibrationally coupled charge transport in nanosytems using the hierarchical quantum master equation (HQME) approach [1-3]. This method allows a systematic convergence of the reduced dynamics of open quantum systems and thus generalizes traditional perturbative master equations. In this contribution, we present an extension of the HQME approach to calculate current fluctuations within the framework of full counting statistics. The method is applied to a model of a single-molecule junction including an electronic level coupled to fermionic leads as well as a vibrational mode in nonequilibrium. In the regime of strong electronic-vibrational coupling, we analyze the influence of higher-order cotunneling processes on avalanche-like transport [4,5]. Furthermore, in the off-resonant transport regime, inelastic corrections to shot noise are studied in some detail.

[1] Y. Tanimura *et al.*, J. Phys. Soc. Jpn. **75**, 082001 (2006).
[2] J. Jin *et al.*, J. Chem. Phys. **128**, 234703 (2008).
[3] C. Schinabeck *et al.*, Phys. Rev. B **94**, 201407 (2016).
[4] J. Koch *et al.*, Phys. Rev. B **74**, 205438 (2006).
[5] C. Schinabeck *et al.*, Phys. Rev. B **90**, 075409 (2014).

TT 84.4 Thu 10:15 HFT-FT 131

Noninvasive Quantum Measurement of Arbitrary Operator Order by Engineered Non-Markovian Detectors — Johann Bülte[1], •Adam Bednorz[2], Christoph Bruder[3], and Wolfgang Belzig[2] — [1]Fachbereich Physik, Universität Konstanz, D-78457 Konstanz, Germany — [2]Faculty of Physics, University of Warsaw, ul. Pasteura 5, PL02-093 Warsaw, Poland — [3]Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland

The development of solid-state quantum technologies requires the understanding of quantum measurements in interacting, non-isolated quantum systems. In general, a permanent coupling of detectors to a quantum system leads to memory effects that have to be taken into account in interpreting the measurement results. We analyze a generic setup of two detectors coupled to a quantum system and derive a compact formula in the weak-measurement limit that interpolates between an instantaneous (text-book type) and almost continuous - detector dynamics-dependent - measurement. A quantum memory effect that we term system-mediated detector-detector interaction is crucial to observe non-commuting observables simultaneously. Finally, we propose a mesoscopic double-dot detector setup in which the memory effect is tunable and that can be used to explore the transition to non-Markovian quantum measurements experimentally [arXiv:1711.11347].

TT 84.5 Thu 10:30 HFT-FT 131

Continuous-Variable Entanglement Test in a Driven Quantum Contact — •hongxin zhan[1], mihajlo vanević[2], and wolfgang belzig[1] — [1]Fachbereich Physik, Universität Konstanz, D-78457 Konstanz, Germany — [2]Department of Physics, University of Belgrade, 11158 Belgrade, Serbia

The standard entanglement test [1] using Clauser-Horne-Shimony-Holt inequality is known to fail in mesoscopic junctions at finite temperatures [2]. Since this is due to the bidirectional particle flow, a similar failure is expected to occur in an ac-driven contact. We develop a continuous-variable entanglement test suitable for electrons and holes that are created by the ac drive [3]. The generalized Bell inequality [4] is violated in junctions with low conductance or small number of transport channels and with ac voltages which create few electron-hole pairs per cycle. Our ac entanglement test depends on the total number of electron-hole pairs [5] and on the distribution of probabilities of pair creations similar to the Fano factor.

[1] N. M. Chtchelkatchev, G. Blatter, G. B. Lesovik, T. Martin, Phys. Rev. B **66**, 161320(2002).
[2] W. R. Hannes, M. Titov, Phys. Rev. B **77**, 115323(2008).
[3] H. Zhan, M. Vanević, W. Belzig, arXiv:1711.11461.
[4] A. Bednorz and W. Belzig, Phys. Rev. B **83**, 125304(2011).
[5] M. Vanević, Y. V. Nazarov, W. Belzig, Phys. Rev. Lett **99**, 076601(2007); Phys. Rev. B **78**, 245308(2008).

TT 84.6 Thu 10:45 HFT-FT 131

Detection of spin precessions in a quantum-dot spin valve via counting statistics — •Philipp Stegmann, Jürgen König, and Stephan Weiss — Theoretische Physik, Universität Duisburg-Essen and CENIDE, 47048 Duisburg, Germany

We propose to use the full counting statistics of electron transport to reveal spin precessions in a quantum-dot spin valve, i.e., a quantum dot tunnel coupled to two ferromagnets with noncollinear magnetizations. The spin precession has an unique impact on the statistics which can be identified by generalized factorial cumulants [1,2]. Quantities like the current noise, the waiting time distribution, or ordinary cumulants are affected by the spin precession only for strongly spin-polarized ferromagnets. In contrast, our detection scheme succeeds even for arbitrary small polarizations and especially for the experimentally most favored materials [3].

[1] P. Stegmann and J. König, Phys. Rev. B **92**, 155413 (2015).
[2] P. Stegmann and J. König, New J. Phys. **19**, 023018 (2017).
[3] A. D. Crisan et al., Nat. Commun. **7**, 10451 (2016).

TT 84.7 Thu 11:00 HFT-FT 131

Single-electron thermal devices coupled to a mesoscopic gate — •Rafael Sánchez[1], Holger Thierschmann[2], and Laurens W. Molenkamp[3] — [1]Universidad Autónoma de Madrid — [2]Delft University of Technology — [3]Universität Würzburg

Fluctuations are strong in mesoscopic systems and have to be taken into account for the description of transport. We show that they can even be used as a resource for the operation of a system as a device.

We use the physics of single-electron tunneling to propose a bipartite device [1,2] working as a thermal transistor[3,4]. Charge and heat currents in a two terminal conductor can be gated by thermal fluctuations from a third terminal to which it is capacitively coupled. The gate system can act as a switch that injects neither charge nor energy into the conductor hence achieving huge amplification factors. Non-thermal properties of the tunneling electrons can be exploited to operate the device with no energy consumption.

[1] R. Sánchez, M. Büttiker, Phys. Rev. B 83, 085428 (2011)
[2] H. Thierschmann et al., Nature Nanotech. 10, 854 (2015)
[3] R. Sánchez, H. Thierschmann, L. W. Molenkamp, Phys. Rev. B 95, 241401 (2017)
[4] R. Sánchez, H. Thierschmann, L. W. Molenkamp, New J. Phys. 19, 113040 (2017)