# TT 60: Quantum Dots, Quantum Wires, Point Contacts

Time: Thursday 17:15–19:00 Location: HSZ 03

TT 60.1 Thu 17:15 HSZ 03

**Spin-texture topology in curved circuits driven by spin-orbit interactions** — Alberto Hijano[1,2], Eusebio J. Rodríguez[3], •Dario Bercioux[4,5], and Diego Frustaglia[3] — [1]Centro de Física de Materiales (CFM-MPC) Centro Mixto CSIC-UPV/EHU, E-20018 Donostia-San Sebastián, Spain — [2]Department of Condensed Matter Physics, University of the Basque Country UPV/EHU, 48080 Bilbao, Spain — [3]Departamento de Física Aplicada II, Universidad de Sevilla, E-41012 Sevilla, Spain — [4]Donostia International Physics Center (DIPC), 20018 Donostia–San Sebastián, Spain — [5]IKERBASQUE, Basque Foundation for Science, Plaza Euskadi 548009 Bilbao, Spain

We study the response of spin carriers to the effective field textures developed in curved one-dimensional circuits subject to the joint action of Rashba and Dresselhaus spin-orbit interactions. By using a quantum network technique, we establish that the interplay between these two non-Abelian fields and the circuit's geometry modify the geometrical characteristics of the spinors, particularly on square circuits, leading to the localisation of the electronic wave function and the suppression of the quantum conductance. We propose a topological interpretation by classifying the corresponding spin textures in terms of winding numbers.

[1] A. Hijano *el al.*, arXiv:2209.11653 [cond-mat.mes-hall]

TT 60.2 Thu 17:30 HSZ 03

**Stochastic resonance of electron tunneling in a quantum dot in spite of a periodically blind eye** — •Eric Kleinherbers, Hendrik Mannel, Johann Zöllner, Marcel Zöllner, Martin Geller, Axel Lorke, and Jürgen König — Faculty of Physics and CENIDE, University Duisburg-Essen, 47057 Duisburg, Germany

The key idea of stochastic resonance is to amplify a signal by adding noise. For electron tunneling in a quantum dot, this can be used to facilitate a periodic electron transfer, where during each period a single electron enters and leaves the quantum dot. In stochastic resonance, the noise (tunneling) rate must be well adjusted to the frequency of the periodic drive that is applied to the quantum dot. The Fano factor is a possible indicator of this effect [1]. Here, we study the full counting statistics and, in particular, factorial cumulants as higher-order indicators of stochastic resonance. We discuss experimental data of electron tunneling into and out of a self-assembled InAs quantum dot, where the full counting statistics is measured using a resonance fluorescence readout scheme. We find that even if the detector is blind during half of each period, a stochastic resonance is visible in the full counting statistics.

[1] T. Wagner *et al.*, Nat. Phys. 15, 330 (2019)

TT 60.3 Thu 17:45 HSZ 03

**Modifications of the local dissipation profile imposed by quantum point contacts** — •Nico Leumer — Université de Strasbourg, CNRS, IPCMS, UMR 7504, F-67000 Strasbourg, France

Recent experimental progress provides access to local temperature changes on the nanoscale, three orders of magnitude lower than the sample temperature itself [1]. Since electric current is accompanied by an energy loss of the charge carriers, this advance implies that the dissipated power became in fact a local observable. The key role is adopted by electron-phonon interactions transferring the electronic energy loss to the bulk material and thus; stimulating the sample temperature profile.

Quantum point contacts (QPC) have been reported to modify the dissipation and, especially, the energy loss of charge carriers may be distributed asymmetrically around the QPC. Inspired by this feature, we develop a theory to determine why, where and how much dissipation occurs in experimental relevant geometries.

[1] D. Halbertal et al., Nature 539, 407 (2016)
[2] C. Blaas-Anselmi et al., SciPost Phys. 12, 105 (2022)

TT 60.4 Thu 18:00 HSZ 03

**Resonant tunneling energy harvesters: Improving performance via quantum interference.** — •José Balduque[1] and Rafael Sánchez[1,2] — [1]Departamento de Física Teórica de la Materia Condensada, Universidad Autónoma de Madrid, Madrid, Spain. — [2]Condensed Matter Physics Center (IFIMAC), and Instituto Nicolás Cabrera, Universidad Autónoma de Madrid, Madrid, Spain.

The spectral filtering of quantum dots can be used for heat to power conversion in electronic conductors. A proposal based on resonant-tunneling three-terminal devices [1] has been recently verified experimentally [2]. Two quantum dots connect the two terminals of a conductor to a hot electronic cavity where carriers exchange heat via thermalization. We propose the heat source to be separated from the conductor via a beam-splitter (e.g., the tip of a scanning microscope) that mediates the system-bath coupling. The resulting ballistic electron propagation gives rise to interferences [3] able to improve the engine performance, both in the extracted power and efficiency [4].

[1] A.N. Jordan *et al.*, Phys. Rev. B **87**, 075312 (2013)
[2] G. Jaliel *et al.*, Phys. Rev. Lett. **123**, 117701 (2019)
[3] R. Sánchez *et al.*, Phys. Rev. B **104**, 115430 (2021)
[4] J. Balduque and R. Sánchez, in preparation.

TT 60.5 Thu 18:15 HSZ 03

**Vibrational instabilities arising from non-conservative current-induced forces in nanosystems: A comparison of quantum and semi-classical approaches** — •Samuel Rudge, Christoph Kaspar, and Michael Thoss — Institute of Physics, University of Freiburg, Germany

Understanding the vibrational dynamics of molecular junctions is of paramount importance to creating junctions that are mechanically stable. In systems with more than one vibrational degree of freedom, instabilities can arise due to non-conservative current-induced forces, an effect that can occur at lower voltages than the well-understood mechanism of current-induced heating [1].

In recent years, such non-conservative forces have been largely explored with semi-classical Langevin-type equations for the vibrational degrees of freedom, where the electronic friction tensor and average electronic force can be analyzed directly [1]. In this work, however, we employ both a semi-classical Langevin equation as well as a quantum master equation approach to explore instabilities in a model system with two electronic levels and two vibrational modes. Both approaches derive from the numerically exact hierarchical equations of motion (HEOM) method [2], and the resulting analysis is able to show in which regimes such semi-classical treatments can be used.

[1] J. T. Lü *et al.*, Phys. Rev. B **85**, 245444 (2012)
[2] S.L. Rudge, Y. Ke, and M. Thoss, arXiv:2211.14215 (2022)

TT 60.6 Thu 18:30 HSZ 03

**Asymmetric couplings of quantum dot systems to environments** — •Lukas Litzba, Nikodem Szpak, Eric Kleinherbers, and Jürgen König — Fakultät für Physik, Universität Duisburg-Essen, Lotharstraße 1, 47057 Duisburg, Germany

We study systems with a few quantum dots, represented by the Fermi-Hubbard model, coupled to several Markovian baths with different coupling strengths. On the one hand, we compare different approximations (such as Redfield equation, coherent Lindblad approximation [1]) for a Master equation in first order of the quantum dot–bath coupling for strongly interacting electrons. On the other hand, we find exact solutions for non-interacting electrons. We compare the results for different coupling strength regimes and discuss the qualitative changes in the system behavior. Thereby we observe significant effects of the coupling asymmetry on energy coherences, which is linked to local versus global coupling. We look closer at systems from two to ten dots and study the non-equilibrium dynamics based on dressed excitation energies of the system as well as the associated damping rates. In this context we find transitions from global to local coupling behavior with increasing coupling strength asymmetry.

[1] E. Kleinherbers, N. Szpak, J. König, R. Schützhold, PRB 101, 125131 (2020)

TT 60.7 Thu 18:45 HSZ 03

**Relaxation dynamics in Fermi-Hubbard systems coupled to environment** — •Nikodem Szpak[1], Gernot Schaller[2], Ralf Schützhold[2,3], and Jürgen König[1] — [1]Theoretische Physik und CENIDE, Universität Duisburg-Essen, Lotharstr. 21, 47048 Duisburg — [2]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden — [3]Institut für Theoretis- che Physik, Technische Universität Dresden, 01062 Dresden

We study a chain of quantum dots coupled to enviroment and describe it with the Fermi-Hubbard model coupled to fermionic baths. For different coupling regimes (interdot vs bath-dot) we derive separate Lindblad master equations and compare their properties. It is shown that for strong repulsive onsite (Coulomb) interactions and low bath temperatures the system quickly reaches a low-energy sector described effectively by the Heisenberg model. Within this sector the further dynamics depends strongly on the relative coupling strengths. For weak bath-dot coupling, the system relaxes globally to the unique anti-ferromagnetic ground state with zero total spin. For strong bath-dot coupling, the system increases its total spin to the maximal possible value and ends up in (degenerate) states exhibiting ferromagnetic order. We provide rigorous derivations as well as numerical examples.

[1] E. Kleinherbers, N. Szpak, J. König, and R. Schützhold, Phys. Rev. B 101, 125131 (2020)

[2] G. Schaller, F. Queisser, N. Szpak, J. König, and R. Schützhold, Phys. Rev. B 105, 115139 (2022)