TT 78: Quantum Dots and Point Contacts (joint session TT/HL)

Time: Thursday 11:00–12:45 Location: HSZ/0101

TT 78.1 Thu 11:00 HSZ/0101

Mapping dissipation in a quantum dot junction — •Johannes Höfer[1], Subhomoy Haldar[2], Ville Maisi[2], Hervé Courtois[1], and Clemens B. Winkelmann[1,3] — [1]Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 25 rue des Martyrs, Grenoble, France — [2]NanoLund and Solid State Physics, Lund University, 22100 Lund, Sweden — [3]Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG-Pheliqs, Grenoble, France

Characterization of quantum devices relies primarily on electrical properties. It is usually assumed that all parts of the device remain at the same temperature, but the inevitable presence of local dissipation can lead to significant deviations and degrade device performance [1].

Here, we present simultaneous measurement of the current through a quantum dot junction as well as the dissipation generated by the current. To this end, we thermally isolate the drain contact of an epitaxially defined quantum dot in an InAs nanowire. The electron temperature is measured via the zero-bias conductance of a Josephson junction [2]. Due to the energy-selective transport through a single quantum level, we can tune the dissipation solely with a gate voltage, while keeping both the current and voltage across the dot constant.

The presented device enables future investigations of local dissipation in nanoscale devices, e.g. for mitigation of detrimental heating effects, as well as implementations of proposed experiments in the field of quantum thermodynamics.

[1] S.G.J. Philips et al., Nature 609 (2022) 919
[2] B. Karimi, & J.P. Pekola, Phys. Rev. Applied 10 (2018) 054048

TT 78.2 Thu 11:15 HSZ/0101

Lindblad-based linear response of hybrid semiconductor-superconductor devices — •Tobias Kuhn, Raffael L. Klees, and Monica Benito — Augsburg University, Augsburg, Germany

The field of hybrid semiconductor-superconductor quantum dots is pushing towards the development of functional devices that harness the advantages of both worlds. Their complexity calls for a complete theoretical framework to understand responses to different probe fields and dissipation induced by the environment. We present a Lindblad-based linear response formalism, built upon the framework introduced in Ref. [1]. It captures not only the inherently multi-level nature of these devices but also their probe-readout flexibility and non-unitary effects of the finite-frequency response. We exemplify the framework using quantum dot based Kitaev chain setups which are promising candidates for topologically protected qubits [2,3].

[1] L. Peri, M. Benito, C. J. B. Ford, and M. F. Gonzalez-Zalba, npj Quantum Inf **10**, 1 (2024)
[2] M. Leijnse and K. Flensberg, Phys. Rev. B **86**, 134528 (2012)
[3] D.M.Pino, R.S.Souto, R.Aguado, Phys. Rev. B**109**, 075101 (2024)

TT 78.3 Thu 11:30 HSZ/0101

Dynamics of strong correlations of a hybrid quantum dot system with superconducting and ferromagnetic electrodes — •Antoni Jankiewicz, Kacper Wrześniewski, and Ireneusz Weymann — Institute of Spintronics and Quantum Information, Adam Mickiewicz University, Poznań, Poland

We theoretically explore the non-equilibrium dynamics of a quantum dot coupled to superconducting and ferromagnetic electrodes. This hybrid setup offers a rich platform to investigate the interplay between strong correlations, superconductivity, and ferromagnetism at the nanoscale. To perform the analysis we employ the numerical renormalization group and its time-dependent extension. These methods enable us to capture the subtle nature of dynamical quantum phase transitions induced by abrupt changes in Hamiltonian parameters, known as quantum quenches. Such transitions are crucial for understanding the stability and evolution of many-body states in response to external perturbations.

The aim of this work is to examine the competition between the superconducting pairing and the dot's spin. For that, we determine the time dependence of key observables, including the dot's spin and the on-dot pairing correlations. We demonstrate that these quantities reveal the competing character of correlations as they oscillate in counter-phase. Furthermore, we also analyze the dynamical quantum phase transitions in the system by determining the Loschmidt echo and the return function, which provide direct measures of the system's sensitivity to quenches.

TT 78.4 Thu 11:45 HSZ/0101

Tunneling resonances through periodically driven quantum dots — •Jan Mathis Giesen, Daniel Weber, and Sebastian Eggert — RPTU University Kaiserslautern-Landau, D-67663 Kaiserslautern, Germany

We consider a general setup of transport through a time-periodically driven quantum dot using Floquet theory. An analytic non-equilibrium solution of the problem is developed which allows the analytic prediction and analysis of the tunneling amplitudes as a function of frequency, driving amplitude, and energy levels on the dot. One main result is the discovery of a previously unknown resonant switching effect, where a very small control signal on a weakly connected quantum dot can induce perfect transmission. This opens the door for the design of novel efficient nano-electronic devices. The results are also relevant for corresponding setups using magnonic systems, photonic waveguides, or ultra-cold gases in optical lattices.

TT 78.5 Thu 12:00 HSZ/0101

Spectroscopic-imaging Coulomb blockade microscopy — Junho Bang[1], Byeongin Lee[1], Hankyu Lee[1], •Jianfeng Ge[2], and Doohee Cho[1] — [1]Department of Physics, Yonsei University, Seoul 03722, Republic of Korea — [2]Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

We use scanning tunneling microscopy (STM) to directly visualize Coulomb blockade (CB) phenomena in the double-barrier tunnel junction formed between the STM tip and crystalline indium nanoislands on semiconducting black phosphorus. Spatially resolved tunneling spectra reveal bias-dependent dispersions of CB peaks across individual nanoislands. Strikingly, the trajectories of CB peaks exhibit twofold asymmetries: (i) their curvatures reverse sign across a nonzero bias offset, and (ii) the trajectories lack mirror symmetry about this bias offset. Simulations based on orthodox theory faithfully reproduce both asymmetries, which we trace to work-function mismatches at (i) the island-tip and (ii) the island-substrate interfaces, respectively. These results establish spectroscopic-imaging Coulomb-blockade microscopy as a quantitative probe of junction parameters, offering a pathway for diagnosing and optimizing single-electron charge sensors relevant to quantum-computing architectures.

TT 78.6 Thu 12:15 HSZ/0101

Electromigrated palladium nano-contacts: formation of atomic contacts and non linear current-voltage characteristics — •Samanwita Biswas[1], Thomas Hultzsch[1], Marcel Strohmeier[2], Elke Scheer[2], and Regina Hoffmann-Vogel[1] — [1]Institute of Physics and Astronomy, University of Potsdam — [2]Department of Physics, University of Konstanz

We investigate the electronic transport properties of atomic-size Pd contacts fabricated by electromigration (EM) of lithographically defined nano-constrictions, at room temperature in different environments. In particular we study changes in the conductance upon EM with a focus on possible shell effects [1]. By systematic analysis of a large number of data sets in the conductance range up to $\sim 10G_0$ (with the conductance quantum $G_0 = 2e^2/h$), we identify preferential conductance values and compare these with the ones expected for shell closure in multivalent metals. For contacts with $G \lesssim 5G_0$, the current-voltage characteristics often become nonlinear on a scale of few 100mV; we discuss this observation with respect to structural changes during the thinning process of EM. By monitoring the smallest conductances, we often identify a decrement of resistance inside a cycle, opposite to the overall trend, indicating the transition to the ballistic regime. Our results suggest that metallic few atomic contacts of Pd, despite being more reactive than noble metals, can be stabilized even at room temperature.

[1] Mares & van Ruitenbeek, Phys. Rev. B 72, 205402 (2005)

TT 78.7 Thu 12:30 HSZ/0101

Readout of multi-level quantum geometry from electronic transport — •Raffael L. Klees and Mónica Benito — Institute of Physics, University of Augsburg, D-86159 Augsburg, Germany

The quantum geometric tensor (QGT) of a quantum system in a given parameter space captures both the geometry of the state manifold and the topology of the system [1]. While the local QGT elements have been successfully measured in various platforms, the challenge of detecting them in electronic transport systems – such as tunnel or molecular junctions – has yet to be resolved. To fill this gap, we propose a measurement protocol based on weak and resonant parameter modulations [2], and theoretically demonstrate how the local QGT in such systems can be directly probed from changes of the tunnel conductance [3]. This approach enables the measurement of both geometrical and topological features of quantum states in a broad class of transport-based quantum systems.

[1] M. Kolodrubetz *et al.*, Phys. Rep. **697**, 1 (2017)
[2] T. Ozawa and N. Goldman, Phys. Rev. B **97**, 201117(R) (2018)
[3] R. L. Klees and M. Benito, arXiv:2508.08239 (2025)