TT 13: Quantum Dots, Quantum Wires, Point Contacts

Time: Tuesday 9:30–11:00 Location: H23

TT 13.1 Tue 9:30 H23

Precession of entangled spin and pseudospin in double quantum dots — •Christoph Rohrmeier and Andrea Donarini — University Regensburg

Quantum dot spin valves are characterized by exchange fields [1] which induce spin precession and generate anomalous spin resonances [2]. Analogous effects have been studied in double quantum dots, in which the orbital degree of freedom replaces the role of the spin in the valve configuration [3]. We generalize, now, this setup to allow for arbitrary spin and orbital polarization of the leads, thus obtaining an even richer variety of current resonances, stemming from the entangled precession dynamics of the spin and pseudospin [4]. We observe for both vectors a delicate interplay of decoherence, pumping and precession which can only be understood by including the dynamics of the spin-pseudospin correlators. The results are obtained in the framework of a generalized master equation within the cotunneling approximation and are complemented by a coherent sequential tunneling model.

[1] Braun et al., Phys. Rev. B 70 (2004) 195345
[2] Hell et al., Phys. Rev. B 91 (2015) 195404
[3] Rohrmeier et al., Phys. Rev. B 103 (2021) 205420
[4] Rohrmeier et al., Phys. Rev. B 105 (2022) 205418

TT 13.2 Tue 9:45 H23

Pair-amplitude dynamics in superconductor-quantum dot hybrids — •Markus Heckschen and Björn Sothmann — Universität Duisburg-Essen, Duisburg, Deutschland

We consider a three-terminal system consisting of a quantum dot strongly coupled to two superconducting reservoirs in the infinite gap limit and weakly coupled to a normal metal. Using a real-time diagrammatic approach, we calculate the dynamics of the proximity-induced pair amplitude on the quantum dot. We find that after a quench the pair amplitude shows pronounced oscillations with a frequency determined by the coupling to the superconductors. In addition, it decays exponentially on a time scale set by the coupling to the normal metal. Strong oscillations of the pair amplitude occur also when the system is periodically driven both in the adiabatic and fast-driving limit. We relate the dynamics of the pair amplitude to the Josephson and Andreev current through the dot to demonstrate that it is an experimentally accessible quantity.

[1] M. Heckschen and B. Sothmann, Phys. Rev. B 105 (2022) 045420

TT 13.3 Tue 10:00 H23

Staggered spin-orbit interaction in a nanoscale device — Lauriane Contamin[1], Tino Cubaynes[1], William Legrand[1], •Magdalena Marganska[2], Matthieu Desjardins[1], Matthieu Dartiailh[1], Zaki Leghtas[1,3,4], Andre Thiaville[5], Stanislas Rohart[5], Audrey Cottet[1], Matthieu Delbecq[1], and Takis Kontos[1] — [1]Laboratoire de Physique de l'Ecole Normale Superieure, ENS, Universite PSL, CNRS, Sorbonne Universite, Universite Paris-Diderot, Sorbonne Paris Cite, Paris, France — [2]Institute for Theoretical Physics, University of Regensburg, Germany — [3]QUANTIC Team, INRIA de Paris, Paris, France — [4]Centre Automatique et Systemes, Mines Paris-Tech, PSL Research University, Paris, France — [5]Laboratoire de Physique des Solides, Universite Paris-Saclay, CNRS, UMR 8502, Orsay, France

The coupling of the spin and the motion of charge carriers is an important ingredient for the manipulation of the spin degree of freedom and for the emergence of topological matter. Creating domain walls in the spin-orbit interaction at the nanoscale may turn out to be a crucial resource for engineering topological excitations suitable for universal topological quantum computing or for new schemes for spin quantum bits. Realizing this in natural platforms remains a challenge. Using high resolution circuit quantum electrodynamics magneto-spectroscopy, we show how this can be implemented in carbon nanotubes with a staggered synthetic spin-orbit interaction induced by two lithographically patterned magnetically textured gates.

TT 13.4 Tue 10:15 H23

Jahn-Teller effects in charge transport through single-molecule junctions: a hierarchical equation of motion approach — •Christoph Kaspar and Michael Thoss — University of Freiburg

Molecules with degenerate electronic states may exhibit Jahn-Teller effects [1]. In this contribution, we investigate charge transport through such molecules bound to metal electrodes within a molecular junction [2]. The study employs the hierarchical equation of motion approach [3,4] to open quantum system dynamics. This method generalizes perturbative master equation methods by including higher-order contributions as well as non-Markovian memory, thus allowing for a systematic convergence of the results. Extending previous studies [5], we find that the molecule can become trapped in a nonconducting state resulting in a current-blockade, out of which only higher-order processes such as cotunneling provide an escape mechanism.

[1] M. O'Brien *et al.*, Am. J. Phys. **61**, 688 (1993)
[2] C. Kaspar *et al.*, Phys. Rev. B **105**, 195435 (2022)
[3] Y. Tanimura, J. Chem. Phys. **153**, 020901 (2020)
[4] C. Schinabeck *et al.*, Phys. Rev. B **94**, 201407R (2016)
[5] M. Schultz *et al.*, Phys. Rev. B **77**, 075323 (2008)

TT 13.5 Tue 10:30 H23

Evolution of single-level-model parameters in the mechanically controllable break junctions — •M. Lokamani[1,2], F. Kilibarda[2], F. Günther[3], J. Kelling[1], A. Strobel[2], P. Zahn[2], G. Juckeland[1], K. Gothelf[4], E. Scheer[5], S. Gemming[6], and A. Erbe[2] — [1]FWCC, HZDR, Dresden, Germany — [2]FWIO, HZDR, Dresden, Germany — [3]IFSC, São Carlos, Brazil — [4]iNANO, Aarhus, Denmark — [5]Department of Physics, Uni Konstanz, Germany — [6]Institute of Physics, TU Chemnitz, Germany

The electrical properties of single molecules can be investigated using atomically sharp metallic electrodes in mechanically controllable break junctions (MCBJs). The current-voltage (IV) characteristics of single molecules in such junctions are influenced by the binding positions of the end groups on the tip-facets and tip-tip separation. In this talk, we present MCBJ experiments on N,N'-Bis(5-ethynylbenzenethiol-salicylidene)ethylenediamine (Salen). We discuss the evolution of the single level model (SLM) parameters namely, a) the energetic level ϵ of the dominant conducting channel and b) the coupling Γ of the dominant conducting channel to the metallic electrodes. The SLM-parameters were evaluated for IV-curves recorded during opening measurements and fitted to the single level model. We propose a novel, high-throughput approach to model the evolution of the SLM-parameters and explain the recurring peak-like features in the experimentally measured evolution of Γ with increasing tip-tip separation, which we relate to the deformation of the molecule and the sliding of the anchor group above the electrode surface.

TT 13.6 Tue 10:45 H23

Relaxation dynamics in a Hubbard trimer and tetramer coupled to fermionic baths: antiferromagnetic order and persistent spin currents — •Nikodem Szpak[1], Gernot Schaller[2], Friedemann Queisser[2], Ralf Schützhold[2,3], and Jürgen König[1] — [1]Theoretische Physik, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg — [2]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden — [3]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden

We study relaxation dynamics in a strongly-interacting three and four-site Fermi-Hubbard system (quantum dots) coupled to environment represented by fermionic baths. Starting with an ab initio approach, we derive several variants of the Lindblad master equation for the quantum dots systems by applying different approaches: local and global, secular and coherent [1,2]. At low temperatures, depending on the particular parameter ratios and applied approximations, the system tends to or destroys antiferromagnetic order [2]. In three quantun dots, the system becomes spin-frustrated and relaxes to a stable persistent spin current.

[1] E. Kleinherbers, N. Szpak, J. König, and R. Schützhold, Phys. Rev. B 101, 125131
[2] G. Schaller, F. Queisser, N. Szpak, J. König, and R. Schützhold, Phys. Rev. B 105, 115139