MON 11: Quantum Transport I

Time: Monday 14:15–16:00 Location: ZHG104

MON 11.1 Mon 14:15 ZHG104

Scattering approach to quantum radiative heat transfer — •Matthias Hübler[1], Denis M. Basko[2], and Wolfgang Belzig[1] — [1]Universität Konstanz, Konstanz, Deutschland — [2]University Grenoble Alpes CNRS LPMMC, Grenoble, France

We formulate the problem of near-field radiative heat transfer as an effective quantum scattering theory for excitations of the matter. Built from the same ingredients as the semiclassical fluctuational electrodynamics, the standard tool to handle this problem, our construction makes manifest its relation to the Landauer-Büttiker scattering framework, which appears only implicitly in the fluctuational electrodynamics. We show how to construct the scattering matrix for the matter excitations and give a general expression for the energy current in terms of this scattering matrix. We show that the energy current has an important non-dissipative contribution that can dominate the finite-frequency noise while being absent in the average current. Our construction provides a unified description of near-field radiative heat transfer in diverse physical systems.

MON 11.2 Mon 14:30 ZHG104

Anisotropic Electrical Transport in Quasi-1D $ZrSe_3$-Stripes — •Davin Höllmann[1], Lars Thole[1], Sonja Locmelis[2], and Rolf J. Haug[1,3] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Institut für Anorganische Chemie, Leibniz Universität Hannover, 30167 Hannover, Germany — [3]Laboratorium für Nano- und Quantenengineering, Leibniz Universität Hannover, 30167 Hannover, Germany

The anisotropy in form of quasi one-dimensional (1D) chains in transition metal trichalcogenides (TMTCs), like ZrS_3 and $ZrSe_3$, makes them stand out compared to other more conventional two-dimensional (2D) materials [1]. We investigated the electrical properties of thin stripes of TMTCs, in particular $ZrSe_3$, regarding their width and thickness. Highlighting the influence of anisotropic effective electron masses [2] in the 2D-plane. The bulk material used was fabricated by a chemical vapor transport method and then exfoliated to achieve thin stripes.

We compared narrow samples with wider samples where both have comparably similar length and thickness and found that the conductivity happens dominantly in the outer selenium atoms i.e. across the chains [3]. We confirmed this using angle dependent electrical transport measurements.

[1] J. O. Island et al., 2D Materials 4, 0220033 (2017)
[2] Y. Jin et al., Phys. Chem. Chem. Phys. 17, 18665-18669 (2015)
[3] D. Höllmann et al., ACS Appl. Electron. Mater. 7, 9, 4049-4054 (2025)

MON 11.3 Mon 14:45 ZHG104

Boundary-driven magnetization transport in the spin-1/2 XXZ chain and the role of the system-bath coupling strength — •Mariel Kempa[1], Markus Kraft[1], Sourav Nandy[2], Jacek Herbrych[3], Jiaozi Wang[1], Jochen Gemmer[1], and Robin Steinigeweg[1] — [1]University of Osnabrueck, D-49076 Osnabrueck, Germany — [2]Max Planck Institute for Physics of Complex Systems, D-01187 Dresden, Germany — [3]Wroclaw University of Science and Technology, 50-370 Wroclaw, Poland

We revisit the Lindblad equation in the context of boundary-driven magnetization transport in integrable spin-1/2 XXZ chain. In particular, we explore the influence of the system-bath coupling strength γ on the quantitative value of the diffusion constant D. Employing numerical simulations on the basis of stochastic unraveling and time-evolving block decimation, we obtain the curve $D(\gamma)$ for finite system sizes, yet outside the range of exact diagonalization. We unveil that $D(\gamma)$, as extracted from the steady state, depends significantly on γ and disagrees with the Kubo formula. We suggest a physical explanation of this disagreement.

MON 11.4 Mon 15:00 ZHG104

Scaling of diffusion constants in perturbed easy-axis Heisenberg spin chains — •Markus Kraft[1], Mariel Kempa[1], Jiaozi Wang[1], Sourav Nandy[2], and Robin Steinigeweg[1] — [1]University of Osnabrück, Department of Mathematics/Computer Science/Physics, D-49076 Osnabrück, Germany — [2]Max Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany

Understanding the physics of the integrable spin-1/2 XXZ chain has witnessed substantial progress, due to the development and application of sophisticated analytical and numerical techniques. Since integrability is rather the exception than the rule, a crucial question is the change of infinite-temperature magnetization transport under integrability-breaking perturbations. This question includes the stability of superdiffusion at the isotropic point and the change of diffusion constants in the easy-axis regime. In our work, we study this change of diffusion constants by a variety of methods and cover both, linear response theory in the closed system and the Lindblad equation in the open system, where we throughout focus on periodic boundary conditions. In the closed system, we find evidence for a continuous change of diffusion constants over the full range of perturbation strengths. In the open system weakly coupled to baths, we find diffusion constants in quantitative agreement with the ones in the closed system in a range of nonweak perturbations, but disagreement in the limit of weak perturbations. Using a simple model in this limit, we point out the possibility of a diverging diffusion constant in such an open system.

MON 11.5 Mon 15:15 ZHG104

Andreev reflection and interferometry of integer quantum Hall edge states — •Tom Menei and Thomas L. Schmidt — Department of Physics and Materials Science, University of Luxembourg, Luxembourg

Recent experimental work has demonstrated the possibility of coupling superconductors (SCs) to quantum Hall (QH) systems at both integer and fractional filling factors. However, the theoretical modeling of such QH/SC interfaces remains challenging due to the strong magnetic fields required and the presence of disorder. In this work, we develop a theoretical framework based on QH edge state theory and incorporate realistic models of the superconductor to derive the effective coupling mechanisms at the interface. We analyze the resulting normal and Andreev reflection processes, as well as correlations probed through interference between multiple edge states across the QH/SC interface, and discuss their signatures in transport experiments.

MON 11.6 Mon 15:30 ZHG104

Unconventional Josephson Supercurrent Diode Effect Induced by Chiral Spin-Orbit Coupling — •Andreas Costa[1], Osamu Kanehira[2], Hiroaki Matsueda[2], and Jaroslav Fabian[1] — [1]University of Regensburg, Germany — [2]Tohoku University, Japan

First-principles calculations have recently predicted that chiral materials lacking mirror symmetries—such as twisted van der Waals homobilayers—can feature unconventional radial Rashba coupling with spins aligned fully parallel (instead of tangential) to momentum.

In this talk, we will address Josephson transport through vertical superconductor/ferromagnet/superconductor junctions hosting crossed (radial and tangential) Rashba fields at the interfaces and demonstrate that their interplay with ferromagnetic exchange can lead to supercurrent rectification even when the magnetization is collinear with the current. This so-called unconventional supercurrent diode effect (SDE) originates from spin precessions inside the ferromagnet, which imprint polarity-dependent transmission probabilities on the Cooper pairs being well-distinct from the conventional SDE, and provides a sensitive probe of chiral spin textures.

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MON 11.7 Mon 15:45 ZHG104

Josephson vortex pinning in two-dimensional SNS-arrays — •Christian Schäfer[1,2], Justus Teller[1,2], Benjamin Bennemann[3], Matvey Lyatti[1,2], Florian Lentz[4], Detlev Grützmacher[1,2], Roman-Pascal Riwar[5], and Thomas Schäpers[1,2] — [1]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA-Fundamentals of Future Information Technology, Jülich-Aachen Research Alliance, Forschungszentrum Jülich and RWTH Aachen University, Germany — [3]Peter Grünberg Institut (PGI-10), Forschungszentrum Jülich, 52425 Jülich, Germany — [4]Helmholtz Nano Facility, Forschungszentrum Jülich, 52425 Jülich, Germany — [5]Peter Grünberg Institut (PGI-2), Forschungszentrum Jülich, 52425 Jülich, Germany

We fabricated Josephson arrays by etching stacked platinum-niobium

(Pt-Nb) thin films. By analyzing both small (3×3) and large (30×30 and 50×50) arrays, we examined how array size and edge effects affect the frustration patterns created by the flow of Josephson vortices. Upon cooling the arrays below 300 mK, the energy barrier for vortex motion increases, immobilizing the vortices and causing the array's behavior to resemble that of a single reference junction. In this vortex-pinned regime, we studied the switching dynamics of the arrays. To determine the distribution of single-junction critical currents within the array, we compared our experimental findings with simulations based on the resistively and capacitively shunted junction (RCSJ) model.