Poster Booklet

Ali Asgharpour: *Control of spin pumping in magnetic tunnel junctions by manipulation of the electrical environment*

Spin currents and their electrical control are at the heart of spintronics and its applications. Spin pumping is a way to create spin currents. Here, we show that such spin currents may be controlled by manipulating the electrical environment.

Vinayak Shantaram Bhat: *Tuning Interactions via Topological Defects in Kagome Artificial Spin Ice for Reprogrammable Magnonics*

Kagome artificial spin ice (KASI) is a network of Ising type nanobars on a kagome lattice [1,2]. We investigate spin dynamics of topological defects in a KASIs comprising Ni81Fe19 (Py) nanomagnets arranged on a disconnected kagome lattice using broadband ferromagnetic resonance (FMR) and micromagnetic simulations [3]. Two KASI samples were prepared using electron beam lithography and lift-off techniques. Each KASI covered a writefield area of 120 µm × 120 µm and was repeated on a 35 × 5 array to increase the signal-to-noise ratio broadband spectroscopy measurements. The nominal length, width, and thickness of a Ni81Fe19 (Py) nanobar were kept at 400 nm, 130 nm, and 25 nm, respectively. The shortest distances between two nanobars in samples named Sample-I and Sample-II were 60 nm and 300 nm, respectively. We observed spin wave spectra that varied characteristically upon the separation between the two nanobars resulting in distinct slope changes in frequency vs. H and depends upon topological defect configuration. We further studied reprogrammable characteristics of spin wave spectra in strongly and weakly dipolarly coupled kagome artificial spin ices.
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Aleksander Sanjuan Ciepielewski: *Transport signatures of van-Hove singularities in mesoscopic twisted bilayer graphene*

Magic-angle twisted bilayer graphene is a fascinating strongly correlated electron system. It has exceptionally flat low-energy bands with van Hove singularities close to the Fermi level, and it is believed that the van Hove singularities play a prominent role in the exotic phenomena of magic-angle twisted bilayer graphene by amplifying the electron correlation effects. Most theoretical and experimental research of twisted bilayer graphene has so far focused on observables in the thermodynamic limit, and transport in large samples in the semiclassical regime where inelastic scattering is important. In this work, we instead concentrate on mesoscopic ballistic samples in the quantum transport regime, which allows us to probe the quantum states and band structure in an energy-resolved fashion. We calculate the four-terminal conductance of twisted bilayer graphene as a function of the twist angle, interlayer hopping amplitude and energy, and we identify signatures of different types of van Hove singularities.

Pieter Gunnink: *Non-linear dynamics of the non-Hermitian Su-Schrieffer-Heeger model*

We numerically determine the robustness of the lasing edge modes in a spin-torque oscillator array which realizes a non-Hermitian Su-Schrieffer-Heeger model. In the topological regime, the lasing edge mode is driven into auto-oscillation, while the bulk dynamics are suppressed. We consider the full non-linear and stochastic dynamics, which are of great importance in spin-torque oscillators. Our analysis shows that the lasing edge mode dynamics persist in the non-linear domain for a wide range of parameters. We investigate the effects of perturbations relevant to experimental implementations and discuss which ones might be detrimental to the stability of the lasing edge mode. Finally, we map our model into a photonic model. We believe that our analysis has the potential to shed light onto the dynamics of many non-Hermitian systems with non-linearities.

Viktor Harkov: *Impact of partially bosonized collective fluctuations on electronic degrees of freedom*

In this poster we introduce a simple efficient method called dual triply irreducible local expansion (D-TRILEX) method which is based on a standard dual fermion/boson scheme with the interaction truncated at the two-particle level. We show that after performing the parametrization of the local four-point vertex of the auxiliary impurity model a unique choice of the bare interaction allow us to exclude the irreducible contributions. The approximated vertex can then be expressed in terms of screened interaction and the three-point vertex. This reduces the computational costs drastically. We apply our method to a two-dimensional single-band Hubbard model to study the impact of partially bosonized collective fluctuations on electronic degrees of freedom. Thereby, we find that in the regime, where the ladder dual fermion approximation provides an accurate solution of the problem, the leading contribution to the self-energy is given by the longitudional bosonic modes. Our results justify the applicability of the D-TRILEX method that represents one of the simplest consistent diagrammatic extensions of the dynamical mean-field theory.

Joren Harms: *Non-linear analysis of synthetic antiferromagnetic spin-torque oscillators near exceptional points*

We study the non-linear behavior of a synthetic antiferromagnetic spin torque oscillators in the vicinity of an exceptional point. Through analytical linear and non-linear analysis, we characterize the long time behavior of this system by finding it's limit cycles. This agrees very well with the numerical phase diagrams, showing the extremely sensitive non-linear behavior near the phase space values for which the exceptional point is present. Our findings can have direct technological applications as emitter, memory, magnetometer or sensor to measure transport properties such as the interlayer coupling, magnetic damping, spin Hall angle.

Lukasz Karwacki: *Long-range phonon spin current in magnetomechanical system*

Andrej Lehmann: *Change of magnetic structure by doping in interacting kagome lattice*

Simon Michel: *Adiabatic spin dynamics in the Haldane model*

We study the dynamics of classical degrees of freedom (DOF) coupled to quantum systems with gapped, non-degenerate ground states. Typically the inherent time scale of the quantum system is much faster than the dynamics of the classical parameters. Exploiting the adiabatic theorem and constraining the dynamics of the quantum system, initially prepared in its ground state, to instantaneously adapt to the slow

dynamics of the classical DOF leads to non-Hamiltonian equations of motion. This is due to an emergent geometrical spin-torque that governs the dynamics of the classical DOF and originates as a feedback of the Berry physics of the quantum system.
As a prototypical example, we study classical spins (magnetic impurities) locally coupled to a spinful Haldane model as the quantum host. The spatial structure of the spin-Berry curvature tensor is investigated as well as its dependence on the model parameters of the host. The contribution of the geometrical spin torque to the impurity-spin dynamics is found to be typically small for impurities deep in the bulk, and we argue that it is finite and a continuous function of the host parameters even across a topological phase transition. On the hand hand, we demonstrate that it diverges when the classical DOF are coupled to the edge of the host.

Jannis Neuhaus-Steinmetz: *Complex magnetic ground states and topological electronic phases of atomic spin chains on superconductors*

Understanding the magnetic properties of atomic chains and nanoscopic wires on superconductors is an essential cornerstone on the road towards controlling and constructing topological matter. Yet, even in the simplest models of suspended chains, the classes of available magnetic ground states remain debated.
Ferromagnetic (FM), antiferromagnetic (AFM), and spiral configurations have been suggested and experimentally detected, while additionally non-coplanar and complex collinear phases have been conjectured. Here, we resolve a recent controversy by determining the magnetic ground states of chains of magnetic atoms in proximity to a superconductor with Monte-Carlo methods, which employ the initial tight-binding model directly without further simplifications. We confirm the existence of FM, AFM and spiral ground states, and identify additional more complex ground states. We topologically classify the electronic structures, and investigate the stability of the magnetic states against increasing superconductivity. In addition, we introduce a computationally efficient alternative for approximating the magnetic ground state with an effective Heisenberg model, which we demonstrate by using our previous results as a benchmark for this new method.

Tania Paul: *Interplay of quantum spin Hall effect and spontaneous time-reversal symmetry breaking in electron-hole bilayers : Zero-field topological superconductivity*

It has been proposed that band-inverted electron-hole bilayers support a phase transition from an insulating phase with spontaneously broken time-reversal symmetry to a quantum spin Hall insulator phase as a function of increasing electron and hole densities. Here, we show that in the presence of proximity-induced superconductivity it is possible to realize Majorana zero modes in the time-reversal symmetry broken phase in the absence of magnetic field. We develop an effective low-energy theory for the system in the presence of time-reversal symmetry breaking order parameter to obtain analytically the Majorana zero modes and we find a good agreement between the numerical and analytical results in the limit of weakly broken time-reversal symmetry. We show that the Majorana zero modes can be detected in superconductor/time-reversal symmetry broken insulator/superconductor Josephson junctions through the measurement of a 4pi Josephson current. We also demonstrate that the Majorana fusion-rule detection is feasible by utilizing the gate voltage dependence of the spontaneous time-reversal symmetry breaking order parameter.

Robin Quade: *Controlled real-time spin dynamics in topological systems*

The time-dependent state of two classes of topological composite systems consisting of (A) individual or (B) collections of classical spins locally exchange coupled to an underlying electronic structure is studied numerically by solving the full set of coupled microscopic equations of motion for the spin(s) and the electron system. Namely, we consider (A) a single classical spin coupled to the helical boundary modes of a topologically nontrivial Kane Mele model [1] and (B) a Yu-Shiba-Rusinov chain of classical spins coupled to a generic s-wave superconducting host giving rise to Majorana zero modes bound to the ends of the chain when the topologically nontrivial phase is realised. In both setups we study the mutual effects of classical spin dynamics and topological class focussing on dynamical signatures of the sole classical spin in (A) while exploring the possibilities for real-time control over topological phase transitions and non-Abelian dynamical braiding in (B). In either case, dynamics in the long-time limit is accessible thanks to dissipative terms in the form of electronic Lindblad boundary conditions or classical spin Gilbert damping within the Landau-Lifschitz-Gilbert scheme. [1] Robin Quade, Michael Potthoff, Phys. Rev. B 105, 035406 (2022).

Amanda Teodora Preda: *Tuning electronic band structure properties in Lieb-like lattices*

The study of topological materials has expanded greatly in the last years, as it brings together condensed matter and fundamental physics, while also being relevant on a technological and practical level, e.g. in applications like spintronics, ferromagnetic materials, superconductivity and topological quantum computing [1]. In particular, materials with Lieb-like lattice structures are prominent examples, which have been extensively studied in the framework of the tight binding models. The ideal Lieb lattice (LL) is characterized by a topological flat band with highly degenerated single particle states leading to strongly correlated phenomena.

However, the practical realization of LLs poses tough challenges. Some approaches for achieving the characteristic LL band structures are based on atomistic frameworks, either by surface patterning using add-atoms [2] or, more recently, by synthesizing covalent-organic [3] or metal-organic [4] frameworks. The 3D equivalent of Lieb lattices are the perovskite-related structures [5], like e.g. ReO3 type structures, which ideally provide a double-degenerate flat band.

We focus here on tuning the electron band structure of Lieb-like lattices using a continuous model, which is more realistic from the perspective of the lithography technique. Each atom in the lattice now corresponds to a potential well of given (circular) shape and, by imposing periodic boundary conditions, and by tuning the potential wells accordingly, we first reproduced the band structure of an ideal Lieb lattice. For different potential configurations, we also obtain the gapped band structures with flat bands, predicted by the tight binding models. By varying the essential parameters (potential energy, radius, distance, shape and position of the quantum wells etc.) we can create classes of similar systems which may be further explored efficiently by employing machine learning techniques. This investigation can be further augmented by inclusion of spin-orbit interaction and Coulomb effects.

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Pradosh Kumar Sahoo: *Magneto-transport studies on topological crystalline insulator SnTe thin film*

In the current decade, the topological materials have shown a wide range of phenomena which can bring crucial change in the future technologies through new generation of topological devices [1, 2]. Here we present the magneto-transport study of a topological crystalline insulator (TCI) SnTe thin film. The film was grown using molecular beam epitaxy (MBE) technique on GaAs substrate with CdTe buffer layers. TCI crystals have significant intrinsic bulk conductivity which makes it difficult to study the topological surface states through transport measurements [3]. One of the solutions for this issue is nanostructurization of these materials which can enhance the contribution from the surface states.We have carved a Hall bar pattern of width 750 nm on a SnTe film of thickness 100 nm using electron beam lithography and ICP-RIE etching process. We have measured the longitudinal resistivity at different magnetic fields (0, 1, 3, 5, 7 and 9 Tesla) perpendicular to the film plane from 300 K to 2 K. We also measured the magnetoresistance at different temperatures from 300 K to 2 K by sweeping the magnetic field from +9T to -9T. The longitudinal magnetoresistance (MR) varies in a quadratic manner for

temperatures above 5 K. At 2 K around zero magnetic fields, we observed a valley which can be attributed to weak anti-localization in the transport by the surface states [4, 5].
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Pardeep Kumar Tanwar: *Possible Thermal chiral anomaly in magnetic topological Weyl semimetal NdAlSi*

A chiral anomaly in condensed matter describes a violation of the chiral current conservation when an electric field (or thermal gradient) is applied parallel to a magnetic field. As a consequence, charge and energy pumping occurs between Weyl points of opposite chirality. This phenomenon has been intensively explored through electrical transport, however, less by thermal measurements. Here we studied the magnetic Weyl semimetal NdAlSi with the richness of magnetic phases (antiferromagnetic, ferrimagnetic, field induce ferromagnetic (FIF), etc.) and with broken inversion as well as time-reversal symmetry. Electrical conductivity (σ) and thermal conductivity (κ) of the Weyl semimetal NdAlSi were measured. At low temperature, σ increases with the magnetic field, likely as a result of the chiral anomaly in the paramagnetic and FIF phase. Remarkably, the corresponding $\kappa(B)$ dependences are similar, i.e. the thermal conductivity increases in the high field limit. We ascribed such an anomalous behavior to the presence of the thermal chiral anomaly.

Matteo Vandelli: *D-TRILEX approach to strongly interacting electronic systems*

As a consequence of the Coulomb interaction between the electrons, materials can develop strong electronic correlations. State-of-the-art methods for strongly correlated materials, such as the dynamical mean field theory (DMFT), are based on assumptions on the locality of the correlations. In this poster, we discuss D-TRILEX, a diagrammatic extension of DMFT that allows for the inclusion of the long-range non-local correlation effects. In particular, we focus on multi-orbital systems. We investigate the performances of the method for the exactly-solvable multi-orbital Hubbard-Kanamori dimer. Finally, we present results for a lattice system where non-local correlations are responsible for the appearance of a metallic and an insulating phase, while DMFT predicts a simple Mott insulator.

Lucia Vigliotti: *Unconventional transport of Cooper pairs in topological Josephson junctions*

It is well known that Josephson junctions (JJs) in presence of a perpendicular magnetic field exhibit qualitatively different interference patterns depending on the length of the junction and the current density profile. Two paradigmatic scenarios are the SQUID and the Fraunhofer patterns, corresponding to a current density sharply peaked at the edges of the junction or to a homogeneous current density profile, respectively. In these simple cases the electrons within the Cooper pair (CP) can be treated effectively as a single entity. However, it is not hard to run into physical mechanisms under which this assumption does not hold, leading to new features in the pattern. An example is the even-odd effect in SQUID patterns due to a non-local transmission of CPs, with the two electrons travelling along opposite edges. In fancier JJs, such as in presence of inter-edge tunnelling or broadened edge states, the two electrons can propagate and explore the junction independently. We analyse the consequences of a major role acquired by the single-electron physics in the superconducting context: the relevant flux quantum doubles, introducing unexpected periodicities, and new patterns arise.

Ashutosh Wadge: *Surface decorated topological Lifshitz transition in Weyl semimetal: NbP*

Topological Weyl semimetals (WSM) have proven themselves as promising materials in condensed matter physics due to their exotic features. The most significant features of WSM are topologically protected Weyl nodes and Fermi arcs (open Fermi surface). An interplay between them explains the phenomena such as magneto-transport, quantum oscillations and chiral effects. Nowadays proximity induced superconductivity in WSM is considered as the most reliable way to manifest Majorana zero bias modes hence it is important to modify Fermi arcs. Here, we chose to deposit Pb on cleaved (0 0 1) surface (in-situ) of NbP single crystal. The data investigated by angle-resolved photoemission spectroscopy (ARPES) showed that 1 ML of Pb was good enough to modify the 2D Fermi surface as well as an electronic structure of WSM. Topological characteristics were preserved even after the modification which indicated a good Pb/NbP interface. The modifications were due to topological quantum Lifshitz transition in which Fermi arcs connected to Weyl nodes changed their connection pattern in the 2D surface Brillouin zone.