SPICE Online Workshop

November 17th - 19th 2020, Mainz, Germany

COHERENT ORDER AND TRANSPORT IN SPIN-ACTIVE SYSTEMS

THIS WORKSHOP IS SUPPORTED BY

Alexander von Humboldt Stiftung/Foundation

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

COHERENT ORDER AND TRANSPORT IN SPIN-ACTIVE SYSTEMS

SCIENTIFIC ORGANIZERS

Wolfgang Belzig	(University of Konstanz)
Katharina Franke	(Freie Universitaet Berlin)
Akashdeep Kamra	(Norwegian University of Science and Technology)

COORDINATION AND GUEST RELATIONS

Elena Hilp
Institute of Physics
Staudinger Weg 7
55128 Mainz, Germany
Phone: +49 171 – 6206497
spice@uni-mainz.de

FIND US ON SOCIAL MEDIA

facebook.com/spicemainz

youtube.com/c/spicemainz

Program

Afternoon Session – Tuesday, November 17th

14:00 – 14:20 **Opening Remarks**

14:20 – 15:20 **Jagadeesh MOODERA, MIT**
In Search of Majorana Pair Along The Golden Path

15:20 – 15:50 **Alexandra PALACIO MORALES, Université Paris-Sud**
Real-space visualization of Majorana edge modes on the Nano-scale magnet-superconductor hybrid system

15:50 – 16:20 **Coffee Break**

16:20 – 16:50 **Felix VON OPPEN, FU Berlin**
Photon-assisted resonant Andreev reflections: Yu-Shiba-Rusinov and Majorana states

16:50 – 17:20 **Peter LILJEROTH, Aalto University**
Topological superconductivity in van der Waals heterostructures

17:20 – 17:50 **Jose LADO, Aalto University**
Solitons and topological superconductivity in antiferromagnet-superconductor interfaces

20:00 – 22:00 **Interplay of Coherent Beer and Spin-Active Wine**

Morning Session – Wednesday, November 18th

10:00 – 11:00	**Rembert DUINE, Utrecht University** Spin current in all its guises
11:00 – 11:30	**Tomosato HIOKI, Tokyo University** Coherent Interconversion and bi-reflection of magnons hybridized with phonons
11:30 – 12:00	**Coffee Break**
12:00 – 12:30	**So TAKEI, City University of New York** Spintronics meets quantum spin liquids: A novel spectral probe of quantum magnets based on spin Hall phenomena
12:30 – 13:00	**Sebastian GOENNENWEIN, TU Dresden** Nonlocal spin transport experiments
13:10 – 14:10	**Poster Session**

Afternoon Session – Wednesday, November 18th

14:30 – 15:30	**Dimitri EFETOV, ICFO Barcelona** Magic Angle Bilayer Graphene - Superconductors, Orbital Magnets, Correlated States and beyond
15:30 – 16:00	**Ali YAZDANI, Princeton University** Spectroscopy of electrons in Moiré Flat Bands
16:00 – 16:30	**Coffee Break**
16:30 – 17:00	**Debanjan CHOWDHURY, Cornell University** What really sets the highest possible superconducting Tc in two-dimensions?
17:00 – 17:30	**Bart VAN WEES, University of Groningen** Electrical and Thermal Generation of Spin Currents by Magnetic Graphene
17:30 – 18:00	**Victor GALITSKI, University of Maryland** Exotic Physics in Topological Insulator/Ferromagnet Heterostructures

Morning Session – Thursday, November 19th

10:00 – 11:00	**Tero HEIKKILÄ, University of Jyväskylä** Nonequilibrium phenomena in superconductors in proximity to magnets
11:00 – 11:30	**Elke SCHEER, University of Konstanz** Probing Triplet Superconductivity by Scanning Tunneling Spectroscopy
11:30 – 12:00	**Coffee Break**
12:00 – 12:30	**Irina BOBKOVA, Institute of Solid State Physics, Moscow** Odd triplet superconductivity induced by the moving condensate
12:30 – 13:00	**Chiara CICCARELLI, Cambridge University** Spin pumping into a superconductor: evidence of superconducting pure spin currents
13:10 – 14:10	**Poster Session**

Afternoon Session – Thurday, November 19th

14:30 – 15:00	**Andrew MACKENZIE, MPI for Chemical Physics of Solids** Two-phase superconductivity in CeRh2As2 and the role of Rashba spin-orbit coupling
15:00 – 15:30	**Burkard HILLEBRANDS, TU Kaiserslautern** Bose-Einstein condensation of magnons in confined systems
15:30 – 16:00	**Benedetta FLEBUS, University of Texas at Austen** Non-Hermitian topological phases in magnetic systems
16:00 – 16:30	**Coffee Break**
16:30 – 17:00	**Arne BRATAAS, Norwegian University of Science and Technology** Current control of magnetism in two-dimensional Fe_3GeTe_2
17:00 – 17:30	**Yaroslav TSERKOVNYAK, University of California Los Angeles** Squeezing spin entanglement out of magnons
17:30 – 18:00	**Harold HWANG, Stanford University** Superconductivity in Infinite Layer Nickelates - Is Magnetism Relevant?
18:00 – 18:10	**Closing Remarks**

Speaker Abstracts

Tuesday, November 17th, 14:20

In Search of Majorana Pair Along The Golden Path

Jagadeesh MOODERA
MIT

One of the excellent examples for the topologically driven nontrivial quantum phenomena is the prediction of Majorana zero modes (MZMs or the Majorana pair) to occur in a topological superconductor (TSC) – viz., superconducting surface state of gold. [1] MZMs form when a fermion splits in a TSC into two parts well separated in space, and thus always appear in pair together with its partner. Each of the Majorana pair is an antiparticle of itself. Potter and Lee, [1] predicted that under the right conditions, a superconducting gold nanowire with (111) crystalline surface with its large Rashba spin-orbit (S-O) splitting could host the Majorana pair. In search of this golden pair, creating the needed topological superconductivity and Zeeman field in carefully optimized Au (111) surface we laid the foundation to realize MZM. [2] We experimentally achieved the needed novel stable heterostructures, to directly observe the MZM pair using a low temperature with high vector field scanning tunneling microscope - probing the superconducting gold surface having ferromagnetic EuS nano islands (that provides the crucial internal exchange field). [3] This success opens many questions about the Majorana properties enabling plenty opportunities for future investigations. Through this two-dimensional stable metal platform, with induced superconductivity of the Shockley surface states (SS) of (111)-gold (Au), we can envision a scalable system for building non-local qubits that are intrinsically fault-tolerant. In this talk I will be presenting our path towards the observation of MZMs.

[1] A. C. Potter & P. A. Lee PRL 105, 227003 (2010); PRB 85, 094516 (2012)

[2] Peng Wei, Sujit Manna, Marius Eich, Patrick Lee and J. S. Moodera, Phys. Rev. Lett. 122, 247002 (2019)

[3] Sujit Manna, Peng Wei, Yingming Xie, Kam Tuen Law, Patrick A. Lee and Jagadeesh S. Moodera, Proc. Natl. Acad. Sci. 117 (16) 8775-8782 (Apr. 21, 2020)

Tuesday, November 17th, 15:20

Real-space visualization of Majorana edge modes on the Nano-scale magnet-superconductor hybrid system

Alexandra PALACIO MORALES
Université Paris-Sud

Hybrid magnetic-superconducting systems have attracted widespread interest for their promising potential in topological quantum computation. Nano-fabrication techniques combined with local probe microscopies revealed the emergence of zero-energy modes on ferromagnetic chains [1] and ferromagnetic nanoislands [2] on s-wave superconductors. However, the observation of Majorana Fermion (MF) modes in these hybrid systems is still a subject of debate and has raised questions about experimental considerations that must be accounted. Lack of well-defined structures, MF spatial distribution and evolution inside the hybrid structures are among the reasons of these concerns. Nevertheless, advances in nano-fabrication techniques such as atom manipulation combined with local probe microscopies will paved the way to overcome them.

Here, we report on the evolution of Yu-Shiba-Rusinov bands into MF by atomic length manipulation of Fe magnetic chain on Re(0001) surface [3]. Moreover, we report on the first unambiguous experimental detection and visualization of chiral Majorana edge states in a monolayer topological superconductor, a prototypical magnet-superconductor hybrid system comprised of nanoscale Fe islands of monoatomic height on a Re(0001)-O(2×1) surface [4, 5].

[1] S. Nadj-Perge et al., Science 346, 602 (2014)
[2] G. C. Ménard et al., Nat. Comm. 8, 2040 (2017)
[3] H. Kim et al., Science Adv. 4, eaar5251 (2018)
[4] A. Palacio-Morales et al., Nano Lett. 16, 6252-6256 (2016)
[5] A. Palacio-Morales et al., Science Adv. 5, eaav6600 (2019)

Tuesday, November 17th, 16:20

Photon-assisted resonant Andreev reflections: Yu-Shiba-Rusinov and Majorana states

Felix VON OPPEN
FU Berlin

Photon-assisted tunneling frequently provides detailed information on the underlying charge-transfer process. In particular, the Tien-Gordon approach and its extensions predict that the side-band spacing in bias voltage is a direct fingerprint of the number of electrons transferred in a single tunneling event. In this talk, I will focus on photon-assisted tunneling into subgap states in superconductors in the limit of small temperatures and bias voltages where tunneling is dominated by resonant Andreev processes. I will review recent experiments [1] on photon-assisted tunneling into YuShiba-Rusinov states which exhibit striking deviations from the predictions of simple Tien-Gordon theory and discuss a systematic Keldysh calculation of the subgap conductance, which provides a detailed analytical understanding of these experiment and is in excellent agreement with experiment [2]. I will conclude by extending the analysis to tunneling into Majorana bound states. Here, photon-assisted Andreev reflections provide a high-accuracy method to measure small but nonzero energies of subgap states which can be important for distinguishing conventional subgap states from Majorana bound states.

[1] O. Peters, N. Bogdanoff, S. Acero González, L. Melischek, J.R. Simon, G. Reecht, C.B. Winkelmann, F. von Oppen, K.J. Franke, Resonant Andreev reflections probed by photon-assisted tunnelling at the atomic scale, Nature Physics https://doi.org/10.1038/s41567-020-0972-z (2020)

[2] S. Acero González, L. Melischek, O. Peters, K. Flensberg, K.J. Franke, F. von Oppen, Photon-assisted resonant Andreev reflections: Yu-Shiba-Rusinov and Majorana states, Phys. Rev. B 102, 045413 (2020)

Tuesday, November 17th, 16:50

Topological superconductivity in van der Waals heterostructures

Peter LILJEROTH
Aalto University

Quantum designer materials that realize electronic responses not found in naturally occurring materials have recently attracted intense interest. For example, topological superconductivity [1] - a key ingredient in topological quantum computing – may not exist in any single material. However, using designer van der Waals (vdW) heterostructures, it is possible to realize the desired physics through the engineered interactions between the different components.

We use molecular-beam epitaxy to grow islands of ferromagnetic CrBr3 [2] on a superconducting NbSe2 substrate [3]. This combines out of plane ferromagnetism with Rashba spin-orbit interactions and s-wave superconductivity and allows us to realize topological superconductivity in a van der Waals heterostructure [4]. We characterize the resulting one-dimensional edge modes using low-temperature scanning tunneling microscopy (STM) and spectroscopy (STS). Achieving topological superconductivity in a vdW heterostructure facilitates its incorporation in future device structures and potentially allows further control through e.g. electrostatic gating.

[1] M. Sato, and Y. Ando, Topological superconductors: a review. Rep. Prog. Phys. 80, 076501 (2017)

[2] W. Chen, Z. Sun, Z. Wang, L. Gu, X. Xu, S. Wu, C. Gao, Direct observation of van der Waals stacking–dependent interlayer magnetism. Science 366, 983 (2019)

[3] S. Kezilebieke, M.N. Huda, O.J. Silveira, V. Vaňo, J. Lahtinen, R. Mansell, S. van Dijken, A.S. Foster, P. Liljeroth, Electronic and magnetic characterization of epitaxial CrBr3 monolayers, arxiv:2009.13465 (2020)

[4] S. Kezilebieke, M. N. Huda, V. Vaňo, M. Aapro, S.C. Ganguli, O.J. Silveira, S. Głodzik, A.S. Foster, T. Ojanen, P. Liljeroth, Topological superconductivity in a designer ferromagnet-superconductor van der Waals heterostructure, arXiv:2002.02141 (2020)

Tuesday, November 17th, 17:20

Solitons and topological superconductivity in antiferromagnet-superconductor interfaces

Jose LADO
Aalto University

The interplay of magnetism and superconductivity provides one of the most fertile platforms to engineer unconventional quantum matter, with the paradigmatic example of Majorana excitations in artificial topological superconductors. In particular, the potential of Majorana excitations for topological quantum computing has motivated outstanding efforts for their engineering by combining ferromagnetism, strong spin-orbit coupling, and conventional superconductivity. Here we introduce a platform alternative to those mechanisms that exploit the emergence of solitonic excitations between antiferromagnetic insulators and a conventional superconductor. First, we show that solitons at interfaces between three-dimensional antiferromagnets and superconductors can be used to engineer a two-dimensional topological superconductor, whose topological gap stems from intrinsic spin-orbit coupling [1]. Second, we show that at interfaces between two-dimensional antiferromagnetic insulators and superconductors, topological superconductivity emerges from solitons with a purely interaction- driven topological gap, requiring no spin-orbit coupling effects [2]. Ultimately, we demonstrate that many-body solitons emerge even at interfaces between quantum entangled antiferromagnets and superconductors, providing a stepping stone towards exploring emergent excitations in quantum-spin liquid superconductor junctions [3]. Our findings exemplify the potential of solitonic excitation in antiferromagnet-superconductor interfaces to engineer topological superconductivity and exotic quantum many-body states.

[1] Jose L. Lado and Manfred Sigrist, Phys. Rev. Lett. 121, 037002 (2018)
[2] Senna Luntama, Jose L. Lado and Päivi Törmä, in preparation (2020)
[3] Jose L. Lado and Manfred Sigrist, Phys. Rev. Research 2, 023347 (2020)

Wednesday, November 18th, 10:00

Spin current in all its guises

Rembert DUINE
Utrecht University

In this talk I will review spin currents in various materials and how they may be carried by electronic quasiparticles, collective excitations, or non-linear dynamics of, for example, the magnetic order. Examples will be discussed of magnon, phonon, and other types of spin transport.

Wednesday, November 18th, 1!:00

Coherent Interconversion and bi-reflection of magnons hybridized with phonons

Tomosato HIOKI
Tokyo University

In recent years, it was demonstrated that spin angular momentum transfer in magnetic insulators is enhanced or modulated by hybridizing magnons with phonons [1-3]. The hybridization refers to formation of new normal state as a result of interaction between two different excitations. By the hybridization with phonons, some characteristics of phonons are transferred to magnons such as long lifetime and mode degree of freedom.

In this talk, I will discuss the coherent interconversion between magnons and phonons, and demonstration of transfer of mode degree of freedom of phonons to magnons. We developed time-resolved magneto-optical imaging technique by combining conventional magneto-optical imaging and pump-and-probe spectroscopy, which enables us to obtain snapshots of spin-wave propagation dynamics in real space with sub nanoseconds temporal resolutions. In a Bi-doped magnetic garnet, $Lu_2Bi_1Fe_{3.4}Ga_{1.6}O_{12}$, we observed coherent temporal oscillation between magnons and phonons as a result of hybridization, where magnons and phonons are coherently interconverted to each other during propagation. It is also found that the magnon-phonon hybridized wave exhibits abnormal reflection at the sample edge owing to the mode degree of freedom of phonons [4]. Since phonons have longitudinal and transverse modes, both modes may not be an eigenstate where translational symmetry is broken down, such as a sample edge. Owing to the mode degree of freedom, the hybridized wave may split into two reflected waves with the same frequency, which is not the case for pure magnon propagation. The experimental demonstration of these dynamics of magnon-phonon hybridized waves will be reported in the talk.

[1] T. Kikkawa, K. Shen, B. Flebus, R. A. Duine, K. Uchida, Z. Qiu, G. E. W. Bauer, and E. Saitoh, Phys. Rev. Lett, 117, 207203 (2016)

[2] J. Holanda, D. S. Maior, A. Azevedo, and S. M. Rezende, Nat. Phys. 14, 500-506 (2018)

[3] K. An, A. N. Litvinenko, R. Kohno, A. A. Fuad, V. V. Naletov, L. Vila, U. Ebels, G. de Loubens, H. Hurdequint, N. Beaulieu, J. Ben Youssef, N. Vukadinovic, G. E. W. Bauer, A. N. Slavin, V. S. Tiberkevich, and O. Klein, Phys. Rev. B, 101, 060407(R) (2020)

[4] T. Hioki, Y. Hashimoto, E. Saitoh, Commun. Phys. 3, 188 (2020)

Wednesday, November 18th, 12:00

Spintronics meets quantum spin liquids: A novel spectral probe of quantum magnets based on spin Hall phenomena

So TAKEI
City University of New York

We propose an experimental method utilizing a strongly spin-orbit coupled metal to quantum magnet bilayer that will probe quantum magnets lacking long-range magnetic order via examination of the voltage noise spectrum in the metal layer. The bilayer is held in thermal equilibrium, and spin fluctuations arising across the single interface are converted into voltage fluctuations in the metal as a result of the inverse spin Hall effect (ISHE). We elucidate the theoretical workings of the proposed bilayer system and provide precise predictions for the frequency characteristics of the enhancement to the AC electrical resistance measured in the metal layer for three candidate quantum spin liquid models: the quantum Heisenberg antiferromagnet on the kagomé lattice, fermionic spinons coupled to a U(1) gauge field, and the Kitaev model in the gapless spin liquid phase. The ISHE-facilitated spin noise probe is then applied to quantum spin systems hosting elementary bosonic excitations with topologically nontrivial band structures. We show how the method can be used to detect topological phase transitions in these systems by directly probing the topologically-protected fractional spin excitations localized at their edges.

Wednesday, November 18th, 12:30

Nonlocal spin transport experiments

Sebastian GOENNENWEIN
TU Dresden

The coupling between charge and spin transport channels provided by the spin Hall effect enables a variety of charge-driven and/or charge-detected spin transport experiments. Magnetic insulators hereby are a very attractive class of materials, since they allow for pure spin current transport, while charge currents are prohibited.

The presentation shall give an overview over non-local spin transport experiments in magnetic insulator/metal heterostructures. More specifically, I will introduce the socalled magnon mediated magnetoresistance (MMR) detected in non-local charge transport experiments in yttrium iron garnet/Pt bilayers [1,2]. I will then critically discuss the importance of magnons for the MMR, and show that the MMR concept enables studying the incoherent superposition of magnons generated by several different spin Hall active Pt metal strips. Last but not least, I will address recent MMR type experiments aimed at detecting magnon condensates.

[1] Cornelissen et al., Nat. Phys. 11, 1022 (2015)
[2] Goennenwein et al., Appl. Phys. Lett. 107, 172405 (2015)

Wednesday, November 18th, 14:30

Magic Angle Bilayer Graphene - Superconductors, Orbital Magnets, Correlated States and beyond

Dimitri EFETOV
ICFO Barcelona

When twisted close to a magic relative orientation angle near 1 degree, bilayer graphene has flat moire superlattice minibands that have emerged as a rich and highly tunable source of strong correlation physics, notably the appearance of superconductivity close to interaction-induced insulating states. Here we report on the fabrication of bilayer graphene devices with exceptionally uniform twist angles. We show that the reduction in twist angle disorder reveals insulating states at all integer occupancies of the four-fold spin/valley degenerate flat conduction and valence bands, i.e. at moire band filling factors nu = 0, +(-) 1, +(-) 2, +(-) 3, and reveals new superconductivity regions below critical temperatures as high as 3 K close to - 2 filling. In addition we find novel orbital magnetic states with non-zero Chern numbers. Our study shows that symmetry-broken states, interaction driven insulators, and superconducting domes are common across the entire moire flat bands, including near charge neutrality. We further will discuss recent experiments including screened interactions, fragile topology and the first applications of this amazing new materials platform.

Wednesday, November 18th, 15:30

Visualizing Electrons in Moiré Superlattices: A playground for correlation and topology

Ali YAZDANI
Princeton University

Interactions among electrons and the topology of their energy bands can create novel quantum phases of matter. The discovery of electronic bands with flat energy dispersion in magic-angle twisted bilayer graphene (MATBG) has created a unique opportunity to search for new correlated and topological electronic phases. We have developed new scanning tunneling microscopy (STM) and spectroscopy (STS) techniques to probe the nature of electronic correlations and to detect novel topological phases in two-dimensional systems, such as MATBG. Density-tuned STS studies have enabled us to study the properties of MATBG as function of carrier concentration revealing key and new properties of this novel material. These measurements establish that MATBG is a strong correlated system at all partial filling of its flat bands. [1] The strength of the interactions, which can be measured in our experiments, is found to be larger than the flat bandwidth in the non-interacting limit. We demonstrate that these interactions drive a cascade of transitions at each integer filling of these bands, creating likely the insulating states at low temperatures that are spin or valley polarized.[2] Most recently, we developed a new STS technique to detect topological phases and their associated Chern numbers and used it to show that strong interactions drive the formation of unexpected topological insulating phases in MATBG [3]. These phases, which are stabilized by a weak magnetic field, are rare examples of when topology emerges from interaction between electrons. I will describe these experiments, and other ongoing efforts, that illustrate the power of atomic scale experiments in revealing novel physics of electrons in moiré superlattices.

[1] Y. Xie. et al. Nature 572, 101 (2019).
[2] D. Wong, et al. Nature 582, 198 (2020).
[3] K. Nuckolls et al. arXiv:2007.03810, to appear in Nature.

Wednesday, November 18th, 16:30

What really sets the highest possible superconducting Tc in two-dimensions?

Debanjan CHOWDHURY
Cornell University

Inspired by the discovery of superconductivity in moiré materials, I will discuss the long-standing problem on whether superconductivity can exist if the electrons' kinetic energy is completely quenched. This is fundamentally a nonperturbative problem, since the interaction energy scale is the only relevant energy scale, and requires going beyond the traditional Bardeen-Cooper-Schrieffer theory of superconductivity. In the first part of the talk, I will discuss the problem of an interacting two-dimensional system with narrow topological bands using numerically exact quantum Monte Carlo calculations. In the second part of my talk, I will discuss the more realistic problem of magic-angle twisted bilayer graphene with electron-phonon interactions. In particular, I will show that certain umklapp processes, which arise physically as a result of the zone folding due to the moiré superlattice structure, contribute significantly towards enhancing pairing. I will comment on the effect of external screening due to a metallic gate on superconductivity and propose a smoking-gun experiment to detect resonant features associated with the phonon-umklapp processes in the differential conductance.

Wednesday, November 18th, 17:00

Electrical and Thermal Generation of Spin Currents by Magnetic Graphene

Bart VAN WEES
University of Groningen

Graphene-based van der Waals heterostructures have shown to be an excellent choice for twodimensional (2D) spintronic devices as the superior spin and charge transport properties of graphene are enriched via the proximity to other 2D materials. By proximity effects, one can induce spin-orbit and magnetic exchange interactions in the graphene which provide strong coupling between charge and spin currents [1-4]. In particular, our recent spin transport measurements in graphene in proximity of a 2D interlayer antiferromagnet, Chromium Sulfide Bromide (CrSBr) have shown strong spin polarization of conductivity in graphene (~14%) that arises from a large induced exchange interaction. The strong spin-polarization of conductivity also results in the observation of the spindependent Seebeck effect in graphene. This is the first-time experimental realization of the active role of the magnetic graphene in the electrical and thermal generation of spin currents, addressing the most technologically relevant aspects of the magnetism in graphene. Also, the high sensitivity of the spin-transport in graphene to the magnetization of the outer-most layer of the CrSBr provides the tool for studying the magnetic behavior of a single magnetic sublattice. The spin-polarization of conductivity and spin-dependent Seebeck coefficient in magnetic graphene, together with its exceptional long-distance spin transport introduce the magnetic graphene as an ultimate building block for ultra-compact magnetic memory and sensory devices and provides substantial advances in 2D spintronic and caloritronic systems [4].

[1] Ghiasi, T.S., et al., Nano letters 17.12 (2017): 7528-7532
[2] Ghiasi, T.S., et al., Nano letters 19.9 (2019): 5959-5966
[3] Avsar, A., et al., Reviews of Modern Physics 92.2 (2020): 021003
[4] Ghiasi, T.S., et al., arXiv:2007.15597 (2020), submitted to Nature Nanotechnology

Wednesday, November 18th, 17:30

Exotic Physics in Topological Insulator/Ferromagnet Heterostructures

Victor GALITSKI
University of Maryland

TBA

[1] References

Thursday, November 19th, 10:00

Nonequilibrium phenomena in superconductors in proximity to magnets

Tero HEIKKILÄ
University of Jyväskylä

In this tutorial I will describe how the proximity to magnets affects the nonequilibrium properties of superconductors [1,2]. I will in particular emphasize the peculiar superconducting state hosting a spin-splitting field that can be induced into thin superconducting films via in-plane magnetic fields or by their proximity to ferromagnets. Moderate spin splitting does not destroy superconductivity, but results in the presence of an odd-frequency pairing state that also affects the transport properties of the superconductor in a fundamental manner. These transport properties can be studied via tunnelling experiments. In case of local measurements, the spin splitting shows up as a giant thermoelectric effect, whereas the non-local case demonstrates a coupling of the different nonequilibrium modes in the superconductor. The thermoelectric effect can be used for example in new types of superconducting detectors [3]. The dynamic features of the superconducting state are also strongly modified by the spin-splitting field. If the time allows, I will exemplify this via the examples of thermoelectric torques and spin cooling [4], and of the dynamic coupling of magnetization precession and the Higgs amplitude mode in superconductors [5].

[1] F.S. Bergeret, M. Silaev, P. Virtanen, and T.T. Heikkilä, Rev. Mod. Phys. 90, 041001 (2018)

[2] T.T. Heikkilä, M. Silaev, P. Virtanen, and F.S. Bergeret, Prog. Surf. Sci. 94, 100540 (2019)

[3] T.T. Heikkilä, R. Ojajärvi, I.J. Maasilta, E. Strambini, F. Giazotto, and F. Bergeret, Phys. Rev. Applied 10, 034053 (2018)

[4] R. Ojajärvi, J. Manninen, T.T. Heikkilä, and P. Virtanen, Phys. Rev. B 101, 115406 (2020)

[5] M. Silaev, R. Ojajärvi, and T.T. Heikkilä, Phys. Rev. Research 2, 033416 (2020)

Thursday, November 19th, 11:00

Probing Triplet Superconductivity by Scanning Tunneling Spectroscopy

Elke SCHEER
University of Konstanz

In this talk we will address the superconducting proximity effect between a superconductor (S) and a normal metal (N) linked by a spin-active interface. With the help of a low-temperature scanning tunneling microscope we study the local density of states of trilayer systems consisting of Al (S), the ferromagnetic insulator EuS, and the noble metal Ag (N). In several recent studies it has been shown that EuS acts as ferromagnetic insulator with well-defined magnetic properties down to very low thickness [1]. We observe pronounced subgap structures that either reveal a zero-bias peak (ZBP) or an additional zero-bias splitting (ZBS) and that can be tuned by a magnetic field. We interpret our findings in the light of recent theories of odd-triplet contributions created by the spin-active interface [2,3]. In particular, we discuss that the ZBS is a hallmark for spin-polarized triplet pairs, able to carry long-ranged supercurrents in to F, while the ZBP is a signature for short-ranged, mixed-spin triplet pairs.

[1] S. Diesch et al., Nature Commun. 9, 5248 (2018)
[2] B. Li et al., Phys. Rev. Lett. 110, 09700 (2013)
[3] A. Cottet et al., Phys. Rev. B 80, 184511 (2009)

Thursday, November 19th, 12:00

Odd triplet superconductivity induced by the moving condensate

Irina BOBKOVA
Institute of Solid State Physics, Moscow

It has been commonly accepted that electromagnetic fields suppress superconductivity by inducing the ordered motion of Cooper pairs. We demonstrate a mechanism which instead provides generation of perconducting correlations by moving the superconducting condensate. This effect arises in superconductor/ferromagnet heterostructures in the presence of spin-orbit coupling. We predict the odd-frequency spin-triplet superconducting correlations called the Berezinskii order to be switched on in ferromagnets at large distances from the superconductor/ferromagnet interface by application of a static magnetic field or irradiation inducing condensate motion. In the last case the induced spin-triplet superconducting order is

dynamical. The effect is shown to result in the unusual dependence of Josephson current on the applied magnetic field and possibility of a photo-induced Josephson current.

Thursday, November 19th, 12:30

Spin pumping into a superconductor: evidence of superconducting pure spin currents

Chiara CICCARELLI
Cambridge University

Unlike conventional spin-singlet Cooper pairs, spin-triplet pairs can carry spin. Triplet supercurrents were discovered in Josephson junctions with metallic ferromagnet spacers, where spin transport can occur only within the ferromagnet and in conjunction with a charge current. Ferromagnetic resonance injects a pure spin current from a precessing ferromagnet into adjacent non-magnetic materials. For spin-singlet pairing, the ferromagnetic resonance spin pumping efficiency decreases below the critical temperature (Tc) of a coupled superconductor. Here we present ferromagnetic resonance experiments in which spin sink layers with strong spin–orbit coupling are added to the superconductor. We show that the induced spin currents, rather than being suppressed, are substantially larger in the superconducting state compared with the normal state and show that this cannot be mediated by quasiparticles and is most likely a triplet pure spin supercurrent.

Thursday, November 19th, 14:30

Two-phase superconductivity in CeRh2As2 and the role of Rashba spin-orbit coupling

Andrew MACKENZIE
MPI for Chemical Physics of Solids

I will describe the work of colleagues in my Institute and beyond on the discovery of twophase unconventional superconductivity in CeRh2As2. Using thermodynamic probes, we establish that the superconducting critical field of its high-field phase is as high as 14 T, remarkable in a material whose transition temperature is 0.26 K. Furthermore, a c-axis field drives a transition between two different superconducting phases. In spite of the fact that CeRh2As2 is globally centrosymmetric, we show that local inversion symmetry breaking at the Ce sites enables Rashba spin-orbit coupling to play a key role in the underlying physics.

Thursday, November 19th, 15:00

Bose-Einstein condensation of magnons in confined systems

Burkard HILLEBRANDS
TU Kaiserslautern

A room-temperature magnon Bose-Einstein condensate (BEC) observed in magnetic insulators (single-crystal films of yttrium iron garnet, YIG) has a large potential in high-speed and low-power information processing and data transfer. At the same time, the miniaturization of magnon BEC-based magnonic devices constitutes an extraordinary challenge for their future applications.

We present a new and universal approach to enable Bose–Einstein condensation of magnons in confined systems [1]. The essential feature of this approach is the introduction of a disequilibrium of magnons with the phonon bath. After heating to an elevated temperature, a sudden decrease in the temperature of the phonons, which is approximately instant on the time scales of the magnon system, results in a large excess of incoherent magnons. The consequent spectral redistribution of these magnons triggers the Bose–Einstein condensation. We have observed this phenomenon by time-resolved Brillouin light scattering spectroscopy.

Moreover, we have studied by numerical simulations the formation of the magnon BEC in parametrically excited nanoscopic systems and proposed a new way to enhance condensate's lifetime of by lateral confinement [2]. We revealed the role of dipolar interactions in the generation of a magnon BEC as a metastable state in YIG ultrathin film structures. We directly map out the nonlinear magnon scattering processes to show how fast quantized thermalization channels allow the BEC formation in confined structures.

Both our investigations greatly extends the freedom to study dynamics of magnon BEC in confined systems and to design integrated circuits for magnon BEC-based applications at room temperature.

[1] M. Schneider et al., Bose–Einstein condensation of quasiparticles by rapid cooling, Nat. Nanotechnol. 15, 457 (2020).

[2] M. Mohseni et al., Bose-Einstein condensation of nonequilibrium magnons in confined systems, New J. Phys. 22, 083080 (2020).

Thursday, November 19th, 15:30

Non-Hermitian topological phases in magnetic systems

Benedetta FLEBUS
University of Texas at Austen

Magnetic systems have been extensively studied both from a fundamental physics perspective and as building blocks for a variety of applications. Their topological properties, in particular those of excitations, remain relatively unexplored due to their inherently dissipative nature. The recent introduction of non-Hermitian topological classifications opens up new opportunities for engineering topological phases in dissipative systems. Here, we propose a magnonic realization of a non-Hermitian topological system. A crucial ingredient of our proposal is the injection of spin current into the magnetic system, which alters and can even change the sign of terms describing dissipation. We show that the magnetic dynamics of an array of spin-torque oscillators can be mapped onto a non-Hermitian Su-Schrieffer-Heeger model exhibiting topologically protected edge states. Our findings have practical utility for memory devices and spintronics neural networks relying on spin-torque oscillators as constituent units.

Thursday, November 19th, 16:30

Current control of magnetism in two-dimensional Fe_3GeTe_2

Arne BRATAAS
Norwegian University of Science and Technology

The recent discovery of magnetism in two-dimensional van der Waals systems opens the door to discovering exciting physics. We investigate how a current can control the ferromagnetic properties of such materials. Using symmetry arguments, we identify a recently realized system in which the current-induced spin torque is particularly simple and powerful. In Fe3GeTe2, a single parameter determines the strength of the spin-orbit torque for a uniform magnetization. The spin-orbit torque acts as a contribution to the out-of-equilibrium free energy and introduces new in-plane magnetic anisotropies to the system. Therefore, we can tune the system from an easy-axis ferromagnet via an easy-plane ferromagnet to another easy-axis ferromagnet with increasing current density. This finding enables unprecedented control and provides the possibility to study the Berezinskii-Kosterlitz-Thouless phase transition in the 2D XY model and its associated critical exponents.

Thursday, November 19th, 17:00

Squeezing spin entanglement out of magnons

Yaroslav TSERKOVNYAK
University of California Los Angeles

We theoretically study the entanglement between two arbitrary spins in a magnetic material where magnons naturally form a general squeezed coherent state in the presence of an applied magnetic field and axial anisotropies. Employing concurrence as a measure of entanglement, we demonstrate that spins are generally entangled in thermodynamic equilibrium, with the amount of entanglement controlled by the external fields and anisotropies. As a result, the magnetic medium can serve as a resource to store and process quantum information. We furthermore show that the entanglement can jump discontinuously when decreasing the transverse magnetic field. This tunable entanglement can be potentially used as an efficient switch in quantum-information processing tasks.

Thursday, November 19th, 17:30

Superconductivity in Infinite Layer Nickelates - Is Magnetism Relevant?

Harold HWANG
Stanford University

Since their discovery, superconductivity in cuprates has motivated the search for materials with analogous electronic or atomic structure. We have used soft chemistry approaches to synthesize superconducting infinite layer nickelates from their perovskite precursor phase, using topotactic reactions [1,2]. We will present the properties of the nickelate superconductors, our current understanding of the electronic structure [3,4], observation of a doping-dependent superconducting dome in (Nd,Sr)NiO2 [5], and preliminary evidence for substantial magnetic correlations in this system.

[1] D. F. Li, K. Lee, B. Y. Wang, M. Osada, S. Crossley, H. R. Lee, Y. Cui, Y. Hikita, and H. Y. Hwang, Nature 572, 624 (2019).

[2] K. Lee, B. H. Goodge, D. F. Li, M. Osada, B. Y. Wang, Y. Cui, L. F. Kourkoutis, and H. Y. Hwang, APL Materials 8, 041107 (2020).

[3] M. Hepting, D. Li, C. J. Jia, H. Lu, E. Paris, Y. Tseng, X. Feng, M. Osada, E. Been, Y. Hikita, Y.-D. Chuang, Z. Hussain, K. J. Zhou, A. Nag, M. Garcia-Fernandez, M. Rossi, H. Y. Huang, D. J. Huang, Z. X. Shen, T. Schmitt, H. Y. Hwang, B. Moritz, J. Zaanen, T. P. Devereaux, and W. S. Lee, Nature Materials 19, 381 (2020).

[4] B. H. Goodge, D. F. Li, M. Osada, B. Y. Wang, K. Lee, G. A. Sawatzky, H. Y. Hwang, and L. F. Kourkoutis, arXiv:2005.02847.

[5] D. F. Li, B. Y. Wang, K. Lee, S. P. Harvey, M. Osada, B. H. Goodge, L. F. Kourkoutis, and H. Y. Hwang, Physical Review Letters 125, 027001 (2020).

Poster Abstracts

Possible superconducting spin-triplet pair correlations in NbRe/Co bilayers

Carmine Attanasio
University of Saleno

The combined presence of Spin Orbit Coupling (SOC) and magnetic field can give rise to unconventional superconducting pairing. In particular, there are theoretical evidences that SOC can act as a generator of long-ranged spin triplet pairs in superconductor/ferromagnetic (S/F) hybrids [1,2]. The physics arising either when the SOC and the exchange field coexist in the F layer [1,2] or in the presence of interfacial SOC [2-4] have been explored in the literature. On the other hand, the superconducting proximity effect taking place between a NonCentrosymmetric Superconductor (NCS), as intrinsic source of SOC, and a F metal [5,6] has been only theoretically investigated.

In this work we present results obtained on NbRe/Co bilayers, where NbRe (Nb0.18Re0.82) is a NCS with a significant SOC [7,8]. The aim is to investigate the possible presence of superconducting spin-triplet pair correlations in this system, which can represent a unique platform to study both the exotic mixed pairing state peculiar of NCS and to access and manipulate dissipationless spin currents. In particular, we studied the behavior of the superconducting critical temperature (Tc) as a function of the thickness of the Co layer (dCo), to identify the possible presence of a triplet component from the superconducting correlations propagating in the proximized F layer which may carry information on the pairing state in the NCS. Moreover, ferromagnetic resonance experiments were performed to study the effect of spin pumping at the NbRe superconducting transition. This kind of study could give important information concerning the possible presence of triplet correlations in the case of an enhanced damping parameter [9]

[1] I.V. Tokatly and F.S. Bergeret, Phys. Rev. Lett. 110, 117003 (2013)
[2] H.T. Simensen and J. Linder, Phys. Rev. B 97, 054518 (2018)
[3] N. Banerjee et al., Phys. Rev. B 97, 184521 (2018).
[4] N. Satchell and N.O. Birge, Phys. Rev. B 97, 214509 (2018).
[5] G. Annunziata et al., Phys. Rev. B 86, 174514 (2012).
[6] S.H. Jacobsen and J. Linder, Phys. Rev. B 92, 024501 (2015).
[7] C. Cirillo, R. Fittipaldi, M. Smidman, G. Carapella, C. Attanasio, A. Vecchione, R.P. Singh, M.R. Lees, G. Balakrishnan, and M. Cuoco, Phys. Rev. B 91, 134508 (2015)
[8] C. Cirillo, G. Carapella, M. Salvato, R. Arpaia, M. Caputo, and C. Attanasio, Phys. Rev. B 94, 104512 (2016)
[9] K-R. Jeon et al., Nature Materials 17, 499-503 (2018).

Transverse heat conductivity of I1/F I/I2 layered nanostructures at low temperatures

Alexei Bezuglyj
NSC "Kharkov Institute of Physics and Technology"

A kinetic approach to the heat transport by phonons and magnons through a ferromagnetic insulator (F I) layer located between two massive insulators (I1 and I2) is analytically considered. The effective transverse heat conductivity of such a layered system with an arbitrary thickness of the FI layer is calculated, and the thickness at which the size effect is manifested in the thermal conductivity is found.

Magneto-electric effects and chiral anomaly in superconducting topological heterostructures

Mario Cuoco
CNR-SPIN

I will discuss about various quantum platforms marked by spin-singlet or spin-triplet pairing interfaced with magnetism and discuss the nature of the emerging topological phases as well as the transport properties [1,2,3,4,5]. The coexistence of ferromagnetism or antiferromagnetism with spin-triplet superconductivity is also analysed and discussed with respect to relevant materials cases. In particular, we analyse the emergent magneto-electric effects and the potential to design synthetic Weyl points in topological superconducting heterostructure.

[1] M. T. Mercaldo, M. Cuoco, P. Kotetes, Phys. Rev. B 94, 140503(R) (2016).
[2] A. Romano, P. Gentile, C. Noce, I. Vekhter, M. Cuoco, Phys. Rev. Lett. 110, 267002 (2013).
[3] P. Kotetes, M. T. Mercaldo, M. Cuoco, Phys. Rev. Lett. 123, 126802 (2019).
[4] M. T. Mercaldo, P. Kotetes, M. Cuoco, Phys. Rev. B 100, 104519 (2019).
[5] A. Romano, C. Noce, and M. Cuoco, Phys. Rev. B 99, 224507 (2019).

Novel features of Superconductor/Ferromagnet heterostructures with chiral magnetic Skyrmions

Samme Dahir
Ruhr-Universität Bochum

Superconductor-Ferromagnet hybrid structures have attracted much interest in the last decades, due to a variety of interesting phenomena predicted and observed in these structures. Many of those are related to the presence and/or interplay of different types of topological defects.

Our work focuses on novel phenomena caused by the presence of non-trivial topological textures in ferromagnets such as magnetic skyrmions (Sk) and magnetic domain walls (DW’s).

Here, we discuss the effective stray-field and the Meissner currents in a Superconductor/Ferromagnet/Superconductor (S/F/S) junction produced by these textures. We consider both Bloch- and Néel-type Sk and also analyze in detail the periodic structures of different types of DW's-- that is Bloch-type DW (BDW) and Néel-type DW (NDW) of finite width with in- and out-of-plane magnetization vector. The spatial dependence of the fields and Meissner currents are shown to be qualitatively different for the case of Bloch- and Néel-type magnetic textures. While the spatial distributions in the upper and lower S are identical for Bloch-type Sk and DW's they are asymmetric for the case of Néel-type magnetic textures.

We also discuss magnetic skyrmions in the presence of superconducting vortices. For this we consider a chiral ferromagnet which is interfaced by a thin superconducting film via an insulating barrier. We show that there exists an attractive interaction between a skyrmion and a PV, with the vortex drawn to the skyrmion center. Based on this, we find that Pearl vortices (PV) are generated spontaneously in the superconductor within the skyrmion radius, while anti-Pearl vortices compensating the magnetic moment of the Pearl vortices are generated outside of the Sk radius, resulting in an energetically stable topological hybrid structure.

Modeling multiorbital effects in Sr2IrO4 under strain and an external field

Lena Engström
McGill University

Many parallels have been drawn between the spin-orbit coupled Mott insulator Sr2IrO4 and the high-Tc superconducting cuprates. In the undoped compound, an effective two band J = 1/2 model has been shown to capture the observed magnetic order. In other regimes, the applicability of this model is less clear, and the correlated phases are less understood due to potentially complex multiorbital physics. We present a comprehensive study of a three-orbital lattice model suitable for the layered iridate Sr2IrO4. Our analysis includes various on-site interactions as well as compressive strain, and an external magnetic field. We use a self-consistent mean field approach with multiple order parameters to characterize the resulting phases of the system as the strain is increased. For a large compressive strain, the model describes a phase transition into a metallic state where the inclusion of all the bands is necessary. In each phase we characterize the magnetic state by considering the order in both spin and orbital degrees of freedom. Our results qualitatively agree with experiments of Sr2IrO4 under strain induced by a substrate.

Signatures of Domain Wall Superconductivity in Individual InAs/EuS/Al Nanowires

Juan Carlos Estrada Saldana
University of Copenhagen

Domain wall superconductivity (DWS) in ferromagnet/superconductor bilayers is characterized by the spatial modulation of the order parameter of the superconducting layer by the presence of magnetic domain walls in the ferromagnetic layer [1,2]. The modulation ensues from the preclusion/promotion of singlet and triplet Cooper pairing in the superconductor depending on the magnetic texture of the underlying ferromagnet, which is exchange-coupled to the superconductor [3,4].

We report transport signatures of DWS in experiments with magnetic insulator (EuS)/superconductor (Al) ultra-thin bilayer epitaxial films grown on individual InAs nanowires. The unprecedented closed and quasi-1D topology of the bilayer puts constraints on the directions which the magnetic moments at the domain walls can adopt. This in turn affects the magnetic and dynamic behaviour of the re-entrant DWS phase, as revealed by our measurements.

Our experimental results pave the way for DWS race-tracks in nanowires, analogous to magnetic-domain-wall race-tracks in magnetic nanowires [5]. In addition, they shed a new light on the investigation of Majorana zero modes in nanowires with similar coatings [6,7].

[1] Yang, Z., Lange, M., Volodin, A., Szymczak, R., & Moshchalkov, V. V. (2004). Domain-wall superconductivity in superconductor–ferromagnet hybrids. Nat. Mater. 3, 793–798.
[2] Komori, S. et al. (2018). Magnetic Exchange Fields and Domain Wall Superconductivity at an All-Oxide Superconductor-Ferromagnet Insulator Interface. Phys. Rev. Lett. 121, 077003
[3] Buzdin, A. I., & Mel'nikov, A. S. (2003). Domain wall superconductivity in ferromagnetic superconductors. Phys. Rev. B 67, 020503.
[4] Aikebaier, F., Virtanen, P., & Heikkilä, T. (2019). Superconductivity near a magnetic domain wall. Phys. Rev. B 99, 104504.
[5] Parkin, S. S. P., Hayashi, M., & Thomas, L. (2008). Magnetic Domain-Wall Racetrack Memory. Science 320, 190–194.
[6] Liu, Y. et al. (2020). Semiconductor–Ferromagnetic Insulator–Superconductor Nanowires: Stray Field and Exchange Field. Nano Lett. 20, 456–462.
[7] Vaitiekėnas, S., Liu, Y., Krogstrup, P., & Marcus, C. M. (2020). Zero-bias peaks at zero magnetic field in ferromagnetic hybrid nanowires. Nat. Phys.

Topological charge, spin and heat transistor

Victor Fernandez Becerra
Institute of Physics, Polish Academy of Sciences

Spin pumping consists in the injection of spin currents into a non-magnetic material due to the precession of an adjacent ferromagnet. In addition to the pumping of spin the precession always leads to pumping of heat, but in the presence of spin-orbital entanglement it also leads to a charge current. We investigate the pumping of charge, spin and heat in a device where a superconductor and a quantum spin Hall insulator are in proximity contact with a ferromagnetic insulator. We show that the device supports two robust operation regimes arising from topological effects. In one regime, the pumped charge, spin and heat are quantized and related to each other due to a topological winding number of the reflection coefficient in the scattering matrix formalism – translating to a Chern number in the case of Hamiltonian formalism. In the second regime, a Majorana zero mode switches off the pumping of currents owing to the topologically protected perfect Andreev reflection. We show that the interplay of these two topological effects can be utilized so that the device operates as a robust charge, spin and heat transistor.

Electrical and Thermal Transport in Antiferromagnet–Superconductor Junctions

Martin Fonnum Jakobsen
Center for Quantum Spintronics, NTNU

We demonstrate that antiferromagnet–superconductor (AF–S) junctions show qualitatively different transport properties than normal metal–superconductor (N–S) and ferromagnet–superconductor (F–S) junctions. We attribute these transport features to the presence of two new scattering processes in AF–S junctions, i.e., specular reflection of holes and retroreflection of electrons. Using the Blonder–Tinkham–Klapwijk formalism, we find that the electrical and thermal conductance depend nontrivially on antiferromagnetic exchange strength, voltage, and temperature bias. Furthermore, we show that the interplay between the N´eel vector direction and the interfacial Rashba spin-orbit coupling leads to a large anisotropic magnetoresistance. The unusual transport properties make AF–S interfaces unique among the traditional condensed-matter-system-based superconducting junctions.

Proximity effects in superconductor-ferromagnetic insulator bilayers of arbitrary thickness

Alberto Hijano
University of the Basque Country (UPV/EHU)

Superconductivity and magnetism can coexist in hybrid systems through mutual proximity effects. In this work we study the proximity effects in ferromagnetic insulator-superconductor structures (FI/S). Similarly to a Zeeman field, the interfacial exchange field induces triplet correlations in the superconductor and produces a spin-splitting of the superconducting density of states, which is the basis for many applications. We calculate the density of states in FI/S and obtain its phase diagram. We show that both are greatly affected by the thickness of the S layer. Our theory provides the range of parameters where the spin-split peaks are well defined and superconductivity is preserved, which is the desired situation for applications. We compare our findings with recent experiments.

Unified Description of Spin Transport, Weak Antilocalization and Triplet Superconductivity in Systems with Spin-Orbit Coupling

Stefan Ilic
Centro de Fisica de Materiales (CFM-MPC), Donostia

The Eilenberger equation is a standard tool in the description of superconductors with arbitrary-degree of disorder. It can be generalized to systems with linear-in-mometum spin-orbit coupling (SOC), by exploiting the analogy of SOC with a non-abelian background field. Such field mixes singlet and triplet components and yields the rich physics of magnetoelectric phenomena. In this work we show that the application of this equation extends further, beyond superconductivity. In the normal state, the linearized Eilenberger equation describes the coupled spin-charge dynamics. Moreover, its resolvent corresponds to the so called Cooperons, and can be used to calculate the weak localization corrections. Specifically, we show how to solve this equation for any source term and provide a closed-form solution for the case of Rashba SOC. We use this solution to address several problems of interest for spintronics and superconductivity. Firstly, we study spin injection from ferromagnetic electrodes in the normal state, and describe the spatial evolution of spin density in the sample, and the complete crossover from the diffusive to the ballistic limit. Secondly, we address the so-called superconducting Edelstein effect, and generalize the previously known results to arbitrary disorder. Thirdly, we study weak localization correction beyond the diffusive limit, which can be a valuable tool in experimental characterization of materials with very strong SOC. We also address the so-called pure gauge case where the persistent spin helices form. Our work establishes the linearized Eilenberger equation as a powerful and a very versatile method for the study of materials with spin-orbit coupling, which often provides a simpler and more intuitive picture compared to alternative methods.

Macroscale nonlocal transfer of superconducting signatures to a ferromagnet in a cavity

Andreas Janssonn
Norwegian University of Science and Technology

Conventional coupling of superconductors (SC) and ferromagnets (FM) predominantly rely on proximity effects over microscopic distances. By placing them separately inside a cavity, we propose a mechanism by which the SC and the FM may couple over a macroscopic distance (”nonlocally”). A simple proof of concept is presented, along with suggestions for implementations and future prospects. The corresponding article has been accepted for publication as a Rapid Communication in PRB, with the preprint available at https://arxiv.org/abs/2006.12516.

Magnetization reorientation due to the superconducting transition in heavy-metal heterostructures

Lina G. Johnsen
Norwegian University of Science and Technology

Recent experiments [1] have demonstrated how the superconducting critical temperature (Tc) can be modified by rotating the magnetization of a single homogeneous ferromagnet proximity-coupled to the superconducting layer. This occurs when an intermediate heavy normal metal provides an enhanced interfacial Rashba spin-orbit interaction. In the work presented [2], we consider the reciprocal effect: magnetization reorientation driven by the superconducting phase transition. We demonstrate that by lowering the temperature below Tc, it is possible to trigger a reorientation of the favored magnetization direction either within the plane of the interface, or from in-plane to out-of-plane. Furthermore, we find that for ballistic-limit systems, Tc shows a dependence on the in-plane orientation of the magnetization, in contrast to previous results on the diffusive limit [1]. Experimental work done by our collaborators [3], shows a field assisted in-plane magnetization reorientation corresponding to our predicted effect.

[1] N. Banerjee, J. A. Ouassou, Y. Zhu, N. A. Stelmashenko, J. Linder, and M. G. Blamire,
Phys. Rev. B 97, 184521 (2018).
[2] L. G. Johnsen, N. Banerjee, and J. Linder,
Phys. Rev. B 99, 134516 (2019).
[3] C. González-Ruano, L. G. Johnsen, D. Caso, C. Tiusan, M. Hehn, N. Banerjee, J. Linder, F. G. Aliev,
Phys. Rev. B 102, 020405(R) (2020).

Energy storage in magnetic textures driven by vorticity flow

Dalton Jones
UCLA

An experimentally feasible energy-storage concept is formulated based on vorticity (hy- dro)dynamics within an easy-plane insulating magnet. The free energy associated with the magnetic winding texture is built up in a circular easy-plane magnetic structure by injecting a vorticity flow in the radial direction. The latter is accomplished by electrically induced spin-transfer torque, which pumps energy into the magnetic system in proportion to the vortex flux. The resultant magnetic metastable state with a finite winding number can be maintained indefinitely because the process of its relaxation via phase slips is exponentially suppressed when the temperature is brought well below the Curie temperature. We characterize the vorticity-current interaction under- lying the energy-loading mechanism through its contribution to the effective electric inductance in the rf response. Our proposal may open an avenue for naturally powering spintronic circuits and nontraditional magnet-based neuromorphic networks.

GexFem Magnetic Josephson Junctions for artificial synapses

Emilie Jué
NIST

Nano-clustered magnetic Josephson Junctions (MJJs) are hybrid magnetic-superconducting devices that can be used as low energy synaptic devices [1]. More precisely, these devices are Josephson junctions with magnetic nanoclusters in the barrier, which have a critical current that can be tuned by changing the magnetic order in the barrier. Although these devices are very promising, their behavior has been demonstrated in only one material system so far, a Si barrier with Mn nanoclusters between two electrodes of Nb. In this work, we show that we can reproduce the tunability of the critical current with the magnetic order using a barrier of amorphous Ge containing Fe nanoclusters. The barriers were deposited as Nb/[Ge/Fe1000]/Nb with a custom size-selective low-energy nano-particle deposition system [2] and patterned into 8 µm diameter MJJs. The devices are measured in a liquid He flow cryogenic probe station with a base temperature of 4K. The magnetic order of the device is controlled either (1) by heating the sample above its blocking temperature (TB~40 K) and cooling the device in the absence (disordered state) or in the presence of a magnetic field (ordered state), or (2) by applying short pulses of current through the device in the absence (disordered sate) or in the presence of a magnetic field (ordered state). Figure 1 shows an example of the change in critical current when the magnetic order in the barrier is changed. This result shows that the nano-clustered magnetic Josephson junctions can be made with materials other than SiMn, which opens up new options to optimize device parameters for hybrid magnetic-superconducting neural networks.

[1] Schneider et al., Science Advances, Vol. 4, no. 1, e1701329 (2018)
[2] Fischer, A., R. Kruk, and H. Hahn. Review of Scientific Instruments 86, 023304 (2015)

Quasiperiodic criticality and spin-triplet superconductivity in superconductor-antiferromagnet moire patterns

Maryam Khosravian
Aalto University

Quasiperiodic structures are promising playgrounds to engineer critical wavefunctions. Here we show that systems hosting a quasiperiodic modulation of antiferromagnetism and spin-singlet superconductivity, as realized by atomic chains in twisted van der Waals materials, host a localization-delocalization transition as a function of the coupling strength. Associated with this transition, we demonstrate the emergence of a robust quasiperiodic critical point for arbitrary incommensurate potentials. Here [1] we show that inclusion of residual electronic interactions leads to an emergent spin-triplet superconducting state,that gets dramatically enhanced at the vicinity of the quasiperiodic critical point.

[1]. https://arxiv.org/abs/2010.16390

Dimerization-induced topological superconductivity in a Rashba nanowire

Aksel Kobialka
University of Maria Sklodowska-Curie

Interplay between superconductivity, spin orbit coupling and magnetic field can lead to realization of the topological phase [1]. However, there are additional ways to achieve that phase that are not simply a function of system parameters. Thus, we analyze influence of a dimerization on the topological phases of the Rashba nanowire proximitized to a superconducting substrate [2]. We find that periodic alternations of the hopping integral and spin-orbit coupling can lead to band inversion, inducing transition to topologically nontrivial superconducting phase that hosts the Majorana zero-energy modes. This "dimerization-induced topological superconductivity" completely repels the topological phase of the uniform nanowire, whenever they happen to overlap. We provide an analytical justification for this puzzling behavior based on the symmetry and parity considerations and discuss feasible spectroscopic methods for its empirical observation. We also test stability of the topological superconducting phases against electrostatic disorder. Current experimental progress shows promise for such systems to be achievable in near future through atom manipulation using STM [3] or related with the topological bond order of the interacting ultra cold atom systems [4].

[1] Controlling the bound states in a quantum-dot hybrid nanowire, A. Ptok, A. Kobiałka, and T. Domanski, Phys. Rev. B ´ 96, 195430 (2017).
[2] Dimerization-induced topological superconductivity in a Rashba nanowire, A. Kobiałka, N. Sedlmayr, M. M. Maska, and T. Doma ´ nski, Phys. Rev. B ´ 101, 085402 (2020).
[3] Toward tailoring Majorana bound states in artificially constructed magnetic atom chains on elemental superconductors, H. Kim, A. Palacio-Morales, T. Posske, L. Rózsa, K. Palotas, L. Szunyogh, M. Thorwart, and R. Wiesendanger, Sci. Adv. 4, eaar5251 (2018)
[4] Strongly Correlated Bosons on a Dynamical Lattice, D. Gonzalez-Cuadra, P. Grzybowski, A. Dauphin, and M. Lewenstein, Phys. Rev. Lett. 121, 090402 (2018).

Magnon Landau Levels and Spin Responses in Antiferromagnets

Alexey Kovalev
University of Nebraska - Lincoln

We study gauge fields produced by gradients of the Dzyaloshinskii-Moriya interaction and propose a model of AFM topological insulator of magnons. In the long wavelength limit, the Landau levels induced by the inhomogeneous Dzyaloshinskii-Moriya interaction exhibit relativistic physics described by the Klein-Gordon equation. We further study Landau levels in our model of AFM topological insulator and observe unconventional Hofstadter's butterfly. We calculate the spin Nernst response due to formation of magnonic Landau levels and compare it to similar topological responses in skyrmion and vortex-antivortex crystal phases of AFM insulators. Our studies show that AFM insulators exhibit rich physics associated with topological magnon excitations.

Exchange biased Anomalous Hall Effect driven by frustration in the magnetic Kagome material Co3Sn2S2

Ella Lachman
UC Berkeley

Co3Sn2S2 is a ferromagnetic Weyl semimetal that has been the subject of intense scientific interest due to its large anomalous Hall effect. We show that the coupling of this material's topological properties to its magnetic texture leads to a strongly exchange biased anomalous Hall effect. We show evidence that the exchange bias is likely caused by the coexistence of a spin glass phase with ferromagnetism, due to geometric frustration intrinsic to the kagome network of magnetic ions. This spin glass phase is what gives rise to the exchange bias, in an interesting display of intrinsic exchange bias in a single crystal.

References

Generating Long-Range Spin-Triplet Supercurrents with a Single Ferromagnet

Kaveh Lahabi
Leiden University

Spin-triplet Cooper pairs in magnetic hybrids form the foundation of rich and diverse transport phenomena. It is well established that long-range triplet (LRT) correlations can arise at a magnetically inhomogeneous interface with a superconductor. This is commonly achieved using multilayer ferromagnets with non-collinear magnetization. Here we demonstrate an alternative, where the LRT supercurrent is generated by the spin texture of a single ferromagnet. This is realised in a disk-shaped Josephson junction with a cobalt weak-link, which contains a ferromagnetic vortex.

We find that spin texture can lead to a non-trivial distribution of triplet supercurrent, where transport tends to be highly localized at the edges of the junction. Furthermore, we show that by tuning the micromagnetic texture, a single junction can exhibit widely different supercurrent interference patterns. Here, I will describe the relevant mechanisms for LRT generation in our junctions, with an emphasis on the role of spin currents at sample boundaries.

Signatures of Majorana modes leaking into double quantum dots

Piotr Majek
Adam Mickiewicz University, Poznan, Poland

Topological states of matter and nanoscale systems gather broad interest in condensed matter physics. Both theoretical and experimental investigations reveal the signatures of the existence of exotic quasiparticles predicted by Ettore Majorana. Recent experiments also demonstrate the possibility of using quantum dots as a probe for Majorana bound states in topological superconducting nanowires. More complex systems are still under consideration and attract considerable attention.

The goal of this communication is to shed more light on the interplay between strong correlations and topological properties of matter by analyzing the transport properties of a double quantum dot interacting with a Majorana zeromode localized at the end of the topological superconducting nanowire. With the use of the numerical renormalization group procedure, the linear response transport coefficients are calculated focusing on the Kondo regime. When the double quantum dot is decoupled from the Majorana mode, it exhibits the twostage Kondo effect, where besides the increase of linear conductance G with decreasing temperature below the Kondo temperature TK, one observes suppression of G below some specific energy scale associated with temperature T_*. It is shown that attaching the nanowire to one of the quantum dots affects the transport properties significantly by destroying the second stage of the Kondo effect and giving rise to a fractional value of conductance G = 0.5e 2/h in one of the spin channels. This fractional value is robust against quantum dot level detuning and can serve as a smoking-gun signature of the presence of Majorana zero-energy modes in the system.

This work is supported by the National Science Centre in Poland through Project No. DEC-2018/29/B/ST3/00937.

Interplay between magnetism and superconductivity in cuprates and pnictides

Lev Mazov
FRC "Institute of Appled Physics RAS": IPM RAS

In 1991, 5 years after the discovery of HTSC in doped cuprates, it was demonstrated from magnetotransport data that superconducting (SC) transition in these compounds is preceded by magnetic (AF SDW) phase transition in the CuO2-plane (Tc < Tm = T*) (see, e.g. [1]). Below Tc, the magnetic and superconducting orders interplay with one other (SC+SDW state), moreover, magnetic order provides high Tc to appear in cuprates [2]. In result of such normal-state transition, the gap (pseudogap) is opened on symmetrical parts of the Fermi surface (FS), while the rest part of the FS remains to be free for Cooper pairing of mobile charges carriers. Because of incommensurability of this SDW with lattice constant it is accompanied by CDW with one half period □CDW □ □SDW / 2 . Such SDW/CDW state is formed in CuO2-plane as a stripe nanostructure with sequence of alternating conducting, charge (C) and semi-insulating, spin (S) nanostripes with width of the order of 1 nm. The S-stripes in CuO2-planes of doped cuprates can be considered as insulating, AF-ordered domains transformed from insulating, uniformly AFordered CuO2-planes, existing in undoped compounds at T < TN. In their turn, C-stripes appear to be a domain walls between antiphase AF-ordered domains (S-stripes) while periodicity of Cones in fact is, in accordance with the principle of minimum energy, a result of spatial bunching of excess mobile charge carriers (MCC), introduced to uniformly AF-ordered CuO2-planes of parent compounds. The principal feature of such magnetic order is its dynamical character – it fluctuates with characteristic time of the order of 1ps. However, conduction electrons, because of short characteristic time ~ 1 fs, “see” the magnetic order as “frozen” – quasi-static case. Such behavior makes it difficult to be detected – only fast and local techniques should be used. In 1997, similar conclusion about SDW order parameters in doped cuprates was obtained by Richard Klemm (ANL) (see, [2]). The direct evidence for normal-state magnetic phase transition was at last obtained from polarized neutron diffraction experiment only 15 years later [3].

CONTINUES ON NEXT PAGE

Then, it appears that general picture of the normal-state phenomena was predicted well before. It corresponds to well known metal-insulator phase transition proposed by Keldysh and Kopaev [4]. The thermodynamics of such dielectric (D) phase transition is quite similar to that of SC one. And in systems with coexistence of dielectric and SC pairings the first is dielectric phase transition with partial gapping of the Fermi surface, and only then SC transition occurs, so that below Tc the system is in (SC+D)-state (SC+SDW state for doped cuprates [5]). It is interesting that the principal behavior of such systems was specially described for experimentalists in the book [6] (Ch.5), 10 years before discovery of HTSC in doped cuprates.

density of state at the edges of the SDW-dielectric gap (pseudogap) and due to in-plane charge-transfer excitons in S-stripes (in-plane "Ginzburg sandwich") with energy ~ 2 eV. Similar interplay of magnetism and SC is observed in pnictides (selenides) and hydrides as well [7].

References
[1] Mazov L.S. in: Mater.of IV Soviet-German seminar on HTSC (St.Petersburg, October 6-13, 1991), p.81-84; see, also, 2004 Phys.Rev. B 70, 054501.
[2] Mazov L.S. in: Superconductivity Research at the Leading Edge // (Nova Sci. NY, 2004) p.1
[3] Fauque B. et al. 2006 Phys.Rev.Lett. 96 197001.
[4] Keldysh L.V., Kopaev Yu.V. 1964 Fiz.Tverd. Tela 6, 2791.
[5] Mazov L.S. 2007 J.Supercond. and Novel Magn. 20 579; 2012 Phys. Proc. 36, 735-740.
[6] Problem of HTSC (Ed. V.L.Ginzburg, D.A.Kirzhnitz, Nauka Press, Moscow, USSR, 1977).
[7] Mazov L.S. 2014 Bull.Russ.Acad.Sci.Physics 78, 1348; 2018 Europe Phys. J. 185wc, 08003.

Dynamical torques from Shiba states in s-wave superconductors

Archana Mishra
MagTop, IFPAN, Warsaw

Magnetic impurities inserted in a s-wave superconductor give rise to spin-polarized in-gap states called Shiba states. We study the back-action of these induced states on the dynamics of the classical moments. We show that the Shiba state pertains to both reactive and dissipative torques acting on the precessing classical spin that can be detected through ferromagnetic resonance measurements. Moreover, we highlight the influence of the bulk states as well as the effect of the finite linewidth of the Shiba state on the magnetization dynamics. Finally, we demonstrate that the torques are a direct measure of the even and odd frequency triplet pairings generated by the dynamics of the magnetic impurity. Our approach offers non-invasive alternative to the STM techniques used to probe the Shiba states.

Temperature-dependent spin-transport and current-induced torques in superconductor/ferromagnet heterostructures

Manuel Mueller
Walther Meissner Institut

Proximity effects at superconductor(SC)/ferromagnet(FM) interfaces provide novel functionality in the field of superconducting spintronics. We investigate the injection of quasiparticle spin currents in a NbN/Permalloy (Py) heterostructures with a Pt spin sink layer. To this end, we excite ferromagnetic resonance in the Py-layer via the microwave driving field of a coplanar waveguide (CPW). A phase sensitive detection of the microwave transmission signal is used to quantitatively extract the inductive coupling strength between sample and CPW as a function of temperature [1]. Below the superconducting transition temperature Tc, we observe a blocking effect of pure spin current transport in the NbN layer. Moreover, below Tc we find a large field-like current-induced torque. Our findings, reveal symmetry and strength of spin-to-charge current conversion in SC/FM heterostructures and provide guidance for future superconducting spintronics devices [2].

[1] A. Berger et al., Phys. Rev. B 97: 94407. (2018).
[2] M. Müller et al., arXiv:2007.15569.(2020).

Spin and charge currents driven by the Higgs mode in high-field superconductors

Risto Ojajarvi
University of Jyväskylä

Higgs mode in superconducting materials describes slowly-decaying oscillations of the order parameter amplitude. We demonstrate that in superconductors with built-in spin-splitting field Higgs mode is strongly coupled to the spin degrees of freedom allowing for the generation of time-dependent spin currents. Converting such spin currents to electric signals by spin-filtering elements provides a tool for the second-harmonic generation and the electrical detection of the Higgs mode generated by the external irradiation. The non-adiabatic spin torques generated by these spin currents allow for the magnetic detection of the Higgs mode by measuring the precession of magnetic moment in the adjacent ferromagnet. We discuss also the reciprocal effect which is the generation of the Higgs mode by the magnetic precession. Coupling the collective modes in superconductors to light and magnetic dynamics opens the new direction of superconducting optospintronics.

First-principles study of the nontrivial topological phase in chains of 3d transition metals deposited at superconducting surface

Andrzej Ptok
Polish Academy of Sciences

Recent experiments have shown the signatures of Majorana bound states at the ends of magnetic chains deposited on a superconducting substrate [1,2]. Here, we employ firstprinciples calculations to directly investigate the topological properties of 3d transition metal nanochains (i.e., Mn, Cr, Fe and Co). In contrast to the previous studies, we found the exact tight-binding models in the Wannier orbital basis for the isolated chains as well as for the surface-deposited wires. Based on these models, we calculate the topological invariant for all systems. Firstly, for the isolated chains we demonstrate the existence of the topological phase only in Mn and Co systems. Secondly, we showed that a coupling between the chain and substrate leads to strong modification of the band structure. Moreover, the analysis of the topological invariant indicates the possibility of emergence of the topological phase in all studied nanochains deposited on the Pb surface. Therefore, our results demonstrate an important role of the coupling between deposited atoms and a substrate for topological properties of nanosystems, that should be implemented in future studies.

[1] Nadj-Perge et al., Science 346, 602 (2014)
[2] Ruby et al., Nano Lett. 17, 4473 (2017)
[3] A. Kobiałka, P. Piekarz, A. M. Oleś, and A. Ptok, Phys. Rev. B 101, 205143 (2020)

Control of Single Pulse All Optical Magnetization Switching of Ferromagnets

Quentin Remy
Insitut Jean Lamour, UniversitÈ de Lorraine, Nancy

All Optical Helicity Independent Switching (AO-HIS) of magnetization, using single femtosecond laser pulses, has been demonstrated in GdFeCo ferrimagnetic alloys for various concentrations [1] as well as in other structures with antiferromagnetic coupling, Gd/Co, Tb/Co multilayers and Mn2RuxGa [2,3,4]. Up to now, AO-HIS has never been observed for ferromagnetic layer. However, it was shown that a single pulse magnetization reversal of a ferromagnet could be observed in a spin-valve structure [5]. The switching is then achieved by the ultrashort spin current pulse generated from the ultrafast demagnetization of GdFeCo [5,6].

In this work, we study Gdx(FeCo)1-x/Cu/FM spin-valve structures, where FM can be different ferromagnetic layers [7] and the composition x of the GdFeCo alloy is also changed [8]. By increasing the Gadolinium concentration x, we aim at increasing the spin current injected in the copper layer [6]. We show that this can reduce the laser fluence threshold required to observe the FM magnetization reversal. In particular, no AO-HIS of the GdFeCo layer is required and the threshold fluence for the FM layer is around 1.6 mJ/cm² i.e. comparable to GdFeCo and Gd/Co multilayers [1,2] and smaller than what is achieved for Tb/Co [2] and Mn2RuxGa [3]. We also show that by changing the Curie temperature and the Cu/FM interface, one can control the interaction between the spin current and the FM layer and so the laser fluence threshold. Finally, we change the laser pulse duration and show that this not only changes the laser fluence threshold but also the entire laser fluence range where the single pulse FM switching can be observed without having any multidomain state.

[1] Y. Xu, M. Deb, G. Malinowski, M. Hehn, W. Zhao, S. Mangin, Adv. Mater. 2017, 29, 1703474.

[2] M. L. M. Lalieu, M. J. G. Peeters, S. R. R. Haenen, R. Lavrijsen, B. Koopmans, Phys. Rev. B 2017, 96, 220411.

[3] L. Avilés-Félix, A. Olivier, G. Li, C. S. Davies, L. Álvaro-Gómez, M. Rubio-Roy, S. Auffret, A. Kirilyuk, A. V. Kimel, T. Rasing, L. D. Buda-Prejbeanu, R. C. Sousa, B. Dieny, I. L. Prejbeanu, Sci. Rep. 2020, 10, 5211.

[4] C. Banerjee, N. Teichert, K. E. Siewierska, Z. Gercsi, G. Y. P. Atcheson, P. Stamenov, K. Rode, J. M. D. Coey, J. Besbas, Nat. Commun. 2020, 11, 1.

[5] S. Iihama, Y. Xu, M. Deb, G. Malinowski, M. Hehn, J. Gorchon, E. E. Fullerton, S. Mangin, Adv. Mater. 2018, 30, 1804004.

[6] G. M. Choi, B. C. Min, Phys. Rev. B 2018, 97, 014410.

[7] Q. Remy, J. Igarashi, S. Iihama, G. Malinowski, M. Hehn, J. Gorchon, J. Hohlfeld, S. Fukami, H. Ohno, S. Mangin, Adv. Sci. 2020, 2001996.

[8] J. Igarashi, Q. Remy, S. Iihama, G. Malinowski, M. Hehn, J. Gorchon, J. Hohlfeld, S. Fukami, H. Ohno, S. Mangin, Nano Letters 2020 (Accepted).

Theory of topological spin Josephson junctions

Peter Shen
Tsinghua University

We study the spin transport through a 1D quantum Ising|XY|Ising spin link that emulates a topological superconducting|normal|superconducting structure via Jordan-Wigner (JW) transformation. We calculate, both analytically and numerically, the spectrum of spin Andreev bound states and the resulting $\mathbb{Z}2$ fractional spin Josephson effect (JE) pertaining to emerging Majorana JW fermions. Deep in the topological regime, we identify an effective time-reversal symmetry that leads to $\mathbb{Z}4$ fractional spin JE in the presence of interactions within the junction. Moreover, we uncover a hidden inversion time-reversal symmetry that it is showed to protect the $\mathbb{Z}4$ periodicity in odd chain sites even in the absence of interactions. We also analyze the entanglement between pairs of spins by evaluating the concurrence in the presence of spin currents and highlight the effects of the JW Majorana states. We propose to use a microwave cavity setup (cQED) for detecting the aforementioned JEs by dispersive readout methods and show that, surprisingly, the $\mathbb{Z}2$ periodicity is immune to any local magnetic perturbations. Our results are relevant for a plethora of spin systems, such as trapped ions, photonic lattices, electron spins in quantum dots, or magnetic impurities on surfaces.

Large enhancement of spin pumping due to the surface bound states in normal metal/superconductor structures

Mikhail Silaev
Jyväskylä University

This work demonstrates how Andreev bound states can enhance the spin pumping efficiency in ferromagnetic/superconductor bilayer. Bound states in superconducting hybrid structures are central for the further development of quantum information technologies. They appear due to the subsequent Andreev reflections converting electrons to holes near superconducting order parameter inhomogeneities or the interfaces of unconventional superconductors. Previously such states have been probed by tunnelling spectroscopy. The present work shows that they modify also dynamical spin responses. In accordance with recent experimental results Andreev bound states provide significant enhancement of spin pumping efficiency and Gilbert damping. As shown in the figure this effect arises due to the multiple spin-flip scattering of bound electrons and holes from the ferromagnetic interface after experiencing Andreev reflections in the superconductor. This finding together with the developed methodology [1,2] pave the way to the tailored spin pumping properties for probing various bound states in superconducting systems. Such properties can be studied experimentally using the state-of-the-art ferromagnetic resonance techniques.

[1] Finite-frequency spin susceptibility and spin pumping in superconductors with spin-orbit relaxation, M.A. Silaev, Phys. Rev. B 102, 144521 (2020)

[2] Large enhancement of spin pumping due to the surface bound states in normal metal/superconductor structures, M.A. Silaev, arXiv:2008.062 53

Interplay of proximity effects in Nb/FePd heterostructures: domain-superconductivity, spin-triplet Cooper pair generation, and the impact on the ferromagnet

Annika Stellhorn
Forschungszentrum Jülich GmbH, JCNS-2

Proximity effects in superconductor(S)/ferromagnet(F) thin film heterostructures are highly topical issues due to their potential application in superconducting spin valves or fluxonic devices [1, 2]. Superconducting, electric, and magnetic properties can be controlled by an external applied magnetic field [3] and emerge for example as stray-field generated domain-superconductivity or spintriplet superconducting correlations.

These two phenomena arise from fundamentally different origins but can still be studied within one heterostructure system. Our goal is to investigate their interplay and tunability by an external magnetic field, and to obtain information on the inverse proximity effect: a change of magnetization of the F-layer. We use a heterostructure system of Nb(S)/FePd(F) with varying strength of perpendicular magnetic anisotropy and a lateral domain structure, grown by molecular beam epitaxy.

On the one hand, macroscopic magnetoelectric transport measurements reveal a confined superconducting state due to the stray fields of L10-ordered FePd. On the other hand, direct proximity effects at the Nb/FePd interface with a non-collinear magnetization presumably lead to the generation of spin-triplet Cooper pair components with long penetration depth within the F-layer [4]. Grazing-Incidence Small-Angle Neutron Scattering (GISANS) probe exchange mechanisms on the microscopic scale and reveal a change in the ferromagnetic domain pattern by an onset of domain-wall-superconductivity.

[1] J. Linder and J. W. A. Robinson, Nature Physics, vol. 11, pp. 307-315, Apr 2015.
[2] A. M. Kadin, Journal of Applied Physics, vol. 68, p. 5741, Dec 1990.
[3] J. Y. Gu, et al., Physical Review Letters, vol. 89, Dec 2002.
[4] A. Stellhorn et al., New Journal of Physics, vol. 22, p. 093001, Sep 2020.

Magnetic field-induced “mirage” gap in an Ising superconductor

Gaomin Tang
University of Basel

Usual superconductivity is destroyed by a magnetic field due to orbital or Zeeman-induced pair breaking. Surprisingly, the spin-valley locking in a two-dimensional superconductor with spin-orbit interaction makes the superconducting phase resilient to large magnetic fields. We investigate the spectral properties of such an Ising superconductor in a magnetic field taking into account disorder. We find that the interplay of in-plane magnetic field and Ising spin-orbit coupling leads to the emergence of singlet and triplet pairing that manifests itself in the occurrence of “mirage” gaps: at (high) energies of the order of the spin-orbit coupling strength a gap-like structure in the spectrum emerges that mirrors the main superconducting gap. We show that these mirage gaps are signatures of the equal-spin triplet pairing correlation induced by the noncollinear effective field.

Representation of antiferromagnetic eigenstates as squeezed sublattice magnon states in the presence of a static, external magnetic field

Dennis Wuhrer
University of Konstanz

Magnons are well established as the excitations on the ground state of magnetic materials. It was recently shown, that the eigenstates of an antiferromagnet are squeezed sublattice eigenstates connected by the squeezing operators S r~k. For the squeezed vacuum and squeezed one magnon state an expansion in the sublattice ~k = ~0 Fock states was given. Here we expand this investigation, by giving the exact expansion of these squeezed states in all sublattice Fock states. We show, that the statistic for all veck is the same only differing by the squeezing factor r~k. From this one can determine any of the cumulants of the occupation number of the sublattice magnons. We then investigate the dependence of these cumulants with respect to the size of the system and the system determining factor |J|/K. Subsequently, we introduce an static, homogeneous, external magnetic field B~ in an arbitrary direction, with the main result being a change in the probability amplitudes for the sublattice ~k = ~0 Fock states and a nonvanishing amplitude for an unequal number of magnons in the different sublattice

List of Contributions - Talks

Surname	Name	Talk Title
Bobkova	Irina	Odd triplet superconductivity induced by the moving condensate
Brataas	Arne	Current Control of Magnetism in Two-Dimensional Fe3GeTe2
Chowdhury	Debanjan	What really sets the highest possible superconducting Tc in two-dimensions?
Ciccarelli	Chiara	Spin pumping into a superconductor: evidence of superconducting pure spin currents
Duine	Rembert	Spin current in all its guises
Efetov	Dimitri	Magic Angle Bilayer Graphene - Superconductors, Orbital Magnets, Correlated States and beyond
Flebus	Benedetta	Non-Hermitian topology of one-dimensional spin-torque oscillator arrays
Galitski	Victor	Exotic Physics in Topological Insulator/Ferromagnet Heterostructures
Goennenwein	Sebastian	Nonlocal spin transport experiments
Heikkilä	Tero	Nonequilibrium phenomena in superconductors in proximity to magnets
Hillebrands	Burkard	Bose-Einstein condensation of magnons in confined systems
Hioki	Tomosato	Coherent Interconversion and bi-reflection of magnons hybridized with phonons
Hwang	Harold	Superconductivity in Infinite Layer Nickelates - Is Magnetism Relevant?
Lado	Jose	Solitons and topological superconductivity in antiferromagnet-superconductor interfaces
Liljeroth	Peter	Topological superconductivity in van der Waals heterostructures

Surname	**Name**	**Talk Title**
Mackenzie	Andrew	Two-phase superconductivity in CeRh2As2 and the role of Rashba spin-orbit coupling
Moodera	Jagadeesh	In Search of Majorana Pair Along The Golden Path
Palacio Morales	Alexandra	Real-Space Visualization of Majorana Edge Modes on the Nano-Scale Magnet-Superconductor Hybrid System
Scheer	Elke	Probing Triplet Superconductivity by Scanning Tunneling Spectroscopy
Takei	So	Spintronics meets quantum spin liquids: A novel spectral probe of quantum magnets based on spin Hall phenomena
Tserkovnyak	Yaroslav	Squeezing spin entanglement out of magnons
van Wees	Bart	Electrical and Thermal Generation of Spin Currents by Magnetic Graphene
von Oppen	Felix	Photon-assisted resonant Andreev reflections: Yu-Shiba-Rusinov and Majorana states
Yazdani	Ali	Spectroscopy of electrons in Moiré Flat Bands

List of Contributions - Poster

Surname	Name	Poster Title
Bezuglyj	Alexei	Transverse heat conductivity of I1=FI=I2 layered nanostructures at low temperatures
Cuoco	Mario	Magneto-electric effects and chiral anomaly in superconducting topological heterostructures
Dahir	Samme	Novel features of Superconductor/Ferromagnet heterostructures with chiral magnetic Skyrmions
Engström	Lena	Modeling multiorbital effects in Sr2IrO4 under strain and an external field
Estrada Saldana	Juan Carlos	Signatures of Domain Wall Superconductivity in Individual InAs/EuS/Al Nanowires
Fernandez Becerra	Victor	Topological charge, spin and heat transistor
Fonnum Jakobsen	Martin	Electrical and Thermal Transport in Antiferromagnet-Superconductor Junctions
Hijano	Alberto	Proximity effects in superconductor-ferromagnetic insulator bilayers of arnotrary thickness
Ilic	Stefan	United Description of Spin Transport, Weak Antilocalization and Triplet Superconductivity in Systems with Spin-Orbit Coupling
Janssonn	Andreas	Macroscale nonlocal transfer of superconducting signatures to a ferromagnet in a cavity
Johnsen	Lina G.	Magnetization reorientation due to the superconducting transition in heavy-metal heterostructures
Jones	Dalton	Energy storage in magnetic textures driven by vorticity flow
Jue	Emilie	GexFem Magnetic Josephson Junctions for artificial synapses
Khosravian	Maryam	Quasiperiodic criticality and spin-triplet superconductivity in superconductor-antiferromagnet moire patterns
Kobialka	Aksel	Dimerization-induced topological superconductivity in a Rashba nanowire
Kovalev	Alexey	Magnon Landau Levels and Spin Responses in Antiferromagnets

Surname	Name	Talk Title
Lachman	Ella	Exchange biased Anomalous Hall Effect driven by frustration in the magnetic Kagome material Co3Sn2S2
Lahabi	Kaveh	Generating Long-Range Spin-Triplet Supercurrents with a Single Ferromagnet
Majek	Piotr	Signatures of Majorana modes leaking into double quantum dots
Mazov	Lev	Interplay between magnetism and superconductivity in cuprates and pnictides
Mishra	Archana	Dynamical torques from Shiba states in s-wave superconductors
Mueller	Manuel	Temperature-dependent spin-transport and current-induced torques in superconductor/ferromagnet heterostructures
Ojajarvi	Risto	Spin and charge currents driven by the Higgs mode in high-field superconductors
Ptok	Andrzej	First-principles study of the nontrivial topological phase in chains of 3d transition metals deposited at superconducting surface
Remy	Quentin	Control of Single Pulse All Optical Magnetization Switching of Ferromagnets
Shen	Peter	Theory of topological spin Josephson junctions
Silaev	Mikhail	Large enhancement of spin pumping due to the surface bound states in normal metal/superconductor structures
Stellhorn	Annika	Interplay of proximity effects in Nb/FePd heterostructures: domain-superconductivity, spin-triplet Cooper pair generation, and the impact on the ferromagnet
Tang	Gaomin	Magnetic field-induced “mirage” gap in an Ising superconductor
Wuhrer	Dennis	Representation of antiferromagnetic eigenstates as squeezed sublattice magnon states in the presence of a static, external magnetic field
Wuhrer	Dennis	Representation of antiferromagnetic eigenstates as squeezed sublattice magnon states in the presence of a static, external magnetic field

List of Participants

Surname	Name	Affiliation	Email
Aarts	Jan	university leiden	aarts@physics.leidenuniv.nl
Abbasi Eskandari	Mohammad	Sherbrooke university, Department of physics	mohammad.abbasi.eskandari@usherbrooke.ca
Abdizadeh	sachli	iasbs	s.abdizadeh@iasbs.ac.ir
Adhikari	Rajdeep	Johannes Kepler University	rajdeep.adhikari@jku.at
Aharony	Amnon	Tel Aviv University	aaharonyaa@gmail.com
Akbari	Alireza	MPICPfS	alireza@apctp.org
Alldritt	Benjamin	Aalto University	benjamin.alldritt@aalto.fi
Amado-Montero	Mario	University of Salamanca	ma664@cam.ac.uk
Amini	Mohammad	Student	mohammad.amini@aalto.fi
Amundsen	Morten	NORDITA	morten.amundsen@su.se
Andreeva	Marina	Lomonosov Moscow State University	mandreeva1@physics.msu.ru
Andreeva	Marina	Lomonosov Moscow State University	mandreeva1@physics.msu.ru
Antonelli	Tommaso	University of St. Andrews	ta50@st-andrews.ac.uk
Anwar	Muhammad	University of Cambridge	msa60@cam.ac.uk
Aoki	Yuji	Tokyo Metropolitan University	aoki@tmu.ac.jp
asano	Hidefumi	Nagoya University	asano@numse.nagoya-u.ac.jp
Aviles Felix	Luis	Centro Atomico Bariloche	lavilesf@cab.cnea.gov.ar
AWALE	RAHUL	M2 Master Nanoscience UPSUD	rahulawale1991@gmail.com

Surname	**Name**	**Affiliation**	**Email**
Azhar	Maria	Karlsruhe Institute of Technology	maria.azhar@kit.edu
B¸ttner	Felix	Helmholtz-Zentrum Berlin	felix.buettner@helmholtz-berlin.de
Bˆhnert	Tim	International Iberian Nanotechnology Laboratory	tim.boehnert@inl.int
Bˆni	Peter	Technische Universit‰t M¸nchen	peter.boeni@frm2.tum.de
BaldovÌ	JosÈ J.	ICMol, University of Valencia	j.jaime.baldovi@uv.es
Bednarski-Meinke	Connie	Forschungszentrum J¸lich	c.bednarski-meinke@fz-juelich.de
belgibayev	toktar	bltp jinr	belgibaev@theor.jinr.ru
Bergeret	Sebastian	Materials Physics Center, San Sebastian (CSIC)	fs.bergeret@gmail.com
Bergeret	Sebastian	Materials Physics Center, San Sebastian (CSIC)	fs.bergeret@csic.es
Blumberg	Girsh	Rutgers U	girsh@physics.rutgers.edu
Botha	Andre E.	Department of Physics, University of South Africa	bothaae@unisa.ac.za
Br¸ne	Christoph	Department of Physics NTNU Trondheim	christoph.brune@ntnu.no
Burmistrov	Igor	Landau Institute	burmi@itp.ac.ru
Calderon	Maria Jose	Instituto de Ciencia de Materiales de Madrid, CSIC	mariaj.calderon@csic.es
Carreira	Santiago	UnitÈ Mixte de Physique, CNRS, Thales	Santiago.carreira@cnrs-thales.fr
Castel	Vincent	IMT Atlantique	vincent.castel@imt-atlantique.fr
Chebrolu	Narasimha Raju	Central University of Karnataka	narasimharaju.phy@cuk.ac.in
Chelpanova	Oksana	Johannes Gutenberg University of Mainz	okchelpa@uni-mainz.de

Surname	Name	Affiliation	Email
Chen	Jiasheng	University of Cambridge	jc732@cam.ac.uk
Chiolerio	Alessandro	Italian Institute of Technology	alessandro.chiolerio@iit.it
Choi	Deung-Jang	Centro de FÌsica de Materiales (CSIC-UPV/EHU)	djchoi@dipc.org
Chuang	Chien-Wen	Tohoku University	chuang.chien-wen.s1@dc.tohoku.ac.jp
Cinal	Marek	Institute of Physical Chemistry, PAS, Warsaw	mcinal@ichf.edu.pl
Continentinp	Mucio	Centro Brasileiro de Pesquisas FÌsicas	mucio@cbpf.br
Contreras Medrano	Cynthia Paola	Centro Brasileiro de Pesquisas FÌsicas	ccontreras@cbpf.br
Cornelius	Mercedes	University of Cambridge	mc2224@cam.ac.uk
Cuchillo-Florez	Americo	Universidad de Atacama	americo.cuchillo@uda.cl
Dai	Yingying	Institute of Metal Research,CAS	yydai11b@imr.ac.cn
Dash	Saroj	Chalmers University of Technology	saroj.dash@chalmers.se
Davydova	Margarita	MIT	luthien@mit.edu
DE TERESA	JOSE MARIA	CSIC-UNIVERSITY OF ZARAGOZA (SPAIN)	deteresa@unizar.es
Dejene	Fasil	Loughborough University	f.dejene@lboro.ac.uk
Dhanasekhar	C	IIT Bombay	dsekhar21@iitb.ac.in
DÌaz	Sebastian	University of Basel	s.diaz@unibas.ch
dos Santos	Raimundo	Universidade Federal do Rio de Janeiro	rrds@if.ufrj.br
dutta	tanmay	Empa (Swiss Federal Laboratories for Materials Sc)	tanmay.dutta@u.nus.edu

Surname	Name	Affiliation	Email
Eaton	Alex	University of Cambridge	age28@cam.ac.uk
Ebrahimian	Ali	Institute for Research in Foundamental Sciences	aliebrahimian@ipm.ir
Entin-Wohlman	Ora	Tel Aviv University	orawohlman@gmail.com
Eremin	Ilya	Ruhr-University Bochum	Ilya.Eremin@rub.de
Eremin	Ilya	Ruhr-University Bochum	Ilya.Eremin@rub.de
Esteras	Dorye	University of Valencia	doescor@uv.es
Everett	Nathan	University of California, Irvine	everettn@uci.edu
fang	yawen	cornell university	yf257@cornell.edu
Fasano	Yanina	Instituto Balseiro, Bariloche, Argentina	yanina.fasano@gmail.com
FAVIERES	CRISTINA	LABORATORY OF MAGNETISM. PUBLIC UNIVERSITY NAVARRE	favieresc@unavarra.es
Fedotov	Alexander	Belarusian State University	fedotov@bsu.by
Feiguin	Adrian	Northeastern University	a.feiguin@northeastern.edu
Felsch	Wolfgang	Universit‰t Gˆttingen, I.Physikalisches Institut	wfelsch@gwdg.de
Fermin	Remko	Universiteit Leiden	fermin@physics.leidenuniv.nl
Fumega	Adolfo	Universidade de Santiago de Compostela	adolfo.otero.fumega@usc.es
Gallego	Silvia	Materials Science Institute of Madrid, CSIC	sgallego@icmm.csic.es
Ganguli	Somesh	Aalto University	somesh.ganguli@aalto.fi
Garcia	Carlos	Universidad Tecnica Federico Santa Maria	carlos.garcia@usm.cl

Surname	Name	Affiliation	Email
Garcia Flores	Ali Francisco	Universidade de Campinas	agarcia@ifi.unicamp.br
Gareeva	Zukhra	Institute of Molecule and Crystal Physics	zukhragzv@yandex.ru
Ghosh	Sayak	Cornell University	sg2235@cornell.edu
Gliga	Sebastian	Paul Scherrer Institute	sebastian.gliga@psi.ch
Goebel	Boerge	Martin-Luther-Universität Halle-Wittenberg	boerge.goebel@physik.uni-halle.de
Goetze	Kathrin	University of Warwick	k.gotze@warwick.ac.uk
Goh	Swee K.	The Chinese University of Hong Kong	skgoh@cuhk.edu.hk
Gonz·lez-Orellana	Carmen	Materials Physics Center (CSIC-UPV/EHU)	cgonzalez094@ikasle.ehu.eus
Gorgon	Sebastian	University of Cambridge	sg911@cam.ac.uk
Gupta	Reena	University of Jyv‰skyl‰	reena.r.gupta@jyu.fi
Harms	Joren	Utrecht University	j.s.harms@uu.nl
Haygood	Ian	NIST	ian.haygood@nist.gov
Heinrich	Benjamin	Nature Nanotechnology (Springer Nature)	benjamin.heinrich@nature.com
Herrera Vasco	Edwin	Universidad AutÛnoma de Madrid	edwinherrera24@gmail.com
Hollister	Patrick	Cornell University	pmh74@cornell.edu
Hope	Marius	NTNU Trondheim	mariuskh@stud.ntnu.no
Huang	Xin	Aalto University	xin.huang@aalto.fi
Ikegaya	Satoshi	Max Planck Institute for Solid State Research	S.Ikegaya@fkf.mpg.de

Surname	Name	Affiliation	Email
Ilyn	Maxim	Centro de FÌsica de Materiales CSIC-UPV/ EHU	maxim_ilin@ehu.es
Jacobsen	Sol	Norwegian University of Science and Technology	sol.jacobsen@ntnu.no
Jamali	Shirin	SFSU	sjamali@sfsu.edu
Jara	Alejandro	Universidad Tecnica Federico Santa Maria	alejandro.jaraab@usm.cl
Jeon	Kun-Rok	Max Planck Institute of Microstructure Physics	krjeon@mpi-halle.mpg.de
Jiang	Hong-Chen	SLAC and Stanford University	hcjiang@stanford.edu
Jourdan	Martin	Johannes Gutenberg University Mainz	jourdan@uni-mainz.de
Kaczorowski	Dariusz	Inst. Low Temp. Struct. Res. PAS	d.kaczorowski@intibs.pl
Kamba	Stanislav	Institute of Physics, Czech Academy of Sciences	kamba@fzu.cz
Kamboj	Varun	University of Cambridge	vk302@cam.ac.uk
Karapetrov	Goran	Drexel University	goran@drexel.edu
Karwacki	Lukasz	Utrecht University	l.karwacki@uu.nl
Kato	Takemi	Tohoku University	t.kato@arpes.phys.tohoku.ac.jp
Kavand	Marzieh	Ohio State University	kavand.1@osu.edu
Kaverzin	Alexey	University of Groningen	a.kaverzin@rug.nl
Kawmoto	Yo	Tohoku University	kawamoto.yo@imr.tohoku.ac.jp
Keren	Amit	Technion Israel Institute of Technology	phkeren@technion.ac.il
Khomskii	Daniel	Cologne University	khomskii@ph2.uni-koeln.de

Surname	**Name**	**Affiliation**	**Email**
Kimel	Alexey	Radboud University	aleksei.kimel@ru.nl
Komori	Sachio	University of Cambridge	sk891@cam.ac.uk
Kondovych	Svitlana	Life Chemicals Inc	svitlana.kondovych@gmail.com
Konstantinou	Konstantinos	University of Cambridge	kk688@cam.ac.uk
Koskelo	EliseAnne	University of Cambridge	eck34@cam.ac.uk
Krasnikova	Yulia	P.L.Kapitza Institute	krasnikovamipt@gmail.com
Krivoruchko	Vladimir	Donetsk Institute for Physics and Engineering NAS	krivoruc@gmail.com
Kubicki	Dominik	University of Cambridge	djk47@cam.ac.uk
KUMAR	SUDHANSH U	University of Delhi, Delhi, India	sudhanshu24july@gmail.com
Kuznetsov	Andrey	Institute of Metal Physics UB RAS	a_kuznetsov@imp.uran.ru
Lam	Michelle	University College London	zcapmml@ucl.ac.uk
Lamic	Baptiste	CEA/DRF/IRIG/ DEPHY/PHELIQS/GT	baptiste.lamic@cea.fr
Lechermann	Frank	European XFEL	frank.lechermann@xfel.eu
Lee	Kyung-Jin	Korea Advanced Institute of Science and Technology	kjlee@kaist.ac.kr
Leijnse	Martin	Lund University	martin.leijnse@ftf.lth.se
Li	Danfeng	City University of Hong Kong	danfeng.li@cityu.edu.hk
Li	Lu	University of Michigan	luli@umich.edu
Li	Yangmu	Brookhaven National Laboratory	yangmuli@bnl.gov

Surname	Name	Affiliation	Email
Liebmann	Marcus	RWTH Aachen University	liebmann@physik.rwth-aachen.de
Liu	Tianhan	Florida State University	tl14b@my.fsu.edu
Locatelli	Lorenzo	CNR-IMM-Agrate - MB - University of Milano Bicocca	lorenzo.locatelli@mdm.imm.cnr.it
Lorenzana	JosÈ	ISC-CNR and Sapienza, Rome	jose.lorenzana@cnr.it
Lounis	Samir	Forschungszentrum Juelich	s.lounis@fz-juelich.de
Lu	Yao	University of Jyvaskyla	yao.y.lu@jyu.fi
Ludwig	Tim	Utrecht University	t.ludwig@uu.nl
Lustikova	Jana	Tohoku University	lustikova@tohoku.ac.jp
Lynn	Jeffrey	NIST Center for Neutron Research	jeffrey.lynn@nist.gov
Magalhaes	Sergio	Universidade Federal do Rio Grande do Sul	sgmagal@gmail.com
Maiani	Andrea	Copenhagen University, Niels Bohr Institute	andrea.maiani@nbi.ku.dk
Mangin	Stephane	UniversitÈ de Lorraine	stephane.mangin@univ-lorraine.fr
Mangin	StÈphane	UniversitÈ de Lorraine	stephane.mangin@univ-lorraine.fr
Mantovan	Roberto	CNR-IMM Unit of Agrate Brianza	roberto.mantovan@mdm.imm.cnr.it
Marino	Jamir	Uni Mainz	jamirmarino@gmail.com
Markovic	Igor	University of St Andrews	im79@st-andrews.ac.uk
Mazanik	Andrew	BLTP, JINR - Dubna, Moscow Region, 141980, Russia	mazanik@theor.jinr.ru
Mendez	Juan Felipe	Cornell University	jfm343@cornell.edu

Surname	Name	Affiliation	Email
Menghini	Mariela	IMDEA Nanociencia	mariela.menghini@imdea.org
Mertelj	Tomaz	Jozef Stefan Institute, Ljubljana, Slovenia	tomaz.mertelj@ijs.si
Milla Robles	Tony Wenceslao	National University of San Marcos	particlephysics891@gmail.com
Mishra	Durgamadha b	Indian Institute of Technology	durgamadhab@iitj.ac.in
Mishra	Kshiti	Radboud University	K.Mishra@science.ru.nl
MORGAN	GRACE	University College Dublin	grace.morgan@ucd.ie
Morgenstern	Markus	RWTH Aachen University	mmorgens@physik.rwth-aachen.de
Narang	Deepa S	Indian Institute of Science,Bangalore,Ind ia	deepasn@iisc.ac.in
Nayak	Swagatam	IISER Mohali, Punjab, India	swagtamnayak@iisermohali.ac.in
Nembach	Hans	NIST	hans.nembach@nist.gov
Ning	Shanglong	University of Cambridge	sn538@cam.ac.uk
Nothhelfer	Jonas	Johannes Gutenberg-Universit‰t Mainz	jnothhel@uni-mainz.de
Ochoa	Hector	Columbia University	ho2273@columbia.edu
Ojeda Collado	Hector Pablo	Bariloche Atomic Centre & Balseiro Institute	hpablo1988@gmail.com
PAL	RIJU	SNBNCBS	rijupal07@bose.res.in
Parkin	Stuart	MPI microstructure physics	stuart.parkin@mpi-halle.mpg.de
Patade	Supriya	Dept of Physics, dr. B A M U Aurangabad	patadesupriya227@gmail.com
Patil	Sourabh	University of Konstanz, IISER Pune	patil.sourabh@students.iiserpune.ac.in

Surname	Name	Affiliation	Email
Paul	Tania	MagTop, IFPAN, Warsaw, Poland	tpaul@magtop.ifpan.edu.pl
PAYATTUVA LAPPIL	ABHIJITH	COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY	abhijithpv@cusat.ac.in
Penteado	Poliana	Infis/UFU	polianahp@ufu.br
Pereg-Barnea	Tami	McGill university	tamipb@physics.mcgill.ca
PERRIN	Vivien	LPS,UniversitÈ Paris-Saclay	vivien.perrin@universite-paris-saclay.fr
Pershoguba	Sergey	University of New Hampshire	sergii.pershoguba@unh.edu
Pestka	Benjamin	RWTH AACHEN	benjamin.pestka@rwth-aachen.de
Plakida	Nikolay	Joint Institute for Nuclear Research	plakida@theor.jinr.ru
PLATUNOV	Mikhail	Kirensky Institute of Physics, Federal Research Ce	ms-platunov@yandex.ru
Poddar	Pankaj	CSIR-National Chemical Laboratory	ppoddar@gmail.com
Qaiumzadeh	Alireza	QuSpin, NTNU	alireza.qaiumzadeh@ntnu.no
QIXIAN	LIAO	Tohoku University	liao.qixian.t4@dc.tohoku.ac.jp
Radulov	Iliya	TU Darmstadt	iliya_angelov.radulov@tu-darmstadt.de
Reitz	Derek	University of California, Los Angeles	dreitz@physics.ucla.edu
REPCHENKO	YURIY	NRC Kurchatov institute	kent160@mail.ru
Ribeiro	Pedro	Instituto Superior TÈcnico, Universidade de Lisboa	ribeiro.pedro@tecnico.ulisboa.pt
Rodway-Gant	Gilles	University of Cambridge	gflr2@cam.ac.uk
Rogero	Celia	Materials Physics Center	celia.rogero@ehu.eus

Surname	Name	Affiliation	Email
Sabonis	Deividas	University of Copenhagen	deividas@nbi.ku.dk
Sacksteder	Vincent	Rutgers University, Royal Holloway U of London	vincent@sacksteder.com
Salamone	Tancredi	Norwegian University of Science and Technology	tancredi.salamone@ntnu.no
Sandler	Nancy	Ohio University	sandler@ohio.edu
Sapkota	Aashish	Brookhaven National Laboratory	aashish.sapkota.sap@gmail.com
Schneider	Michael	NIST	michael.schneider@nist.gov
Schulz	Ferdinand	Universit‰t Basel	ferdinand.schulz@unibas.ch
Scott	Cameron	University of Birmingham	CXS792@student.bham.ac.uk
Senz	Stephan	MPI-MSP	senz@mpi-halle.mpg.de
Seoane Souto	RubÈn	Lund University / University of Copenhagen	ruben.seoane_souto@ftf.lth.se
Shan	Guangcun	Beihang University	gcshan@buaa.edu.cn
Sharma	Priya	Royal Holloway University of London	priya.sharma@rhul.ac.uk
Shawulienu	Kezilebieke	Aalto university	kezilebieke.shawulienu@aalto.fi
Shklovskij	Valerij	V.N.Karazin Kharkiv National State University,	shklovskij@univer.kharkov.ua
Shukrinov	Yury	BLTP, JINR, Dubna	shukrinv@theor.jinr.ru
Siemann	Gesa	University of St Andrews	grs6@st-andrews.ac.uk
Sikora	Marcin	AGH University, Krakow, Poland	marcin.sikora@agh.edu.pl
SIMON	Pascal	University Paris Saclay	pascal.simon@u-psud.fr

Surname	Name	Affiliation	Email
Singh	Jitendra	Pohang Accelerator Laboratory Pohang	jitendra_singh2029@rediffmail.com
Singh	Durgesh	Department of PHYSICS, IIT BOMBAY, MUMBAI INDIA	durgeshcsr@gmail.com
Singh Roy	Monalisa	S. N. Bose National Centre for Basic Sciences	monalisa12i@bose.res.in
Somvanshi	Sandeep	Dr. Babasaheb Ambedkar Marathwada University	physics.sbs@bamu.ac.in
Stefanski	Piotr	Institute of Molecular Physics, PAS Poland	piotrs@ifmpan.poznan.pl
Stewart	Rhea	The ETH Zurich and The Paul Scherrer Institut	rhea.stewart@psi.ch
Stremoukhov	Pavel	Radboud University	pavel.stremoukhov@ru.nl
Studer	Andrew	Australian Centre for Neutron Scattering, ANSTO	ajostuder@gmail.com
Su	Xintong	University of Cambridge	xs285@cam.ac.uk
Sukhachov	Pavlo	Yale University	pavlo.sukhachov@yale.edu
Sukhachov	Pavlo	Yale University	pavlo.sukhachov@yale.edu
Takano	Yasu	University of Florida	takano@phys.ufl.edu
Tang	Yifei	Tohoku University, Institute for materials researc	tangyifei@imr.tohoku.ac.jp
Tangoulis	Vassilis	Department of Chemistry, University of Patras, GR	vtango@upatras.gr
Tanhayi Ahari	Mostafa	UCLA	mtanhayi@physics.ucla.edu
Tarazona	Heisemberg	Universidad Nacional Mayor de San Marcos	heisemberg.tarazona@unmsm.edu.pe
Tassi	Camillo	University of Jyv‰skyl‰	camillo.c.tassi@jyu.fi
Terrazas Palomino	Angel	National University of San Marcos	angel.terrazas@unmsm.edu.pe

Surname	Name	Affiliation	Email
Theuss	Florian	Cornell University	ft226@cornell.edu
Tian	Yefan	Texas A&M University	yftian@exchange.tamu.edu
Tjhe	Dionisius Hardjo Lukito	Cavendish Laboratory	dhlt2@cam.ac.uk
Torsello	Daniele	Politecnico di Torino	daniele.torsello@polito.it
Tranquada	John	Brookhaven National Lab	jtran@bnl.gov
Treimer	Wolfgang	Beuth Hochschule f¸r Technik Berlin	treimer@beuth-hochschule.de
Trif	Mircea	Institute of Physics, Polish Academy of Sciences	mtrif@magtop.ifpan.edu.pl
Troncoso	Roberto	Norwegian University of Science and Technology	r.troncoso@ntnu.no
Troncoso	Roberto	Norwegian University of Science and Technology	r.troncoso@ntnu.no
Uldemolins	Mateo	UniversitÈ Paris-Saclay	mateo.uldemolins-nivela@universite-paris-saclay.fr
Ulloa	Sergio	Univ of Copenhagen / DTU	ulloa@ohio.edu
Un	Hio-Ieng	University of Cambridge	hiu20@cam.ac.uk
Vadimov	Vasilii	Aalto University	vasilii.1.vadimov@aalto.fi
Vakhtel	Tess	Leiden University, TU Delft	vakhtel@lorentz.leidenuniv.nl
Valletta	Antonio	CNR - IMM	antonio.valletta@cnr.it
Vasyuchka	Vitaliy	Technische Universit‰t Kaiserslautern	vasyuchka@physik.uni-kl.de
VEKHTER	ILYA	Louisiana State University	vekhter@lsu.edu
Vera-Marun	Ivan	The University of Manchester	ivan.veramarun@manchester.ac.uk

Surname	Name	Affiliation	Email
Virtanen	Pauli	University of Jyv‰skyl‰	pauli.t.virtanen@jyu.fi
Vlaminck	Vincent	Institut Mines Telecom Atlantique	vincent.vlaminck@imt-atlantique.fr
Wagner	Tobias	Johannes Gutenberg-University Mainz	twagner@students.uni-mainz.de
Wagner	Julian	Universit‰t zu Kˆln	wagner@ph2.uni-koeln.de
Walia	Rajan	Deen Dayal Upadhyaya Gorakhpur University Gorakhpu	rajanw@gmail.com
Wang	Tiffany	Stanford University	catwang@stanford.edu
Wiesendanger	Roland	University of Hamburg	wiesendanger@physnet.uni-hamburg.de
Wrzesniewski	Kacper	Adam Mickiewicz University, Faculty of Physics	wrzesniewski@amu.edu.pl
wu	shangfei	Rutgers University	sw666@physics.rutgers.edu
Wuhrer	Dennis	University of Konstanz	dennis.wuhrer@uni-konstanz.de
Wysokinski	Karol Izydor	M. Curie-Sklodowska University	karol.wysokinski@poczta.umcs.lublin.pl
Xie	Yonglong	Harvard	yxie1@g.harvard.edu
Xiong	Peng	Florida State University	pxiong@fsu.edu
yang	TENG	Institute of metal research	yangteng@imr.ac.cn
Yokoyama	Takehito	Tokyo Institute of Technology	yokoyama@stat.phys.titech.ac.jp
Yoon	Ju-Young	Tohoku university	juyoung@riec.tohoku.ac.jp
Yudson	Vladimir	Phys. Dept., Higher School of Economics	vyudson@hse.ru
Zaliznyak	Igor	Brookhaven National Laboratory	zaliznyak@bnl.gov

Surname	**Name**	**Affiliation**	**Email**
Zhang	Shu	University of California, Los Angeles	suzy@physics.ucla.edu
Zhang	Xixiang	King Abdullah Universityof Science & Technology	Xixiang.zhang@kaust.edu.sa
Zhuo	Fengjun	King Abdullah University of Science and Technology	fengjun.zhuo@kaust.edu.sa
Zou	Ji	UCLA	jzeeb@ucla.edu
Dwivedi	Sudhanshu	S.S. Jain Subodh P.G. (Autonomous) College, India	sudhanshu.dwivedi@gmail.com
GAUR	UMESH KUMAR	IPR GANDHINAGAR INDIA	umesh.gaur@ipr.res.in
RESHI	HILAL AHMAD	Department of physics, Govt. Degree College Kulgam	hilal.phy@gmail.com
Seshadri	Ranjani	Ben Gurion University	ranjani.physics@gmail.com
Skryabina	Olga	ISSP RAS Chernogolovka and MIPT Dolgoprudny	oskrya@mail.com
Tengdin	Phoebe	EPFL	phoebe.tengdin@epfl.ch
Vianez	Pedro	University of Cambridge	pmtv2@cam.ac.uk
Virtanen	Pauli	University of Jyv‰skyl‰	pauli.t.virtanen@jyu.fi