Institute of Spintronics and Quantum Information
Faculty of Physics and Astronomy
Adam Mickiewicz University, Poznań

Symposium on Spintronics and Quantum Information 2025

Book of Abstracts

The Będlewo Palace
Research and Conference Centre of the Polish Academy of Sciences
April 24-26, 2025

Symposium Venue

The Symposium on Spintronics and Quantum Information will take place at the Palace in Będlewo – Research and Conference Centre of the Polish Academy of Sciences (www.palacbedlewo.pl/en/).

About Symposium

The Symposium is organized by the Institute of Spintronics and Quantum Information (ISQI) at the Faculty of Physics and Astronomy, Adam Mickiewicz University in Poznań. Since its establishment on January 1, 2021, ISQI has held annual symposia covering a broad range of topics in condensed matter physics and quantum information.

The first Symposium took place on October 21–23, 2021, at the Faculty of Physics of AMU in Poznań and was accompanied by the official inauguration of the Institute. The second Symposium was also held at the Faculty, on December 8–9, 2022. The third edition, held on January 11–13, 2024, took place for the first time outside the Faculty premises—at the Palace in Będlewo.

This year, the Organizing Committee has decided to hold the fourth Symposium once again at the Palace in Będlewo, but this time in the spring—from April 24–26—anticipating that the natural surroundings will enhance the Symposium's atmosphere.

The aim of the Symposium is to provide a platform for the presentation and discussion of novel scientific ideas at the intersection of the fields of quantum information and condensed matter physics, including among others:

- Spintronics and molecular magnetism,
- Magnonics, spin waves and magnonic crystals,
- Quantum information and quantum physics,
- Quantum optics, cavity and circuit QED,
- Strongly correlated systems,
- Quantum simulators and quantum matter,
- Nonlinear dynamics,
- Topological states of matter,
- Quantum transport in low-dimensional systems,
- 2D materials and spin-orbit phenomena,
- Bound states in superconductors.

The Symposium brings together young scientists, their supervisors and senior colleagues from ISQI, along with collaborators from research teams across Poland and abroad. While it serves as a platform for presenting the latest research developments at the Institute, the event goes beyond mere reporting—it fosters scientific exchange and actively promotes the establishment of new collaborations with research institutions, scientific groups, and independent researchers.

More information can be found on the conference webpage: https://symposium-isqi.amu.edu.pl/.

Organizing Committee:

- Karol Bartkiewicz
- Anna Dyrdał,
- Konrad J. Kapcia,
- Jarosław W. Kłos (director of ISQI),
- Aleksandra Trzaskowska,
- Ireneusz Weymann (dean of the Faculty).

Local Committee:

- Kacper Wrześniewski,
- Mateusz Zelent.

Invited speakers

Jan Barański
Polish Air Force University
Transient effects in quantum-dot-superconductor hybrids

Andrzej Janutka
Wrocław University of Science and Technology
Micromagnetic study of response of supermagnetic systems to high-frequency field

Marcin Karczewski
Adam Mickiewicz University
Particle indistinguishability in quantum information

Jan Kisielewski
University of Bialystok
Spin wave freezing in magnetic multilayers

Piotr Kozłowski
Adam Mickiewicz University
Mixed-valent polyoxovanadate cage V_{12} in electric field

Antonio Mandarino
University of Gdansk
Addressing quantum systems with machine learning and simulations

Anna Musiał
Wrocław University of Science and Technology
InP-based material platform for non-classical light sources for quantum cryptography and quantum communication applications

Tomasz Toliński
Institute of Molecular Physics PAS
Magnetic interactions, critical exponents, and magnetic polarons in the topological semimetals candidates $EuIn_2X_2$ $(X = As, P)$

Piotr Trocha
Adam Mickiewicz University
Thermoelectric properties of a quantum dot hybrid with topological material

Beata Ziaja-Motyka
Deutsches Elektronen Synchrotron
Modeling of ultrafast X-ray induced magnetization dynamics in magnetic materials

Schedule

	April 24 Thursday	April 25 Friday	April 26 Saturday
8:00 - 9:00		Breakfast	Breakfast
9:00 - 10:35		Scientific session 3	Scientific session 7
9:00 - 9:35		Anna Musiał	Andrzej Janutka
9:35 - 9:50		Przemysław Chełminiak	Konrad J. Kapcia
9:50 - 10:05		Krzysztof Sobucki	Mateusz Zelent
10:05 - 10:20		Emil Siuda	Ivan Davydenko
10:20 - 10:35		Błażej Szablikowski	Checking out
10:35 - 11:20		Coffee break	Coffee break
11:20 - 12:55		Scientific session 4	Scientific session 8
11:20 - 11:55		Piotr Kozlowski	Piotr Trocha
11:55 - 12:10	Registration	Bivas Rana	Aleksey Alekseev
12:10 - 12:25		Jan Wójcik	Armuta Achutchan
12:25 - 12:40		Sara Memarzadeh	Maciej Krawczyk
12:40 - 12:55		Lorenzo Bagnasacco	Symposium closing
12:55 - 13:10		Conference photo	Transfer to Poznań
13:10 - 14:15		Lunch	
14:15 - 14:30	Symposium opening		
14:30 - 16:10	Scientific session 1	Scientific session 5	
14:30 - 15:05	Beata Ziaja-Motyka	Marcin Karczewski	
15:05 - 15:20	Ireneusz Weymann	Paweł Sobieszczyk	
15:20 - 15:35	Gabriel D. Chaves - O'Flynn	Jędrzej Stempin	
15:35 - 16:10	Jan Kisielewski	Tomasz Toliński	
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16:55 - 17:30	Jan Barański	Antonio Mandarino	
17:30 - 17:45	Krzysztof Szulc	Jarosław W. Kłos	
17:45 - 18:00	Tomasz Polak	Yeimer Zambrano	
18:00 - 18:15	Liubov Ivzhenko	Nikodem Leśniewski	
18:15 - 19:15	Dinner	Poster session	
19:15 - 19:45		Banquet	
19:45 - 20:45			

Thursday, April 24		
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14:15 – 14:30	**OPENING** Jarosław W. Kłos, Director of Institute of Spintronics and Quantum Information, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań	
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14:30 – 15:05	**Invited:** *Modeling of ultrafast X-ray induced magnetization dynamics in magnetic materials* Beata Ziaja-Motyka	25
15:05 – 15:20	*Super-Exchange in a Ferromagnet-Double Quantum Dot System* Ireneusz Weymann	49
15:20 – 15:35	*Steps towards continous modelling of quasi-amorphous ferrimagnetic and sperimagnetic alloys using finite difference algorithms* Gabriel David Chaves-O'Flynn	31
15:35 – 16:10	**Invited:** *Spin wave freezing in magnetic multilayers* Jan Kisielewski	19
16:10 – 16:55	*Coffee break*	
	SCIENTIFIC SESSION 2 Chair: Ireneusz Weymann	
16:55 – 17:30	**Invited:** *Transient effects in quantum-dot-superconductor hybrids* Jan Barański	16
17:30 – 17:45	*Spin-wave transmission through a hybrid magnonic crystal based on vortices in disks* Krzysztof Szulc	47
17:45 – 18:00	*Differentiating between interaction-based and imaginary time-based bosonic pairing mechanisms* Tomasz Polak	40
18:00 – 18:15	*Microwave planar antenna based on an inverse spit ring resonator for excitation and amplification surface spin waves in nanoscae magnonic circuits* Liubov Ivzhenko	34
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9:35 – 9:50	*Rigorous results for mean first-passage time of harmonically trapped particle* Przemysław Chełminiak	32
9:50 – 10:05	*Spin wave amplification in time-varying media* Krzysztof Sobucki	44
10:05 – 10:20	*Influence of the competition between Nagaoka ferromagnetism and superconducting pairing on Andreev current in hybrid quantum dots* Emil Siuda	42
10:20 – 10:35	*Nonautonomous finite-dimensional restrictions of KdV hierarchy.* Błażej Szablikowski	46
10:35 – 11:20	*Coffee break*	
	SCIENTIFIC SESSION 4 Chair: Konrad J. Kapcia	
11:20 – 11:55	**Invited:** *Mixed-valent polyoxovanadate cage V_{12} in electric field* Piotr Kozłowski	20
11:55 – 12:10	*Tailoring interfacial properties in magnetic thin film heterostructures by interface engineering* Bivas Rana	41
12:10 – 12:25	*Topological phenomena in quantum walks* Jan Wójcik	50
12:25 – 12:40	*Nucleation and Arrangement of Abrikosov Vortices in Hybrid Superconductor-Ferromagnetic Nanostructure* Sara Memarzadeh	39
12:40 – 12:55	*Emerging holonomy in electron spin scattering* Lorenzo Bagnasacco	30
12:55 – 13:10	*Conference photo*	
13:10 – 14:30	*Lunch*	
	SCIENTIFIC SESSION 5 Chair: Przemysław Chełminiak	
14:30 – 15:05	**Invited:** *Particle indistinguishability in quantum information* Marcin Karczewski	18
15:05 – 15:20	*Tuning the topological magnon gap in van der Waals CrI_3 monolayer* Paweł Sobieszczyk	43

Time	Event	Page
15:20 – 15:35	*Quantum Synchronizing Words* Jędrzej Stempin	45
15:35 – 16:10	**Invited:** *Magnetic interactions, critical exponents, and magnetic polarons in the topological semimetals candidates* $EuIn_2X_2$ $(X = As, P)$ Tomasz Toliński	23
16:10 – 16:55	*Coffee break*	
	SCIENTIFIC SESSION 6 Chair: Karol Bartkiewicz	
16:55 – 17:30	**Invited:** *Addressing quantum systems with machine learning and simulations* Antonio Mandarino	21
17:30 – 17:45	*Stabilization of skyrmion in hybrid magnetic-superconducting nanostucture* Jarosław W. Kłos	36
17:45 – 18:00	*The Interplay of Confinement and Nearest Neighbor Interaction in Z2 Lattice Gauge Models* Yeimer Zambrano	51
18:00 – 18:15	*Extraordinary dynamics of softened spin waves in films with perpendicular magnetic anisotropy* Nikodem Leśniewski	38
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9:00 – 9:35	**Invited:** *Micromagnetic study of response of supermagnetic systems to high-frequency field* Andrzej Janutka	17
9:35 – 9:50	*Ab initio study of static and dynamical stability of trigonal, orthorombic and tetragonal phases of $Cs_4Pb_2Br_6$ under pressure* Konrad J. Kapcia	35
9:50 – 10:05	*Multistable Skyrmions: Enhanced Stability of Skyrmions by the Magnetostatic Field of Ferromagnetic Rings* Mateusz Zelent	52
10:05 – 10:20	*Investigation of the dissipation-driven acceleration of the entanglement generation in the vicinity of exceptional points* Ivan Davydenko	33
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10:35 – 11:20	*Coffee break*	
	SCIENTIFIC SESSION 8 Chair: Bivas Rana	
11:20 – 11:55	**Invited:** *Thermoelectric properties of a quantum dot hybrid with topological material* Piotr Trocha	24
11:55 – 12:10	*Extended Hubbard model of triangular lattice with charge order: mean-field solution with arbitrary charge density* Aleksey Alekseev	29
12:10 – 12:25	*Effect of CoFeB layer thickness on elastic properties in CoFeB/Au heterostructures - possibility of modification SAW dispersion* Amrutha Achuthan	28
12:25 – 12:40	*Thin film based magnonic crystals with reciprocal or nonreciprocal dispersion relation and their relation to glide symmetry* Maciej Krawczyk	37
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after 12:55	**TRANSFER TO POZNAŃ**	

Abstracts

Invited speakers

TRANSIENT EFFECTS IN QUANTUM-DOT-SUPERCONDUCTOR HYBRIDS

Jan Barański[1]

[1] *Department of General Education, Polish Air Force University, ul. Dywizjonu 303 nr 35, 08521 Dęblin, Poland*

A theoretical analysis of transient phenomena in nanoscopic quantum-dot (QD) systems coupled to superconductors (SC) will be presented, focusing on electron dynamics influenced by local pairing. The discussion will be centered on three distinct setups: (i) a T-shaped double quantum dot coupled between metallic and superconducting leads, (ii) a quantum dot hybridized with a topological superconducting nanowire, and (iii) a serial double quantum dot junction (N-QD1-QD2-S) subject to Zeeman splitting. For the T-shaped geometry, characteristic timescales associated with electron transfer processes, the emergence of quantum interference, and the formation of local electron pairs will be analyzed. The interference times will be compared in cases where quantum coherence is affected by local pairing. In the second setup, the time required for a Majorana quasiparticle to dynamically leak into an adjacent quantum dot will be estimated. Additionally, a feasible experimental protocol for detecting this phenomenon via time-resolved Andreev tunneling spectroscopy will be proposed. Finally, transient signatures of the Andreev blockade in a serial DQD system, where transport is suppressed due to spin-triplet states induced by Zeeman splitting, will be investigated. The buildup and decay times of the blockade under different initial conditions and external biases will be analyzed, and characteristic timescales governing these processes will be determined. Time- and energy-scale estimations will be confronted with experimentally available realizations, using typical hybridization strengths.

MICROMAGNETIC STUDY OF RESPONSE OF SUPERMAGNETIC SYSTEMS TO HIGH-FREQUENCY FIELD

Andrzej Janutka[1]

[1] *Wrocław University of Science and Technology, Dept. of Theoretical Physics, 50-370 Wrocław, Poland*

Providing an overview of high-frequency applications of nanoparticle based materials and media, we talk over results of our study of dynamical magnetic response of structural composites of magnetic nanoparticles (MNPs) embedded in dielectric matrices to high-frequency sub-GHz and GHz field. MNP based composites can offer highly reduced electrical conductivity at strong magnetic response which is significantly modified by dipolar interparticle interactions relative to the response of a single particle. We perform micromagnetic simulations of the dynamical response of arrays of spherical and flat cylindrical MNPs of strong crystalline magnetic anisotropy and of very low diameters in the presence of thermal fluctuations, going beyond the single-domain approximation for MNP magnetization [1]. Magnetostatic interactions of MNPs are found to be crucial for stabilizing the collective high-frequency dynamics. On the other hand, there is a limit diameter of (single-domain in statics) MNPs, above which undesirable effect of the dynamical hysteresis (thus hysteresis lose) appears. A bias magnetic field is found to additionally counteract the thermal instability of the dynamical response of the arrays of MNPs. The magnetic response to extremely high frequency (sub-THz) field of an array of antiferromagnetic particles was also simulated and its strength is compared to the response of the ferromagnetic particles at a certainly reduced frequency [2]. Finally, we discuss additional inertia effects on the magnetic response of ferromagnetic nanoparticles which can be strong in sub-MHz and MHz regimes of frequencies, thus, making magnetization dynamics of magnetic fluids and gels specific among nanostructural magnetic systems.

References:

1 K. Brzuszek, C. A. Ross, and A. Janutka, J. Magn. Magn. Mat. 573, 170651 (2023), IEEE Trans. Magn. 59, 7100306 (2023), J. Magn. Magn. Mat. 599, 172070 (2024).

2 K. Brzuszek, C. A. Ross, and A. Janutka, AIP Adv. 14, 025222 (2024).

PARTICLE INDISTINGUISHABILITY IN QUANTUM INFORMATION

Marcin Karczewski[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

In this talk, I will briefly review selected applications of particle indistinguishability in quantum information. I hope to provide the necessary background to discuss open problems in the ongoing research aimed at characterizing indistinguishability as a genuine quantum resource.

References:

1 J. H. Selby, V. J. Wright, M. Farkas, M. Karczewski, A. B. Sainz, arXiv:2412.20963 [quant-ph], (2024).
2 S. Chin, Y. S. Kim, M. Karczewski, npj Quantum Inf. 10, 67 (2024).
3 P. Blasiak, M. Markiewicz, arXiv:2404.17339 [quant-ph], (2024).
4 M. Karczewski, D. Kaszlikowski, P. Kurzyński, Phys. Rev. Lett. 121, 090403 (2018).

SPIN WAVE FREEZING IN MAGNETIC MULTILAYERS

Jan Kisielewski[1], Sukanta Kumar Jena[2], Kilian Lenz[3], Artem Lynnyk[2], Ryszard Gieniusz[1], Andrzej Wawro[2], and Andrzej Maziewski[1]

[1] *Faculty of Physics, University of Bialystok, Bialystok, Poland *e-mail address: jankis@uwb.edu.pl*

[2] *Institute of Physics, Polish Academy of Sciences, Warsaw, Poland,*

[3] *Helmholtz-Zentrum Dresden-Rosendorf, Germany*

Dispersion relation f(k) between frequency f and wavenumber k describes the possible spin waves (SW) propagation in magnetic materials. In the Damon-Eshbach mode appearing in thin film systems, decreasing the phase and group velocity down to zero, $f = 0$ and $df/dk = 0$, reveals the conditions for SW freezing, when SW neither oscillate nor move [1]. This effect occurs under specific magnetic parameters, like magnetic anisotropy, film thickness, Dzyaloshinskii-Moriya interaction (DMI), as well as the amplitude of applied external in-plane magnetic field H. The SW freezing could be related to the spin reorientation transition (SRT), where the magnetization changes orientation between the homogeneous in-plane state and the out-of-plane state, with possible split into domain structure. The theory of SW freezing is universal, and expected to be applied in a large class of materials. As an example, the real system of (Re/Co/Pt)20 magnetic multilayers was studied. The presence of asymmetric interfaces introduces DMI. Different Co thicknesses were selected, to study samples with different values of magnetic anisotropy (with quality factor $Q > 1$ or $Q < 1$). The magnetization curves (measured by SQUID) with the in-plane applied magnetic field H reveal the saturation fields HS, where the samples reach the H-induced SRT. The same values of HS are also noticed in the H-dependent VNA-FMR experiment, when the character of collective magnetization oscillations (with k=0) is changed while increasing H, starting from multi-band mode typical for magnetic domains, to single-band mode for homogeneous magnetization state for H>HS. Micromagnetic simulations of dispersion relation (with full k-range) were performed, and their zero-wavenumber cross-sections agree well with the experimental VNA results. Below HS low and high frequency VNA signals are ascribed to magnetization excitations at different spin configurations within the domain structures. Around HS the simulated dispersion relations approaches the conditions for SW freezing ($f = 0$ and $df/dk = 0$). The experimental results of static and dynamic behavior, together with micromagnetic simulations, create an overall consistent picture of investigated multilayers.

Acknowledgements: *This work was supported by National Science Centre of Poland, Project No. 2020/37/B/ST5/02299.*

References:

1 J. Kisielewski et al., Phys. Rev. B 107, 134416 (2023).

MIXED-VALENT POLYOXOVANADATE CAGE V_{12} IN ELECTRIC FIELD

Piotr Kozłowski [1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Polyoxovanadates are known to form mixed valent compounds. In the sufficiently symmetric structures such property leads often to the simultaneous presence of localized and itinerant unpaired electrons in one molecule. Both types of unpaired electrons contribute to magnetic properties and the delocalized electrons make the molecule more susceptible to the external electric field.

In this contribution the magnetic properties of mixed valent molecules $[V_{12}As_8O_{40}(HCOO)]$-n (n=3,5) (V_{12}) with itinerant and localized electrons in electric and magnetic field are presented. The magnetic model is determined by means of the density functional theory (DFT) calculations and its parameters are obtained from the fit of the susceptibility curves and from electron paramagnetic resonance (EPR). The influence of electric field is then calculated by exact diagonalization of the resulting Hamiltonian and the effect of electric field screening is estimated by DFT.

It is demonstrated that one of the V_{12} molecules (n=3) is extremely sensitive to the orientation of the external electric field. For some orientations and sufficient intensity of the electric field the itinerant unpaired electrons become practically localized at particular vanadium ions. As the consequence the ground state of the molecule is changed, resulting in the variation of magnetic properties at low temperatures (below 70 K). For some other orientations no effect of electric field is observed. The magnetoelectric effect predicted in these molecules can be used to manipulate the total magnetic moment of the molecule in potential quantum computing applications. The anisotropy of this effect can be exploited e.g. in electric field sensors.

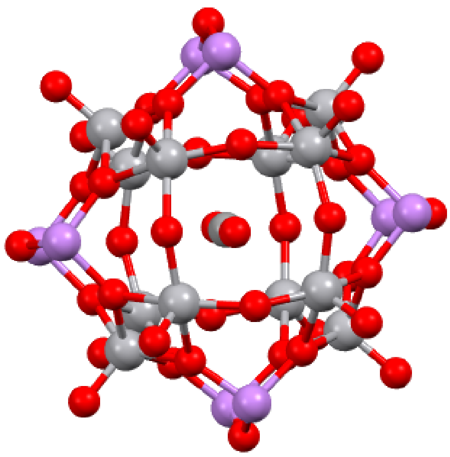

Fig. 1: V_{12} molecule. Color code: grey – V, red – O, violet – As, dark grey (the guest anion) - C

ADDRESSING QUANTUM SYSTEMS WITH MACHINE LEARNING AND SIMULATIONS

Antonio Mandarino[1]

[1] *ICTQT - University of Gdansk*

Machine learning, both classical and quantum, offers a powerful tool for studying critical quantum systems, enabling the analysis of non-analytically solvable models and their phase diagrams. To overcome the challenge of limited training labels in supervised approaches, we employ Physics-Informed Neural Networks (PINNs) in an unsupervised manner, applying them to the anharmonic oscillator and critical spin systems such as the axial next-nearest-neighbor Ising (ANNNI) model. The growing accessibility of quantum processing units (QPUs) has democratized scientific exploration, allowing experimental validation of theoretical predictions without dedicated quantum simulators. We leverage multi-purpose quantum hardware to study scaling laws in quantum-critical phenomena, particularly the defect density as a function of quench time, verifying the Kibble-Zurek mechanism (KZM) in finite-size systems. Our findings demonstrate that digital quantum processors can rival specialized analog simulators in studying criticality and thermalization, laying a foundation for future quantum simulation of complex many-body systems.

InP-BASED MATERIAL PLATFORM FOR NON-CLASSICAL LIGHT SOURCES FOR QUANTUM CRYPTOGRAPHY AND QUANTUM COMMUNICATION APPLICATIONS

Anna Musiał[1]

[1] *Laboratory for Optical Spectroscopyof Nanostructures, Department of Experimental Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland*

Sources of single and entangled photons are highly desirable for applications in quantum commu-nication, in particular quantum key distribution (BB84 or Eckert91 scheme with further modifications) and quantum repeater architectures. Additionally, for practical applications, emission in the III tele-communication window, is beneficial due to the lowest loss in transmission channel, in the case of both silica fibers and free-space. Further requirements include: high photon emission rate and extraction efficiency, on-demand photon generation, high quality of the emitted state, i.e. low probability of multiphoton events, high degree of indistinguishability and/or entanglement fidelity, compact plug and play portable designs, electrical excitation and room temperature operation as well as last, but not least high yield of deterministic fabrication of low cost. It seems that the best quantum emitters up to date, when it comes to quality of generated photon state, are semiconductor quantum dots (QDs), but com-bining all abovementioned properties might not be possible. Different material systems are considered for emission in the telecom C-band. In this contribution the InP-based ones will be reviewed.

InAs(P)/InP QDs can be grown via different epitaxial methods, e.g., molecular beam epitaxy [1,2], metalorganic chemical vapour deposition [3,4] and in different growth modes (among others Stranski-Krastanow and droplet epitaxy [5]) determining their structural and therefore, optical properties. They can be embedded in photonic structure to engineer the spontaneous emission rate and provide directional emission maximizing the amount of useable photons either by enhancing emission into the microcavity mode or inhibiting emission into radiating in-plane modes via dielectric screening effect. InAs(P)/InP QDs have proven emission in the telecom spectral range as well as high single-photon purity [6] and certain level of indistinguishability [7,8], as well as potential for generation of pairs of polarization entangled photons from biexciton-exciton cascade due to minimized fine structure splitting [9] which can be further externally fine-tuned. Operation temperature, increasing photon indistinguishability and extraction efficiency are on the list of remaining challenges.

References:

1 M. Yacob et al., Appl. Phys. Lett. 104, 22113 (2014).
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3 Y. Berdnikov et al., Sci. Reports 14, 23697 (2024).
4 P. Holewa et al., Phys. Rev. B 101, 195304 (2020).
5 P. Holewa et al., Nanophotonics 11, 1515 (2022).
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MAGNETIC INTERACTIONS, CRITICAL EXPONENTS, AND MAGNETIC POLARONS IN THE TOPOLOGICAL SEMIMETALS CANDIDATES $EuIn_2X_2$ (X = As, P)

Tomasz Toliński[1], Qurat U. Ain[1], Karol Synoradzki[1], T. Romanova[2], Karan Singh[2], Orest Pavlosiuk[2], Piotr Wiśniewski [2], and Dariusz. Kaczorowski [2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

[2] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wrocław, Poland*

The compounds $EuIn_2X_2$ (X = P, As) were theoretically predicted to host a variety of topological states depending on the type of magnetic order and crystallographic direction in their hexagonal unit cell. (space group $P6_3/mmc$) [1-3]. For highly anisotropic antiferromagnet $EuIn_2As_2$ (A-type magnetic structure, T_N = 16.1 K) either a higher-order topological insulator phase or an axion insulator phase were foreseen [1]. In turn, it was predicted that the non-collinear ferromagnet $EuIn_2P_2$ (T_C = 24 K) could harbor a Weyl state or a nodal-line Dirac state [4]. In this work, we performed comprehensive studies on the magnetic, magnetocaloric, and electrical transport properties of $EuIn_2P_2$ and $EuIn_2As_2$ with special focus on their anisotropic behaviour. Single crystals of both compounds were prepared by flux method. Within the critical region we employed modified Arrott plots, Kouvel-Fisher method, and magnetic field - scaled magnetocaloric effect analysis to discern the critical exponents. The results fall close to the tricritical mean-field model with some deviations, which can be attributed to the influence of topological states, disturbance by magnetic polarons, and/or magnetic fluctuations. The possible presence of magnetic polarons has been suggested previously for $EuIn_2As_2$ [5], and the case of $EuIn_2P_2$ appears to provide evidence of similar behaviour, which gives rise to the electrical transport governed by the variable-range hopping mechanism [3]. The applicability of the tricritical mean-field model seems to be justified by the presence of metamagnetic transitions in the magnetic phase diagrams of both systems. The influence of the topological states in $EuIn_2As_2$ is substantiated by the presence of finite gapping of the surface states, even in the region above T_N [6].

Acknowledgements: *This study was supported by the National Science Centre (Poland) under grant 2021/41/B/ST3/01141.*

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1 S. Regmi et al., Phys. Rev. B 102, 165153 (2020).
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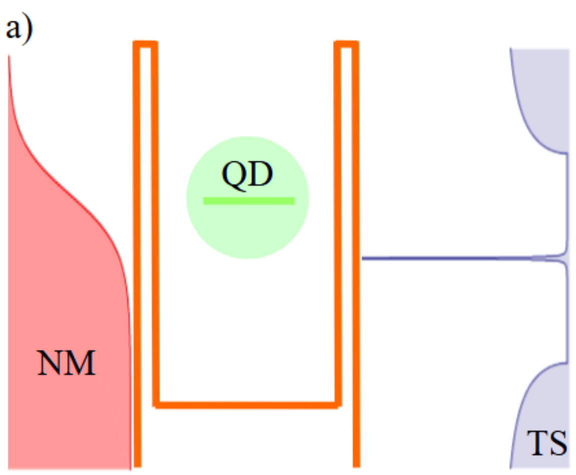
3 T. Toliński et al., Phys. Rev. B 110, 174425 (2024).
4 A. B. Sarkar et al., Phys. Rev. Mater. 6, 044204 (2022).
5 Y. Zhang et al., Phys. Rev. B 101, 205126 (2020),
6 M. Gong et al., Phys. Rev. B 106, 125156 (2022).

THERMOELECTRIC PROPERTIES OF A QUANTUM DOT HYBRID WITH TOPOLOGICAL MATERIAL

Piotr Trocha[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

The thermoelectric properties of a hybrid system consisting of a quantum dot coupled to a normal-metal lead and attached to (a) a topological superconductor wire [1,2] or (b) the surface states of a three-dimensional topological insulator [3] are investigated. These two systems are schematically shown in Fig. 1. In the first case (a), the topological superconductor wire is modelled by a spinless p-wave superconductor which hosts both a Majorana bound state at its extremity and above gap quasiparticle excitations. The main interest is to study the interplay of sub-gap and single-particle tunneling processes and their contributions to the thermoelectric response of the considered system. It is shown that the above gap tunneling driven by a temperature gradient is responsible for relatively large thermopower, whereas sub-gap processes only indirectly influence the thermoelectric response. The system's operation as a heat engine is also considered. The output power and corresponding efficiency are analyzed, revealing that under certain conditions, more power can be extracted in the superconducting phase than in the normal phase, with comparable efficiency. In the second structure (b), on the surface of a three-dimensional topological insulator, massless helical Dirac fermions emerge. The theoretical analysis of thermoelectric properties is conducted with a focus on the emergence of new effects. Additionally, these calculations include the renormalization effects resulting from the spin-dependent coupling of the quantum dot to the ferromagnetic lead, and their influence on the transport properties of the system is discussed. Furthermore, finite spin accumulation in the ferromagnetic electrode gives rise to spin thermoelectric effects, which are also presented.



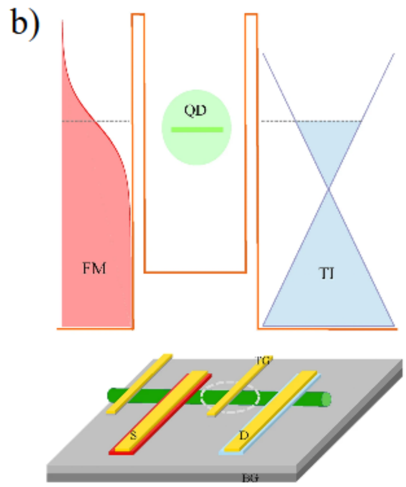


Fig. 1: Schematic description of the setup with topological superconductor (a) and topological insulator (b). A Fermi function (red) on the left hand side represents the normal metal, while in (a) the density of states of the topological superconductor is depicted on the right hand side (purple). In (b) the energy diagram of the surface states of topological insulator (TI) is depicted on the right hand side (blue)

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MODELING OF ULTRAFAST X-RAY INDUCED MAGNETIZATION DYNAMICS IN MAGNETIC MATERIALS

Beata Ziaja[1,2]

[1] *CFEL, DESY, Notkestrasse 85, 22607 Hamburg, Germany*

[2] *Institute of Nuclear Physics PAN, Radzikowskiego 152, 31-324, Kraków, Poland*

for the collaboration with: Konrad J. Kapcia (A. Mickiewicz Univ., Poznań, Poland), Victor Tkachenko (European XFEL, Schenefeld, Germany), Flavio Capotondi (FERMI, Trieste, Italy), Alexander Lichtenstein (Hamburg Univ., Hamburg, Germany), Serguei Molodtsov (European XFEL, Schenefeld, Germany), Przemysław Piekarz (IFJ PAN, Kraków, Poland).

Availability of X-ray free-electron lasers (XFELs), able to generate high-intensity femtosecond X-ray pulses, opened a new field of ultrafast X-ray science, rapidly developing since 2005. XFEL pulses may serve as a probe, providing information on ultrafast transitions in matter, acquired, among others, with the powerful technique of diffractive imaging. High-intensity X rays may also act as a pump, triggering strong excitation of electronic subsystem in solids on femtosecond timescales. This can trigger various transitions in the irradiated solids, depending on the radiation dose absorbed. Here, I focus on magnetic transitions induced by intense X-ray pulses, and report on the collaborative development of novel, dedicated theoretical tools, able to describe the evolution of X-ray irradiated magnetic samples, initially under strongly non-equilibrium conditions, preceding local thermodynamic equilibration of excited electrons. Challenges remaining for the modeling and possible further model developments are discussed.

Contibuted talks

EFFECT OF CoFeB LAYER THICKNESS ON ELASTIC PROPERTIES IN CoFeB/Au HETEROSTRUCTURES - POSSIBILITY OF MODIFICATION SAW DISPERSION

Amrutha V. Achuthan[1], Piotr Kuświk[2], and Aleksandra Trzaskowska[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *Institute of Molecular Physics, Polish Academy of Science, Smoluchowskiego 17, 60-179 Poznan, Poland*

CoFeB/Au structures are promising for memory media [1] and magnetoresistive sensors [2], [3] due to their unique properties. Previous research has shown that CoFeB/Au layers exhibit Dzyaloshinskii-Moriya interaction (DMI), with magnetic properties tailored by layer thickness [4]. This raises questions about the behavior of surface acoustic waves in response to CoFeB layer thickness variations. The CoFeB layers have shown intriguing elastic properties and the phononic characteristics of CoFeB/Au multilayer systems remain insufficiently explored. Our measurements were performed using high-resolution Brillouin light scattering spectroscopy, allowing for a detailed analysis of the propagation of Rayleigh and Sezawa surface acoustic waves within the investigated multilayer structures. For a precise assessment of mode localization and dispersion characteristics, we modeled the dispersion relation of surface acoustic waves in the silicon substrate with layers sputtered on its surface. To validate our experimental results, we used finite element method simulations (COMSOL Multiphysics software). We estimated the elastic parameters (Young's modulus and Poisson's ratio, Fig. 1) and analyzed the impact of CoFeB thickness on surface acoustic wave propagation. This comprehensive approach enables a deeper understanding of the interplay between magnetic and acoustic properties in these heterostructures and will be the focus of our future research.

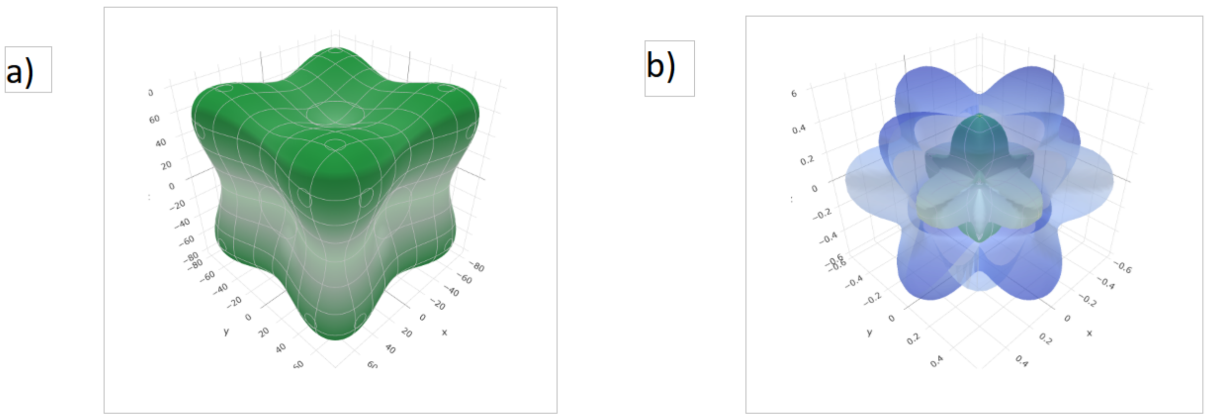

Fig. 1: Young's modulus (a) and Poisson's ratio (b) of the sample $\mathrm{Si/Ti_4/Au_{60}/CoFeB_{0.9}/Au_2}$

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EXTENDED HUBBARD MODEL OF TRIANGULAR LATTICE WITH CHARGE ORDER: MEAN-FIELD SOLUTION WITH ARBITRARY CHARGE DENSITY

Aleksey Alekseev[1], Agnieszka Cichy[1,2], and Konrad J. Kapcia[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 9, 55099 Mainz, Germany*

The triangular lattice is typical for a number of organic conductors, transition-metal oxides and dichalcogenides, can be formed by adsorbed helium atoms on a surface, and can describe the moiré lattices [1]. The latter forms an interesting platform to investigate various strongly-correlated and frustration-induced phenomena, since the interaction parameters and carrier itineracy can be controlled by changing a twisted angle and the choice of two layers out of rich family of 2D materials. The systems with triangular lattice structure are found to host various phenomena, such as superconductivity, variety of charge and magnetic orderings, topological states. Among them, the charge ordering, e.g., Wigner crystals or charge-density waves, attract researchers interest due to its interplay with superconductivity, as well as possible applications in new devices, such as involving pyroelectric or ferroelectric materials. Triangular lattices are commonly recognized to be perspective for searching the exotic charge orders, e.g., a pinball-liquid phase [2]. This phase consists of the lattice sites that are insulating for the charge carriers (pins) but surrounded with the metallic lattice sites (balls), and thus the PL shares some properties of supersolids. To understand the full picture of various charge orders in the triangular lattice, the investigation in the grand-canonical ensemble with arbitrary charge density is required. Interestingly, the mean-field study of such a system can provide significant insights into the problem despite ignoring the correlation effects. Besides using it as a benchmark for further investigations, a number of unusual phenomena can already be found within the men-field approximation (MFA), which makes them both easy to analyse and distinguish with strongly-correlated phenomena. The great advantage here (besides the required computational and time resources) is provided by the opportunity to analyse band structures. Moreover, the non-correlated phases are found within the dynamical mean-field theory when the intersite interaction prevails over the onsite interaction [3]. It is advantageous to use MFA results as a reference in future studies together with the atomic-limit results [4]. We present and analyse the full zero-temperature phase diagram of a triangular-lattice extended Hubbard model on the all-encompassing range of chemical potential values and repulsive onsite and nearest-neighbour electron interactions. Despite the limitations of the mean-field approximation, restriction to the $\sqrt{3} \times \sqrt{3}$ supercells and neglection of a magnetic order, the large variety of features are found. Those are the diverse and numerous phase transitions, including the continuous and discontinuous symmetry breakings; the pinball liquid phase; the strong particle-hole asymmetry manifested in every phase transition with a charge-ordered phase. Both the found phases and the found phase transitions are accompanied by the extensive band-structure analysis that provided clarity and the understanding of the phase diagram. It is evident that the future investigation of the triangular lattice that takes into account the correlated effects can benefit from the insights provided by presented MFA results. Additionally, our research can easily be expanded to include next-nearest-neighbour interactions and finite temperatures. The more work is also required to include magnetic order and to consider the orderings that require larger supercells.

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EMERGING HOLONOMY IN ELECTRON SPIN SCATTERING

Lorenzo Bagnasacco[1], Fabio Taddei[1], and Vittorio Giovannetti[1]

[1] *NEST, Scuola Normale Superiore and Istituto Nanoscienze-CNR, Piazza dei Cavalieri 7, I-56126 Pisa, Italy*

By evidencing the holonomic and dynamical contributions in scattering problems, we develop—Ref.[1]—a method for calculating the scattering matrix of electrons in a one-dimensional coherent conductor connected to two electrodes. To validate our approach, we investigate the spin-resolved scattering of electrons along a wire subjected to a spatially varying magnetic (Zeeman) field. In particular, we show that in the high-energy limit, the transmission matrix aligns with the holonomy, reducing to a pure topological form. We illustrate the method by examining several scenarios with varied in-plane magnetic field profiles. For instance, our results indicate the possibility of achieving near-perfect spin-flip transmission, with implications for use in spintronic applications.

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STEPS TOWARDS CONTINOUS MODELLING OF QUASI-AMORPHOUS FERRIMAGNETIC AND SPERIMAGNETIC ALLOYS USING FINITE DIFFERENCE ALGORITHMS

Gabriel David Chaves-O'Flynn[1], Daniel Kiphart[1], Piotr Kuświk[1], and Feliks Stobiecki[1]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Smoluchowskiego 17, 60-179, Poznań, Poland*

In a recent paper [1], we used the publicly available software packages OOMMF and MUMAX without additional extensions, and without forcing antiparallel alignment between sublattices to qualitatively reproduce features observed in a Rare Earth-Transition Metal amorphous ferrimagnetic film which had been treated with Ion Bombardment. A notable configuration that may be created in ferrimagnetic films via Ion Bombardment is a sharp change in effective magnetization in a very narrow width. This occurs after Ion Bombardment induces a change in ferrimagnetic domination caused by preferential oxidation of the Rare Earth sublattice in the bombarded areas. In consequence, the switching field of bombarded regions is lower than those of the surrounding matrix. The device thus created are able to hold two states: (I) it may present abrupt changes of effective magnetization while the sublattices remain vertically aligned so that there in no contribution to the exchange energy, we have labeled this state as a configuration with domains but no domain walls. (II) In the second state, the magnetization of the sublattices exhibits a special rotation but the effective magnetization points in the same direction at each side of the interface: while this configuration is a magnetic monodomain, it contains an internal domain wall and has higher exchange. This work summarizes mathematical expressions needed to make quantitative comparisons beween experiments on ferrimagnets, atomistic simulations and finite-difference micromagnetic software. Within this framework, we describe stable configurations in term of a minimum of a continous energy functional; in particular we provide analytical solutions for the two states described above, In our approach we can replace the effective magnetization with the a Neel type ferrimagnetic vector which changes smoothly in space even when the magnetization exhibits abrupt changes. Allowing to establish necessary boundary conditions for these systems. We start from a simplified model of an amorphous ferrimagnet which assumes crystalline structure but chemical disorder. Second, we obtain micromagnetic quantities by averaging over possible configurations. For collinear ferrimagnets, we can switch from the magnetization vector to the Neel ferrimagnetic vector as convenient. To finish this work we examine a bilayer structure where the micromagnetic parameters have been modified in a localized region and found metastable configurations akin to the state I and II described above.

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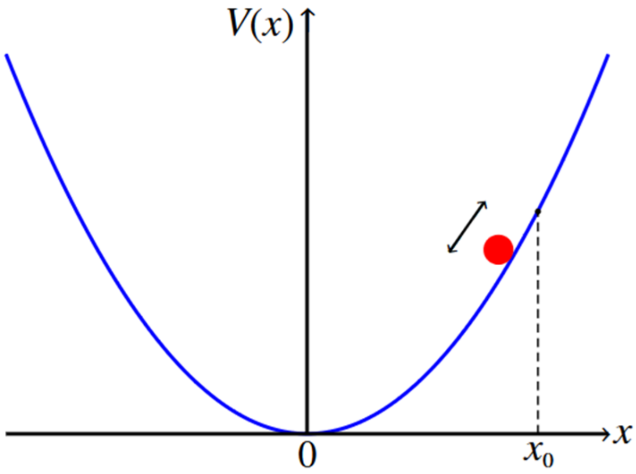
RIGOROUS RESULTS FOR MEAN FIRST-PASSAGE TIME OF HARMONICALLY TRAPPED PARTICLE

Przemysław Chełminiak[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

A nearly century-old problem concerning the Ornstein-Uhlenbeck process of diffusion in the harmonic potential is re-examined in the context of the first-passage time problem. We investigate this problem to the extent that it has not yet been fully resolved and demonstrate exact novel results. They mainly correspond to the mean first-passage time for a particle diffusing downhill and uphill the harmonic potential. We verify the obtained results using a number of analytical techniques and numerical methods.



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INVESTIGATION OF THE DISSIPATION-DRIVEN ACCELERATION OF THE ENTANGLEMENT GENERATION IN THE VICINITY OF EXCEPTIONAL POINTS

Grzegorz Chimczak[1] and Ivan Davydenko[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Open physical systems described by non-Hermitian Hamiltonians have attracted increasing attention from researchers in recent years due to the possibility of the occurrence of so-called exceptional points (EP), which cannot be observed in closed systems described by Hermitian Hamiltonians. EPs are points in parameter space where at least two eigenvectors of the Hamiltonian become parallel, and the corresponding eigenvalues are the same. Many previously unknown physical phenomena occur near EPs, which may have important potential applications, such as detecting very weak signals [1–3]. Another important phenomenon occurring near EPs was theoretically predicted - the acceleration of entangled state generation [4]. The authors have suggested that their scheme can be realized using the three lowest levels of transmon: $|g\rangle$, $|e\rangle$, and $|f\rangle$. However, they have neglected quantum jumps that can occur in this system. Due to the quantum jumps, the probability of success P_s in this scheme is negligibly small (of the order of 10^{-15}), which would not allow observing this experimentally. In this presentation, we shall show the effect of quantum jumps from the level $|e\rangle$ to the ground level $|g\rangle$ on the entanglement generation. To address this, we introduce dimensionless variables $\Gamma = \gamma/4\Omega$ and $j = J/\Omega$ to investigate the performance of the scheme for all allowed parameter values. We demonstrate the existence of the trade-off between the success probability and the speed-up rate as shown in the panels (a) and (b) of Fig. 1. Therefore, the mean time of success would surpass or be of the order of the characteristic time of J^{-1}. Thus, our results demonstrate the impossibility of the beneficial implementation of the proposed scheme by only changing system parameters.

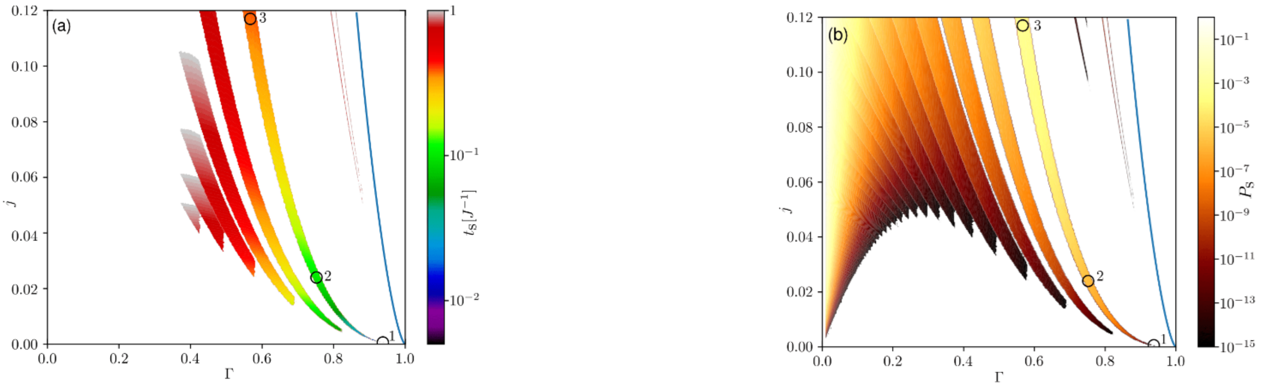

Fig. 1: Time of successful entanglement generation t_S (panel (a)) and probability of success P_S (panel (b)) as functions of dimensionless coupling strength j and damping Γ.

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MICROWAVE PLANAR ANTENNA BASED ON AN INVERSE SPIT RING RESONATOR FOR EXCITATION AND AMPLIFICATION SURFACE SPIN WAVES IN NANOSCALE MAGNONIC CIRCUITS

Liubov Ivzhenko[1], Sergey Polevoy[2], Sergey Nedukh[2], and Maciej Krawczyk[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *O.Ya. Usikov Institute of Radiophysics and Electronics of the NASU, 12, Ac. Proskura st., Kharkiv, Ukraine*

One of the main challenges in magnonics is the efficient transduction of microwave (MW) signals into spin waves (SWs) due to the significant mismatch between MW wavelengths in the GHz range (10-2 m) and SW wavelengths (10-8 m) [1-2]. To address this issue, we propose a novel microwave antenna design based on a half-wavelength H-field resonator implemented as a single inverse split ring resonator (ISRR). This design provides a resonant transduction of MWs into SWs through strong photon-magnon coupling [3], significantly enhancing energy transfer efficiency. Our numerical studies demonstrate that the ISRR-based antenna achieves a fivefold improvement in MW-to-SW conversion efficiency compared to conventional planar antennas (see Fig.1).

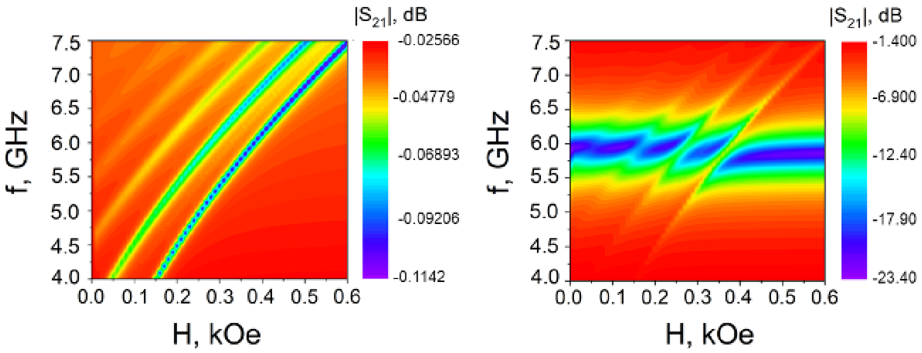

Fig. 1: Transmission parameter S21 as function of frequency and external magnetic field for a microstrip (left) and inverse split ring resonator anti gap (left).

Furthermore, the ISRR structure enables highly localized and efficient MW energy transfer into the magnonic system by confining the strong photon-magnon coupling region to deep subwavelength dimensions relative to the 6 GHz operational frequency. This compact and efficient antenna design presents a significant advantage over conventional planar MW antennas [4], paving the way for scalable and high-performance magnonic circuits. Unlike conventional microstrip antennas, which primarily excite bulk magnetostatic waves (MSWs) via the static magnetic field, the ISRR-based antenna enables the excitation of hybrid magnon modes due to strong photon-magnon coupling. This provides a significant advantage over conventional planar MW antennas for nanoscale magnonic circuits.

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AB INITIO STUDY OF STATIC AND DYNAMICAL STABILITY OF TRIGONAL, ORTHOROMBIC AND TETRAGONAL PHASES OF $Cs_4Pb_2Br_6$ UNDER PRESSURE

Maria Pugaczowa-Michalska[1], Agnieszka Cichy[2,3], and Konrad J. Kapcia[2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, ul. M. Smoluchowskiego 17, 60179 Poznań, Poland*

[2] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[3] *Institut fuer Physik, Johannes Gutenberg-Universitaet Mainz, Staudingerweg 9, 55099 Mainz, Germany*

In Ref. [1], the $Cs_4Pb_2Br_6$ compound was investigated under hydrostatic pressure up to almost 5 GPa, and with increasing pressure the following three phases are found within the diffraction experiment on the monocrystal samples: (i) phase I (trigonal, R-3c, no. 167), (ii) phase II (orthorombic, Cmce, no. 64), and (iii) phase III (tetragonal, P4/mnc, no. 128). Sharp first-order (discontinuous) structural transitions occurs at 2.6 GPa and 3.2 GPa between the mentioned phases [1]. On the other hand, in [2], using the X-ray powder diffraction method, it was reported that the structural phase transitions from rhombohedral (or phase I, R-3c) to monoclinic structure (or phase IV with space group B2/b or C2/c under different conditions, no. 15) in nanocrystals (NCs) of $Cs_4Pb_2Br_6$ under compression. Moreover, the coexistence region of phases I and IV in $Cs_4Pb_2Br_6$ NCs is in the range of 3.0 to 4.0 GPa. According the authors, the monoclinic phase in $Cs_4Pb_2Br_6$ NCs exists up to around 14 GPa, where the amorphization is claimed. In this presentation, using ab initio density functional theory calculations, we show that in bulk $Cs_4Pb_2Br_6$ the mechanical stability conditions are fulfilled for phases I, II, and III, as well as three phases I, II, and III are dynamically stable for pressure ranges in qualitative agreement with the experiment [1]. Moreover, we checked that phase IV in system studied is not stable energetically even for high pressures.

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STABILIZATION OF SKYRMION IN HYBRID MAGNETIC-SUPERCONDUCTING NANOSTUCTURE

Julia Kharlan[1], Mateusz Zelent[1] , Konstantin Y. Guslienko[2], Vladimir O. Golub[3], and Jarosław W. Kłos[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *Departamento Polímeros y Materiales Avanzados: Física, Química y Tecnología, Universidad del Pais Vasco UPV/EHU, San Sebastian, Spain*

[3] *Institute of Magnetism NASU and MESU, Kyiv, Ukraine*

In recent decades, magnetic textures such as domain walls, skyrmions, and vortices have attracted significant attention due to their potential applications in spintronics and magnonics [1]. Domain walls and skyrmions can be used to store and transmit information in racetrack memory systems. Moreover, information encoded in this manner can be processed on neuromorphic platforms.

Conventionally, magnetic skyrmions have been stabilized by the Dzyaloshinskii-Moriya interaction (DMI), which imposes strict constraints on the choice of magnetic materials. Stabilizing skyrmions in a material without DMI requires an inhomogeneous magnetic field, such as a demagnetization field or an Oersted field [2,3].

Here, we propose an alternative method to stabilize skyrmions in a continuous ferromagnetic layer without relying on DMI. We utilize the field generated by Meissner currents in superconducting rings [4] to create a stable skyrmion texture. This approach not only expands the range of magnetic materials suitable for skyrmion formation but also enables efficient writing and deletion of skyrmions, as well as precise control of their radii, while significantly reducing Joule heating. The use of superconducting nanorings allows for the local magnetic field stabilizing the skyrmion to be controlled via a spatially uniform electric field pulse.

We analyze the conditions required for skyrmion stabilization in magnetic layers with perpendicular anisotropy, considering nanoring size and superconducting current. Our results show that the superconducting current must exceed a critical threshold to stabilize the skyrmion. We compare our analytical findings [5,6] with micromagnetic simulations performed for Co and Ga:YIG thin films.

The proposed solution enables the implementation of a magnonic neuromorphic system, where skyrmions act as weights and interconnections within the neural network, while spin waves facilitate signal routing and nonlinear activation.

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THIN FILM BASED MAGNONIC CRYSTALS WITH RECIPROCAL OR NONRECIPROCAL DISPERSION RELATION AND THEIR RELATION TO GLIDE SYMMETRY

Hanna Reshetniak[1], Mateusz Gołębiewski[1], Nikodem Leśniewski[1], Olena Tartakivska[1], and Maciej Krawczyk[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Nonreciprocity is inherently related to time and inversion symmetry breaking. In ferromagnetic materials there are many ways to achieve spin-wave nonreciprocity, the main indicator of which is an asymmetric dispersion relation. It can be induced by Dzialoshynski-Moryia interactions, which also require inversion asymmetry to exist, at the level of the atomic crystal structure or in the composition of the multilayer film [1]. Pure magnetostatic interactions in ferromagnets, especially in the Damon-Eshbach (DE) configuration, are also suitable for non-reciprocal dispersion relations [1]. It has been demonstrated for dipolarly coupled ferromagnetic bilayers (when some kind of asymmetry is present) [2], ferromagnetic films coated on one side with metallic or superconducting films [3], films with asymmetric surface anisotropy [4], films with inhomogeneous and asymmetric magnetisation across the thickness, or films with curvature [5]. In all these cases, the inversion symmetry is broken, but this does not mean that for any film with asymmetry along the thickness, the magnetostatic interactions in the DE configuration give a nonreciprocal dispersion relation (see Fig.). We show that in a ferromagnetic film with periodic infinitely long semicircular groves on both sides of the film, but shifted by half a period, the dispersion relation of spin waves propagating perpendicular to the grove axis is reciprocal (Fig. a). However, nonreciprocity is introduced whenever this glide symmetry is broken (Fig. b). We show the conditions necessary for the existence/breaking of the reciprocity, examples of geometries where it exists (Fig. c-d). Furthermore, we present the magnonic band gap opening due to entering this nonreciprocity, its potential usefulness for sensing applications, and its influence on the perpendicular standing spin waves when their frequency enters the band gap frequency range.

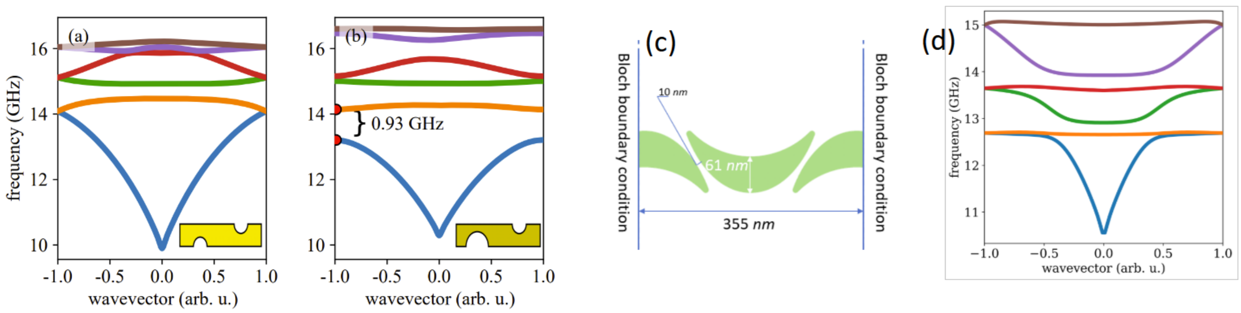

Fig. 1: (a-b) Magnonic band structure of the Py film with semicircular grooves on the upper and lower surface with and without preserved glide symmetry (schematic of the structures in the insets). (c-d) Magnonic crystal composed of periodically arranged crescent-shaped nanorods with every second inverted and its magnonic band structure. All structures are magnetised along the grove (rod) axes with an external magnetic field of 0.1 T.

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EXTRAORDINARY DYNAMICS OF SOFTENED SPIN WAVES IN FILMS WITH PERPENDICULAR MAGNETIC ANISOTROPY

Nikodem Leśniewski[1,2], Yuliya S. Dadoenkova[3] , Florian F. L. Bentivegnaand[1], and Paweł Gruszecki[2]

[1] *CNRS, Lab-STICC, UMR 6285, ENIB, 29238 Brest Cedex 3, France*

[2] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[3] *Universit´e Jean Monnet Saint-Etienne, CNRS, Institut d'Optique Graduate School, Laboratoire Hubert Curien, UMR 5516, 42023 Saint-Etienne, France*

We theoretically investigate the effect of perpendicular magnetic anisotropy (PMA) on spin wave (SW) dynamics at low magnetic fields. PMA exerts an in-plane torque on magnetization, coun- teracting exchange, dipolar, and Zeeman torques, thereby significantly transforming SW dynamics. In ultrathin films, sombrero-like dispersion relation facilitates bireflection [1] and negative reflection of SWs [2], while in thicker films we demonstrate anti-Larmor precession, cowboy-hat-like dispersion relation , and trireflection of SWs. These results open up new opportunities to explore wave phenomena beyond magnonics.

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NUCLEATION AND ARRANGEMENT OF ABRIKOSOV VORTICES IN HYBRID SUPERCONDUCTOR-FERROMAGNETIC NANOSTRUCTURE

Sara Memarzadeh[1], Mateusz Gołębiewski[1], Maciej Krawczyk[1], and Jarosław W. Kłos[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

The ferromagnetic (FM) and superconducting (SC) nanoelements can be coupled not only by direct contact [1], but also by electromagnetic fields [2]. In these hybrid structures, the Abrikosov vortices experience creep-like deformations, gradually settling into steady curved shape [3] due to the interplay of Lorentz forces, vortex interactions, and the system's geometry. By numerically solving the time-dependent Ginzburg-Landau equations coupled with Maxwell's equations, we examine the behavior of Abrikosov vortices in SC-FM hybrid nanostructures under inhomogeneous magnetic field [4]. Unlike uniform magnetic fields, the hybrid system exhibits stronger vortex pinning and more complex vortex configurations. The interplay between inhomogeneous fields and geometric constraints results in competing energy landscapes, helping the system lock into various local minima. Our findings are essential for optimizing superconducting nanodevices operating on Abrikosov vortices.

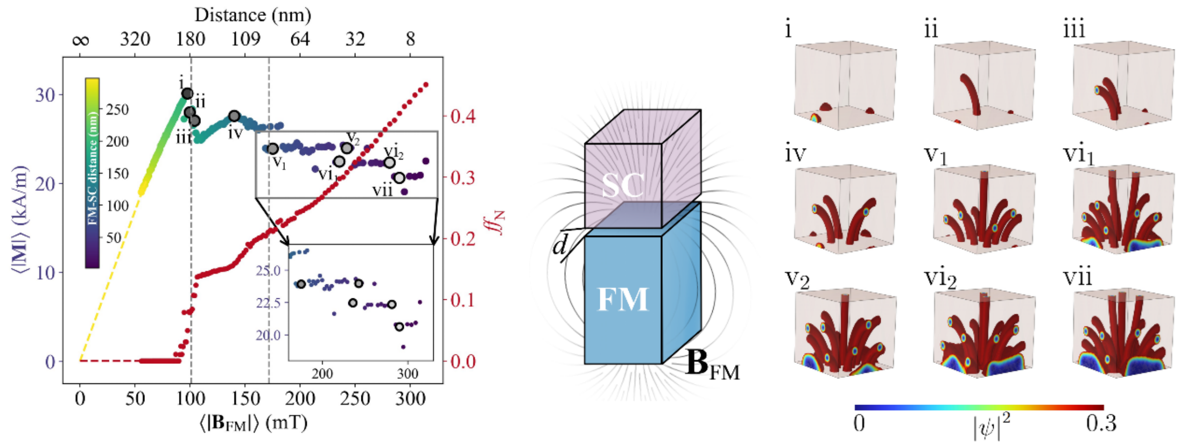

Fig. 1: The left graph shows the average magnetization ⟨|M|⟩ for SC prism (yellow-green-blue points and left edge of the frame) and the volume fraction of Abrikosov vortices ffN (red points and right edge of the frame), plotted versus the average magnetic field ⟨|BFM|⟩ produced by FM (bottom edge of the frame) and the corresponding SC-FM separation (top edge of the frame). The first gray dashed line represents the first critical field, and the second grey dashed line indicates where the first curved vortex becomes straight. The middle graph shows the geometry of the system: the SC prism has a 350 × 350 nm^2 cross-section and is 320 nm in high. On the right, the visualizations (i–viii) of the static vortex configurations at selected field values are presented.

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DIFFERENTIATING BETWEEN INTERACTION-BASED AND IMAGINARY TIME-BASED BOSONIC PAIRING MECHANISMS

Tomasz P. Polak[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

We compare two kinds of bosonic pairing, with two different sources: second order terms in the series expansion of the correlation function and the density-induced tunnelling interaction. Both types of pair condensate strengthen the single condensate phase, increasing the critical temperature of bosonic condensation. Since they stem from two different mechanisms but can conceal each other we prepare protocol to distinguish between them. We apply the self-consistent harmonic approximation to the quantum phase model with single and pair condensation terms to study the thermodynamics of both kinds of pairing and add synthetic magnetic fields into the systems to look for possible ways to differentiate between the two kinds of pair condensate in experiments.

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TAILORING INTERFACIAL PROPERTIES IN MAGNETIC THIN FILM HETEROSTRUCTURES BY INTERFACE ENGINEERING

Shashank Shekhar [1], Aleksandra Trzaskowska [1], Sławomir Mielcarek[1], Hubert Głowiński[2], Maciej Urbaniak[2], Piotr Kuswik[2], and Bivas Rana[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *Institute of Molecular Physics Polish Academy of Sciences, Smoluchowskiego 17, Poznan, Poland*

The interfacial properties like perpendicular magnetic anisotropy (PMA), spin-orbit coupling (SOC), Dzyaloshinskii-Moriya interaction (DMI), damping constant in magnetic thin films and their heterostructures govern the performance and efficiency of many spintronic devices. Higher or lower values of those parameters is desirable depending upon the requirement of specific device application. Therefore, the investigation of underlying mechanism and figuring out efficient ways to control interfacial parameters is crucial for future application point of view [1,2]. In this presentation, I will show that the PMA, damping and DMI in CoFeB/MgO (specifically $Ta/Co_20Fe_60B_20/MgO/Al_2O_3$) heterostructures can be modulated by doping or dusting CoFeB/MgO interface with suitable material with varying SOC strength and d-orbital filling [3]. For this purpose we put ultrathin (0.12 nm) layer of Ta, Ru, Pt, W at CoFeB/MgO interface to investigate how the interfacial properties are modified. The damping constants are measured by broadband vector network analyzer – ferromagnetic resonance (VNA-FMR) technique, whereas DMI are determined by employing conventional Brillouin Light Scattering (BLS) technique. Magnetometry measurement confirms the reduction of saturation magnetization most likely due to the formation of magnetic dead layer because of doping. The interfacial PMA is drastically reduced with the insertion layer because of the modification of orbital hybridization and interfacial SOC strength. The damping constant, which has a significant contribution from interfaces, increases significantly for W because of the formation of thicker magnetic dead layer. Interestingly, the damping constant for Pt insertion layer remains almost unchanged or even reduced a bit as compared to the multilayer without insertion layer in spite of the fact that Pt has strong SOC. The DMI for all the multilayers with insertion layer is reduced significantly. Surprisingly, the DMI for Pt insertion layer becomes negative. We found a correlation between the change in DMI with the filling of d-orbital of the inserted material.

Acknowledgements: *BR acknowledges NCN SONATA-16 project with grant number 2020/39/D/ST3/02378 and Adam Mickiewicz University for "Initiative of Excellence - Research University" (ID-UB) project with grant numbers 038/04/NŚ/0037. The authors sincerely thank Dr. Katsuya Miura and Dr. Hiromasa Takahashi from Hitachi Ltd., Japan and Prof. YoshiChika Otani from RIKEN and University of Tokyo for preparing thin films for the study.*

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INFLUENCE OF THE COMPETITION BETWEEN NAGAOKA FERROMAGNETISM AND SUPERCONDUCTING PAIRING ON ANDREEV CURRENT IN HYBRID QUANTUM DOTS

Emil Siuda[1] and Ireneusz Weymann[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Systems containing quantum dots provide a well-established framework for studying correlated electrons in a highly controllable environment. A notable example of their successful application is the observation of Nagaoka ferromagnetism in a quadruple quantum dot system [1]. Additionally, quantum dots coupled to superconducting leads can host Majorana bound states [2-4], which are promising for solid-state quantum computing. Motivated by these advancements, we analyze the interplay between Nagaoka ferromagnetism and superconducting pairing in a quadruple quantum dot system attached to an s-wave superconductor.

For energies much smaller than the superconducting gap, transport in the system occurs through Andreev bound states via direct and crossed Andreev reflections. Since Cooper pairs consist of two electrons with opposite spins, Andreev reflections compete with Nagaoka ferromagnetic order, leading to complex behavior in the system's magnetic ground state. We characterize the phase space of the system and derive analytical formulas for the phase boundaries in the regime of strong on-dot Coulomb interactions. By attaching a metallic lead to one of the quantum dots, a current is induced through the system. Calculations of the Andreev current and differential conductance reveal signatures of this competition in the transport properties, providing a pathway to observe it using Andreev bias spectroscopy.

Acknowledgements: *This work was supported by the Polish National Science Centre project No. 2022/45/B/ST3/02826.*

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TUNING THE TOPOLOGICAL MAGNON GAP IN VAN DER WAALS CrI_3 MONOLAYER

Verena Brehm[1], Paweł Sobieszczyk[2], Jostein Kløgetvedt[1], Richard F.L. Evans[3], Elton J. G. Santos[4,5,6], and Alireza Qaiumzadeh[1]

[1] *Center for Quantum Spintronics, Norwegian University of Science and Technology, 7034 Trondheim, Norway*

[2] *Institute of Nuclear Physics Polish Academy of Sciences, Radzikowskiego 152, 31-342 Kraków, Poland*

[3] *School of Physics, Engineering and Technology, University of York, York, YO10 5DD, United Kingdom*

[4] *Institute for Condensed Matter Physics and Complex Systems, School of Physics and Astronomy, The University of Edinburgh, Edinburgh EH9 3FD, Untied Kingdom*

[5] *Higgs Centre for Theoretical Physics, The University of Edinburgh, EH9 3FD, United Kingdom*

[6] *Donostia International Physics Center (DIPC), 20018 Donostia-San Sebastian, Basque Country, Spain*

In the recent years, ferromagnetic van der Waals crystals received enormous attention due to their magnetic properties like the existence of the gap along with the topological states at Dirac points. There have been many debates about the origin of the topological magnon band gap in these materials since two main models with distinct characteristics, i.e., Dzyaloshinskii-Moriya (DM) and Kitaev, provided possible explanations with different outcome implications [1, 2]. Here we investigate the angular magnetic field dependence of the magnon gap of CrI_3 using stochastic atomistic spin dynamics simulations together with linear spin wave theory to determine the main differences between Kitaev and DM models [3]. We observe three distinct magnetic field dependencies between these two gap opening mechanisms [4]. First, we demonstrate that the Kitaev-induced magnon gap is influenced by both the direction and amplitude of the applied magnetic field, while the DM-induced gap is solely affected by the magnetic field direction. Second, the position of the Dirac cones within the Kitaev-induced magnon gap shifts in response to changes in the magnetic field direction, whereas they remain unaffected by the magnetic field direction in the DM-induced gap scenario. Third, we find a direct-indirect magnon band-gap transition in the Kitaev model by varying the applied magnetic field direction. These differences may distinguish the origin of topological magnon gaps in CrI_3 and pave the way for exploration and engineering topological gaps in other van der Waals magnetic materials.

Acknowledgements: *P.S. was supported by the Polish National Science Centre with Grant Miniatura No. 2019/03/X/ST3/01968. A.Q. was partially supported by the Research Council of Norway through its Centers of Excellence funding scheme, Project No. 262633, "QuSpin". E.J.G.S. acknowledges computa- tional resources through the CIRRUS Tier-2 HPC Service (ec131 Cirrus Project) at EPCC [62] funded by the University of Edinburgh and EPSRC (No. EP/P020267/1). E.J.G.S. acknowledges the Edinburgh-Rice Strategic Collaboration Awards and the EPSRC Open Fellowship (No. EP/T021578/1) for funding support. V.B. acknowledges L. Chen and P. Dai for helpful discussions. This project has been supported by the Norwegian Financial Mechanism Project No. 2019/34/H/ST3/00515, "2Dtronics".*

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SPIN WAVE AMPLIFICATION IN TIME-VARYING MEDIA

Krzysztof Sobucki[1] and Paweł Gruszecki[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Spin waves are propagating disturbances of magnetic moments in magnetic materials, governed by the Landau-Lifshitz equation. Their appeal lies in their massless and chargeless nature, eliminating Joule heat losses. Spin waves also offer shorter wavelengths than electromagnetic waves at the same frequency, enabling significant miniaturization. However, further theoretical and experimental progress, particularly in efficient methods of spin-wave amplification, is needed to fully integrate spin waves into devices. Time-varying media and phenomena like time reflection and refraction present new opportunities for magnonics, though research to-date remains limited [1,2]. This theoretical work introduces a novel approach to control spin-wave propagation by modulating the local external magnetic field in time and space in ferromagnetic films with perpendicular magnetic anisotropy and Dzyaloshinskii–Moriya interaction, which introduces nonreciprocity. We explore how spatial profiles and temporal modulations of the magnetic field influence spin-wave propagation near the critical bias field, where a phase transition occurs between high-symmetry (uniform in-plane magnetization) and low-symmetry (aligned stripe domains) phases [3]. Micromagnetic simulations in Mumax3 [4] demonstrate phenomena such as spin-wave reflection and refraction at temporal interfaces. Notably, the temporal profile of the bias field modulates time refraction and reflection, leading to spin-wave amplification (Fig. 1). These findings present a practical and easily implementable method for controlling spin waves using external magnetic fields, which can be adjusted via coplanar antennas.

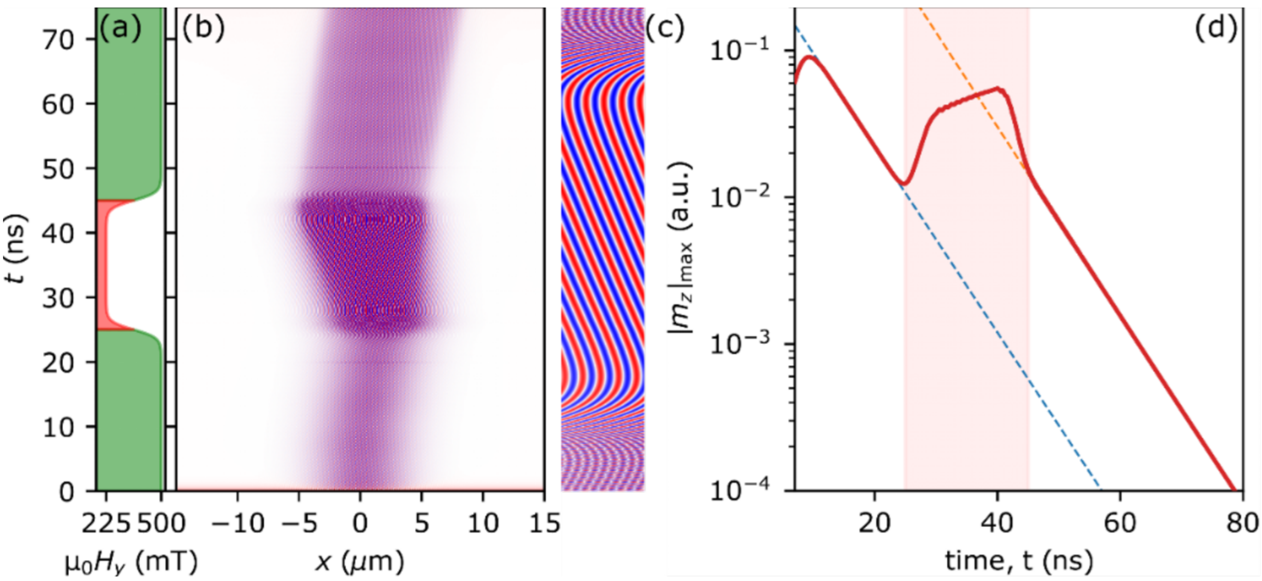

Fig. 1: (a) Time dependence of the spatially uniform bias magnetic field value. (b) Space- and time- dependence of the out-of-plane component of magnetization (). (c) Enlarged region in (b) showing the space and time dependence of as the bias field changes are introduced. (d) maximal value of magnitude as a function of simulation time with the time of lowered external magnetic field indicated with red area in the plot. The blue dashed line in (b) indicates calculated decrease of excited SW wavepacket amplitude in time without lowering of the external magnetic field. In the simulated case lowering of the magnetic field causes amplification of spin waves amplitude by the factor of 20, indicated with a green arrow.

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QUANTUM SYNCHRONIZING WORDS

Andrzej Grudka[1], Marcin Karczewski[1], Paweł Kurzyński[1], Jędrzej Stempin[1], Jan Wójcik[1], and Antoni Wójcik[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Synchronization, a fundamental concept in classical automata theory, provides a mechanism to drive any state of a deterministic system to a designated target state through a well-chosen sequence of transitions. In this work [1], we extend this idea to quantum information theory, demonstrating that a minimal set of quantum channels can achieve a similar effect for qutrit systems. Specifically, we show that with only two quantum channels, any arbitrary qutrit state can be steered close to a predetermined target state. Moreover, following this reset, we establish that any pure real qutrit state can be effectively approximated using the same two-channel framework. Going further, we present a synchronization protocol based purely on unitary evolution, requiring only a two-letter alphabet, and propose implementation within a quantum circuit model on a quantum computer. These results not only introduce a quantum analogue of synchronizing words but also open new avenues for efficient state preparation and minimal universal gate set design in quantum computing.

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NONAUTONOMOUS FINITE-DIMENSIONAL RESTRICTIONS OF KdV HIERARCHY.

Błażej M. Szablikowski[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

I will present preliminary results of joint work with Maciej Błaszak (UAM) and Krzysztof Marciniak (Linköping University). I will try to make the lecture accessible to non-experts in the field of integrable systems.

Since the classical works of Novikov et al. there has been a tremendous amount of research devoted to connections between soliton hierarchies and their integrable finite-dimensional reductions, which was mainly focused on stationary flows. Recently, we have revisited this idea in a novel, systematic way [1–3]. We investigated not only stationary flows but the so-called stationary systems, by which we mean a stationary flow together with all lower flows from the hierarchy, that is finite dimensional systems of evolutionary equations. As result, we were able to show that in the case of the particular soliton hierarchies the related stationary systems can be represented as a classical separable Stäckel systems.

Here, we generalize the above concept of stationary systems to the so-called nonautonomous restrictions of soliton hierarchies. These restrictions are defined through invariant time-dependent constraints that are appropriate deformations of stationary flows through compositions of the so-called master symmetries and lower flows, idea based on [4]. It turns out that this class of time-dependent restrictions of soliton hierarchies is represented by non-autonomous Hamiltonian finite-dimensional dynamical systems of Painlevé type. Let us emphasize that the original Painlevé equations are nonautonomous nonlinear ODE's that, at the beginning of the 20th century, allowed the definition of new transcendental special functions.

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SPIN-WAVE TRANSMISSION THROUGH A HYBRID MAGNONIC CRYSTAL BASED ON VORTICES IN DISKS

Krzysztof Szulc[1,2] Junyoung Hyun[3] Nikolai A. Kuznetsov[3], Lukáš Flajšman[3], Maciej Krawczyk[2], Paweł Gruszecki[2], Carsten Dubs[4], and Sebastiaan van Dijken[3]

[1] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*

[2] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[3] *Department of Applied Physics, Aalto University, Espoo, Finland*

[4] *INNOVENT e.V. Technologieentwicklung, Jena, Germany*

Reconfigurable magnonic devices play a crucial role in spin-wave computing [1]. In this study, we demonstrate the control over spin-wave transport through the magnetic state of CoFeB nanodisk arrays on a YIG film. The system comprises a YIG film (thickness: 63 nm or 70 nm), a CoFeB nanodisk array (thickness: 30–50 nm, diameter: 120–240 nm, period: 390–630 nm), and a 4 nm Ta spacer. Using broadband spin-wave spectroscopy, super-Nyquist sampling magneto-optical Kerr effect microscopy (SNS-MOKE), and micromagnetic simulations, we investigate how spin-wave propagation in YIG is influenced by the transition of CoFeB nanodisks between vortex and single-domain states. We identify distinct transmission gaps in both states, attributed not to conventional Bragg scattering but to mode quantization perpendicular to the propagation direction. Variations in spin-wave transport between the two magnetization states result from changes in the effective magnetic field within YIG. Moreover, the frequency, width, and depth of these transmission gaps can be tuned by modifying the nanodisk array period and disk diameter. This hybrid structure offers a flexible platform for engineered, reconfigurable spin-wave control, contributing to the advancement of magnonic circuits.

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The talk has been withdrawn - anyone interested in this research is invited to contact the corresponding author: patrycja.tulewicz@amu.edu.pl.

ANALYSIS OF ENTANGLEMENT PRESERVATION IN DISTRIBUTED QUANTUM COMPUTING USING A MULTI-COPY ESTIMATION APPROACH

Patrycja Tulewicz[1,2], Davide Ferrari[2], Michele Amoretti[2], and Karol Bartkiewicz[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *Quantum Software Laboratory, University of Parma, 43124 Parma, Italy*

With the growing demand for large-scale quantum computers, distributed quantum computing (DQC) uses multiple smaller quantum processors to solve tasks beyond the capabilities of a single device. Effective benchmarking methods for such systems are needed to determine the performance index of quantum computing platforms and to assess the ability to generate and manipulate quantum states.

In his talk, I will present a DQC benchmarking approach based on multi- copy estimation (MCE) that focuses on critical quantum properties such as entanglement and Bell's nonlocality [1]. Minimising the measurement overhead compared to full quantum state tomography (QST),

Factors such as the number of entangled nodes, node fidelity and processor gate errors have a direct impact on entanglement behaviour in DQC architectures. These findings explain how resource constraints and noise can affect the sharing of quantum states across network nodes, and provide strategies for optimising fault tolerance. In particular, the obtained metrics provide information on the strengths and weaknesses of different topologies and scheduling schemes, thus guiding the design of fault-tolerant, resilient DQC systems [2].

The implementation of MCE allows us to obtain metrics such as Bell negativity and non-locality with fewer measurement settings than typically required by QST. This strategy reduces the measurement overhead that is problematic for distributed architectures, and maximum likelihood method help reduce device and sampling errors. Simulation results highlight the effectiveness of MCE in maintaining accuracy across different network topologies. In this talk, I will show how these methods can be used to compare the scalability and reliability of DQC platforms, revealing important lessons for future system design that is both resource-efficient and fault-tolerant.

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SUPER-EXCHANGE IN A FERROMAGNET-DOUBLE QUANTUM DOT SYSTEM

Zoltan Scherubl[1,2], Ireneusz Weymann[3], Piotr Trocha[3], Mate Suto[1,2], Istvan E. Lukacs[4], Attila Marton[4], Jesper Nygard[5], and Szabolcs Csonka[1,2]

[1] *Department of Physics, Institute of Physics, Budapest University of Technology and Economics, Budapest, Hungary*

[2] *MTA-BME Nanoelectronics Momentum Research Group, Budapest, Hungary*

[3] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[4] *Center for Energy Research, Institute of Technical Physics and Material Science, Budapest, Hungary*

[5] *Center for Quantum Devices and Nano-Science Center, Niels Bohr Institute, Copenhagen, Denmark*

Quantum dots and molecules tunnel-coupled to ferromagnets are subject to an exchange field resulting from spin-resolved charge fluctuations. Such field resembles a real external magnetic field, acting locally on the molecular degrees of freedom, whose strength and sign can be controlled by electrical means. Here, we examine the effect of exchange field in the case of a double quantum dot molecule embedded in a tunnel junction with one ferromagnetic and one nonmagnetic electrode. In addition to the usual exchange field-induced splitting visible in the quantum dot directly attached to the ferromagnet, we observe that the spin splitting is also induced in the second quantum dot. This splitting is a signature of a super-exchange field, which penetrates the second quantum dot through the first one.

Acknowledgements: *This work was supported by the Polish National Science Centre project No. 2022/45/B/ST3/02826.*

TOPOLOGICAL PHENOMENA IN QUANTUM WALKS

Andrzej Grudka[1], Marcin Karczewski[1], Paweł Kurzyński[1], Jan Wójcik[1], and Antoni Wójcik[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

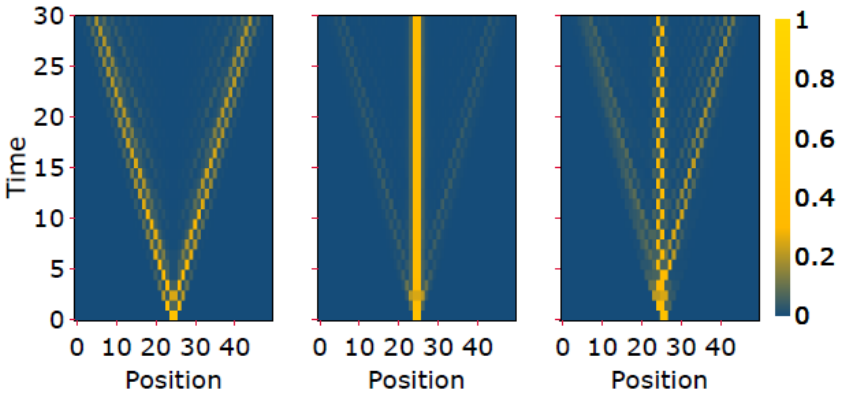
We focus our presentation on discrete-time quantum walks and their topological properties. Quantum walks are periodically driven (Floquet) systems. Their discrete model due to its simplicity may be a very powerful tool while studying complex systems. They've been studied both theoretically and experimentally [1]. As was previously shown even the most basic model of the quantum walk may have some interesting topological properties. Quantum walks can help study topological phenomena as was shown in [2-3]

The dynamic of a quantum walk consists of two parts, the step of the walker and the coin toss. We can distinguish the topological properties of the quantum walk based on the coin toss operator.

We define topological properties for translational invariant walks. Due to this symmetry, we define a unique map from the first Brillouin zone to the Bloch sphere. We want to infer the topological properties of discrete-time quantum walks only by studying this map.

Until now the most popular way to approach the distinction of topological phases in quantum walks is the usage of a winding number.

In a recent paper [5] we show possible issues regarding inferring the topological properties of a quantum walk only from studying the winding number. We propose a new approach. Using relative homotopy we propose a new topological invariant. We show that it agrees with previous models and more generalized ones. Our invariant indicates the number of edge states at the interface between two topological phases. We identify those states for arbitrary coin toss operators. Those states we found to be protected by PHS. We manage to find the exact form of topological edge states in the sharp edge model.



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THE INTERPLAY OF CONFINEMENT AND NEAREST NEIGHBOR INTERACTION IN Z2 LATTICE GAUGE MODELS

Zambrano Yeimer[1], Aleksey Alekseev[1], Konrad J. Kapcia[1], and Agnieszka Cichy[1,2]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 9, 55099 Mainz, Germany*

We explore the rich phase diagram and confinement-induced frustration in a one-dimensional Z2 lattice gauge theory (LGT) with dynamical matter coupled to gauge fields and interacting via nearest-neighbor (NN) interactions [1]. We present a comprehensive study of confinement-induced frustration and emergent quantum phases in a one-dimensional Z2 lattice gauge theory (LGT) with dynamical matter and second nearest-neighbor interactions. Using the Density-Matrix Renormalization Group (DMRG) method, we explore half-filling scenarios where competition between confinement and NN repulsion gives rise to novel quantum phases [2, 3], including Mott insulators, Luttinger liquids, and a highly frustrated parton-plasma regime. The phase diagram is mapped using static structure factors, Green's functions, and pair-pair correlators to distinguish confined and deconfined regimes.

Our numerical results, obtained via DMRG provide new insights into the physics of confinement, frustration, and strongly correlated quantum matter. These findings have direct relevance for quantum simulation platforms using ultracold atoms, offering experimental pathways to explore Z2 gauge theories and their exotic quantum phases.

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MULTISTABLE SKYRMIONS: ENHANCED STABILITY OF SKYRMIONS BY THE MAGNETOSTATIC FIELD OF FERROMAGNETIC RINGS

Mateusz Zelent[1], Konstantin Y. Guslienko[2,3], and Maciej Krawczyk[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *Departamento de Física de Materiales, Universidad del País Vasco, UPV/EHU, 20018 San Sebastian, Spain*

[3] *IKERBASQUE, The Basque Foundation for Science, 48013 Bilbao, Spain*

We demonstrate a novel approach to control and manipulate magnetic skyrmions in ultrathin multilayer systems using spatially engineered magnetostatic fields generated by ferromagnetic rings. Using both analytical modelling and micromagnetic simulations, we show that the stray fields from a Co/Pd ferromagnetic ring with perpendicular magnetic anisotropy can significantly enhance skyrmion stability in an Ir/Co/Pt nanodot, even in the complete absence of Dzyaloshinskii-Moriya interaction.

We observe a multistability phenomenon where skyrmions can be stabilised at two or three different diameters depending on the magnetization orientation of the ring (see Fig. 1). The resulting high energy barriers between these states, suggesting potential applications for binary or multibit data storage. We demonstrate that transitions between these stable states can be reliably controlled through the application of modest magnetic field pulses (100-300 mT) with short durations (0.5-1.0 ns).

By varying the geometric parameters of the ring structure (thickness, inner and outer radii), we demonstrate precise control over skyrmion size and stability, opening pathways for advanced spintronic devices that do not rely solely on conventional DMI-based stabilization mechanisms. Our approach provides a comprehensive framework for designing skyrmion-based spintronic devices with tailored stability properties by engineering the magnetostatic energy landscape.

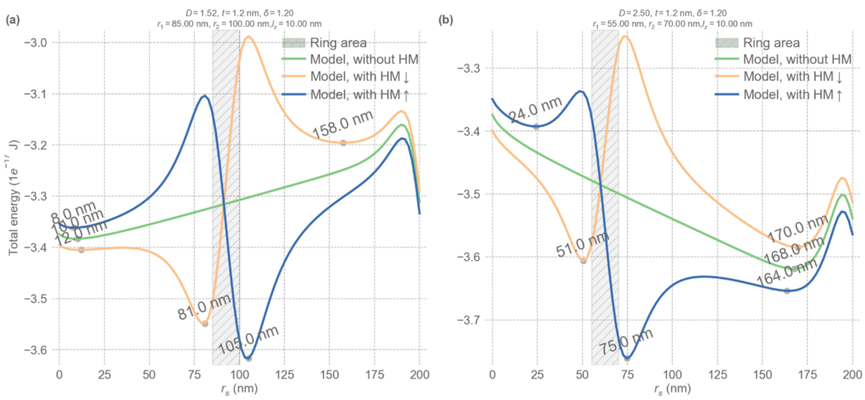

Fig. 1: Total energy of the Néel skyrmion as a function of its radius. The analytical calculations were performed in the absence of DMI for a nanodot of thickness t = 1.2 nm and radius 200 nm. The shaded region indicates the spatial extent of the HMR, with inner and outer radii of r1 = 75.0 nm and r2 = 90.0 nm, respectively. Solid lines represent the analytical model, while dashed lines correspond to micromagnetic simulations. The green curve denotes the reference case without the HMR. The blue and orange curves correspond to cases where the HMR is magnetized perpendicularly downward and upward, respectively.

Poster Session

IN SEARCH OF THE SARMA PHASE - ANALYTICAL RESULTS FOR THE ATTRACTIVE HUBBARD MODEL IN AN EXTERNAL MAGNETIC FIELD

Maciej Bąk[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Recent advances in the control of ultracold atoms allow for the experimental realization of many solid-state theoretical models with almost arbitrary values of Hamiltonian parameters. In particular, we can prepare spin-imbalanced systems, where one can examine the stability of the superfluid phase competing with a natural tendency to magnetism in such systems. This competition seems to be inherent in many high-temperature superconductors. An interesting problem is the existence of the Sarma phase (a.k.a. interior gas superfluid, magnetized superfluid of breached pair phase) - a homogeneous superfluid with gapless fermionic excitations. Such a phase may appear not only in high-temperature superconductors but is also suspected in neutron stars [1,2]. Theoretically it can be obtained already on the mean-field level in the attractive Hubbard model in an external magnetic field - but only within a narrow range of parameters in three dimensions (3d) [3]; similar calculations in 2d show no such phase [4]. The present paper examines the existence of the Sarma phase in the attractive Hubbard model for the rectangular density of states (dos) - it reminds 3d-dos system, as it does not have a singularity, and allows for some analytic solutions, which may give better insight into the problem than the more realistic numerical results.

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MAGNETO-ROTATION COUPLING FOR FERROMAGNETIC NANOELEMENT EMBEDDED IN ELASTIC SUBSTRATE

Grzegorz Centała[1] and Jarosław W. Kłos[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

This study investigates magneto-rotational coupling [1,2] as a distinct contribution to magnetoelastic interactions, which can be influenced by magnetic anisotropy. We determine magneto-rotational coupling coefficients that incorporate the shape anisotropy of a magnetic nanoelement (strip) and demonstrate that this type of coupling can be modified through geometric adjustments [3]. Furthermore, we analyze the magneto-rotational contribution to the magnetoelastic field in a ferromagnetic strip embedded in a nonmagnetic substrate. Both Rayleigh and Love waves are considered sources of the magnetoelastic field, and we examine how the strength of the magneto-rotational coupling varies with the direction of the in-plane applied magnetic field. We found that in the absence of magnetocrystalline anisotropy the magneto-rotational contribution to the magnetoelastic field decreases with a reduction in the thickness-to-width ratio of the strip for a Rayleigh wave, whereas for a Love wave, it changes non-monotonically. These findings enhance the understanding of magneto-rotational coupling in magnonic nanostructures.

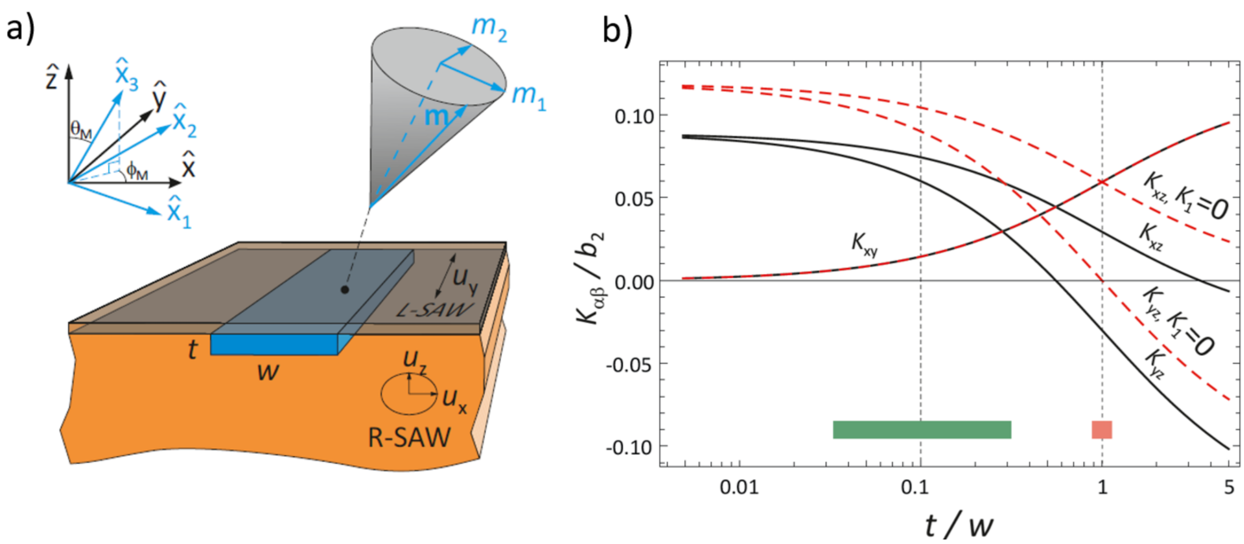

Fig. 1: (a) Magnetoelastic interaction between the fundamental mode of the precessing magnetization in a ferromagnetic strip (blue) and surface acoustic waves (SAW) propagating in a non-magnetic substrate (orange) along the x-direction, i.e. perpendicular to the strip. The interaction is not only due to the intrinsic magnetostriction of the ferromagnetic material but also caused by the magnetic anisotropy and related to the magneto-rotation coupling. (b) The coefficients $K_{\alpha\beta}$ for the magneto-rotation coupling as a function of the aspect ratio thickness/width (t/w) of the ferromagnetic strip. The calculation was performed for surface anisotropy $K_s = 1.05$ mJ/m^2, saturation magnetization $M_s = 1150$ kA/m and conventional magneto-elastic constant $b_2 = 7$MJ/m3. We have fixed the thickness of the strip $t = 5$ nm and varied its width w.

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RESERVOIR COMPUTING WITH THE USE OF MAGNONIC RESONATORS

Paweł Gruszecki[1], Mathieu Moalic[1], Nikodem Leśniewski[1,2], and Maciej Krawczyk[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *CNRS, Lab-STICC, UMR 6285, ENIB, 29238 Brest Cedex 3, France*

Reservoir computing is a computational framework derived from recurrent neural networks, where only the output layer is trained while the internal dynamics remain fixed. In classical reservoir computing, multiple input nodes are typically used, with each feature of the input data mapped to a separate node. An alternative approach, time-multiplexed reservoir computing, introduced by Appeltant et al., utilizes delay-based systems to efficiently process information using a single dynamical node [1]. This method encodes input signals into a temporal mask, which is then scaled and time-multiplexed into a single input stream. Multiplying the input signal with the temporal mask signal enhances the system's performance by introducing complexity and diversity into the input data. The nonlinear dynamics of the reservoir, often implemented using optical devices, enable efficient realization of complex tasks such as time-series prediction and classification [2]. More recently, this approach has also been explored in magnonics [3].

In this study, we apply time-multiplexed reservoir computing to a system consisting of a Yttrium Iron Garnet (YIG) film and a noncollinearly magnetized magnonic resonator. In this setup, spin waves are excited in the YIG film before reaching the resonator, and their transmission is measured after passing through it. Additionally, we leverage the fact that at higher input powers, the resonance frequency may depend on the amplitude of the incoming spin waves (so-called resonance frequency detuning). This induces a nonlinear system response, a key property for neuromorphic computing, including reservoir computing. Here, we present our results of numerical modelling and evaluate the feasibility of this system as a platform for magnon-based reservoir computing.

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DYNAMICS OF INTERPLAY BETWEEN SUPERCONDUCTING AND FERROMAGNETIC CORRELATIONS IN QUANTUM DOT SYSTEM

Antoni Jankiewicz[1], Kacper Wrześniewski[1], and Ireneusz Weymann[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

We theoretically explore the non-equilibrium dynamics of a single quantum dot system coupled to both ferromagnetic and superconducting electrodes. To investigate its time evolution, we utilize the time-dependent numerical renormalization group technique, which effectively captures the system's response to abrupt parameter changes. Our analysis focuses on dynamics following a sudden modification in the lead's coupling strength and shift of the orbital level.

In particular, we calculate the time evolution of the on-dot induced superconducting pairing correlations and magnetization, as well as transient Andreev current. The influence of ferromagnetic lead's polarization is thoroughly examined. Moreover, we study the behavior of the Loschmidt echo and the return function to find signatures of dynamical quantum phase transitions. The determined dependencies reveal non-trivial competition between relevant correlations and deepen our understanding of dynamical behavior of nanoscale hybrid systems.

SPIN WAVE DISPERSION IN ROTATING CYLINDRICAL WIRE

Dorian Lagreve[1] and Jarosław W. Klos[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

The effect of mechanical rotation of a medium on wave [1] or transport phenomena [2] arises from non-trivial changes induced by transitioning to a rotating reference frame. In this work, we investigate the impact of rotation on the dispersion relation of spin waves in a cylindrical magnonic wire.

Spin wave propagation in ferromagnetic wires, like other types of waves in waveguides with finite cross-section, exhibits a multimode character. The dispersion relation features multiple branches resulting from the quantization of the wave across the wire's cross-section. In our study, we focus on how mechanical rotation influences spin wave frequencies due to the presence of non-zero orbital angular momentum (OAM), which arises from quantization in the azimuthal (circumferential) direction. A similar phenomenon—frequency shifts in modes with non-zero OAM due to rotation of the wave source or medium—has been observed in acoustic systems.

We present analytical results extending previous studies on spin wave propagation in cylindrical geometries, emphasizing the role of rotation and OAM in shaping the dispersion relation.

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DOMAIN WALL MOTION DUE TO STRAY MAGNETIC FIELD FROM SPIN WAVES

Uladzislau Makartsou[1], Mateusz Zelent[1], Paweł Gruszecki[1], and Maciej Krawczyk[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

In this study, we use micromagnetic simulations [1, 2] to investigate the dynamics of a domain wall (DW) within a ferromagnetic Ni strip deposited on a yttrium-iron-garnet (YIG) thin film. The aim is to initiate and control the displacement of the DW by the stray magnetic field generated by spin waves (SW) propagating in the YIG layer. By comparing the ferromagnetic resonance (FMR) frequency spectra in the strip and a DW displacement over different SW frequencies (Fig. 1), we uncovered interesting correlations. Specifically, we found that at certain SW frequencies - 3.96 GHz and 6.26 GHz - the DW shows a pronounced shift up to 150 and 200 nm from the equilibrium position, and these frequencies coincide with selected resonance peaks in the FMR spectra. We attribute this effect to the spatial localisation of the SW oscillations exclusively in the DW at these frequencies. In contrast, at other FMR peaks, the SW amplitude is distributed throughout the strip or is restricted to end regions, and the resulting DW motion remains insignificant. Interestingly, when the stray magnetic field from the SWs is removed, the DWs return to equilibrium.

These findings are promising for the development compact memory and logic elements for magnonic circuits, laying the groundwork for SW data storage and processing units, including magnetic data flip-flops for sequential logic operations and magnonic artificial neural networks.

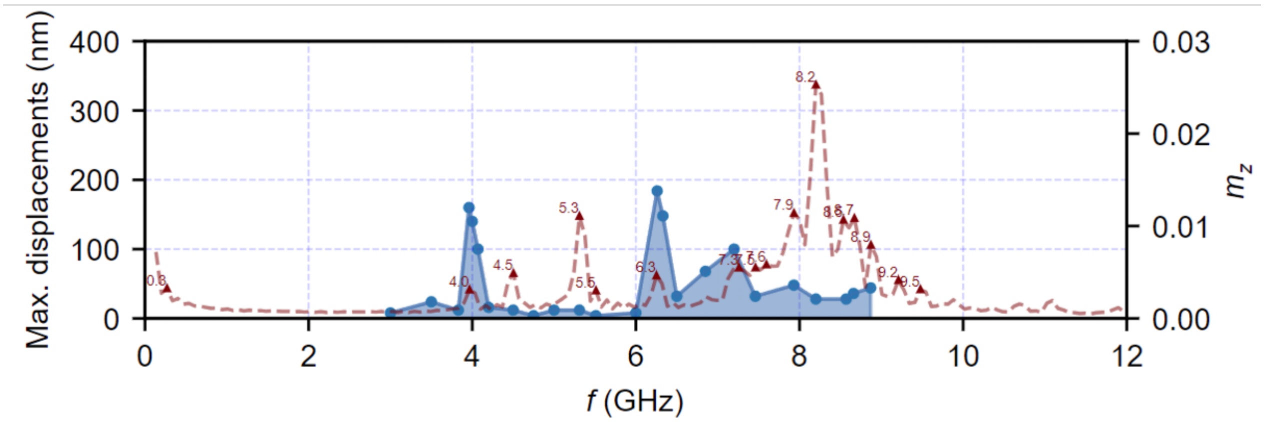

Fig. 1: DW displacement versus frequency (0–12 GHz) [blue data point and left axis], highlighting peaks at 3.96 GHz and 6.26 GHz where SW induce a significant shift of the DW. Red dashed line (and right axis) indicates FMR spectra in the Ni strip.

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GROUND STATE OF DOUBLE QUANTUM DOT ANDREEV MOLECULE

Kacper Wrześniewski[1], Peter Zalom[2] , Tomáš Novotný[3], and Ireneusz Weymann[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

[2] *Institute of Physics, Czech Academy of Sciences, Na Slovance 2, CZ-18200 Praha 8, Czech Republic*

[3] *Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Ke Karlovu 5, CZ-121 16 Praha 2, Czech Republic*

We study the phase diagram of a parallel double-quantum-dot Andreev molecule, where the two quantum dots are coupled to a superconducting lead. Using the numerical renormalization group method, we map out the evolution of the ground state across a wide parameter space of level detunings, size of the superconducting gap, lead couplings, and interdot coupling strength. The intricate phase diagrams feature singlet, doublet, and a relatively uncommon triplet ground states, with the latter being a distinct signature of strong lead-mediated interactions between the quantum dots.

We benchmark all commonly used effective models and find that, with the exception of the extended zero-bandwidth approximation, none accurately reproduce the triplet ground state and instead yield several false predictions. These findings provide crucial insights for interpreting experimental observations and designing superconducting devices based on quantum dots.

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RECONSTRUCTION OF TOPOLOGICAL SPIN TEXTURES IN FERROMAGENTIC NANODOTS USING A CONDITIONAL VARIATIONAL AUTOENCODER

Jakub Zwoniarski[1], Mateusz Zelent[1], and Maciej Krawczyk[1]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Magnetic spin textures that we are interested in are vortexes, out-of-plane and in-plane states and domain walls, which can stabilize in the ferromagnetic thin nanodot. Accurate reconstruction and classification of these magnetic textures is crucial for phase mapping and device design, but it remains challenging due to the enormous parameter space [2, 3]. For instance, a systematic variation of material or field parameters can produce thousands of distinct magnetization configurations that traditionally require manual analysis [2]. This difficulty motivates the use of machine-learning methods to automate this process [3].

In this work, we demonstrate a deep neural network approach for reconstructing and identifying spin textures. We train a convolutional conditional variational autoencoder (cVAE [5]) on scaled magnetization maps (300×300×3 grids) generated from micromagnetic simulations of thin-nanodot shape ferromagnets [4]. The cVAE learns a compact latent representation of each 2D magnetization configuration that characterize the target texture and is conditioned on two parameters, T_x, T_z, i.e., the radius and thickness of the nanodot. This enables us to specify the type of magnetic state and reliably reconstruct its full magnetization (M_x, M_y, M_z) structure.

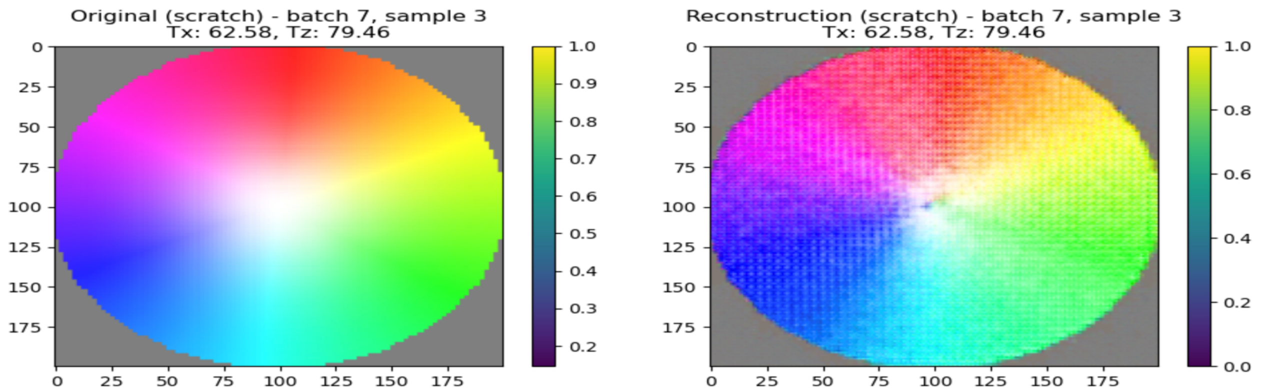

Fig. 1: Comparison between original and reconstructed spin textures for representative conditions (selected T_x, T_z values in nanometers): the cVAE-generated magnetization patterns reproduce the vortex's swirling profile and orientation with minimal error. These results confirm that the cVAE can maintain the correct topological charge of the spin textures during compression and decoding.

Our approach opens up several potential applications in magnetics. First, the trained cVAE can serve as a surrogate model for fast simulation – it can rapidly generate or predict magnetization patterns for given conditions, bypassing computationally expensive micromagnetic simulations [4]. Second, the latent space of the autoencoder provides a natural feature space for clustering and phase identification: distinct magnetization states (in-plane, out-of-plane, domain-wall, vortex, skyrmions, etc.) tend to form separate clusters, enabling automated phase recognition and phase diagram construction [3]. Third, this generative model can be utilized for material design or inverse problems: by tuning the conditional inputs and latent variables, one can explore novel magnetization configurations and potentially discover conditions (e.g. anisotropy, field) to realize a desired spin texture [1,3]. In summary, our cVAE-based framework combines micromagnetic simulations with deep learning to accurately reconstruct complex magnetic textures, offering a powerful tool for rapid analysis of magnetic states and guiding the design of future spintronic devices [1,2].

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Presenting authors