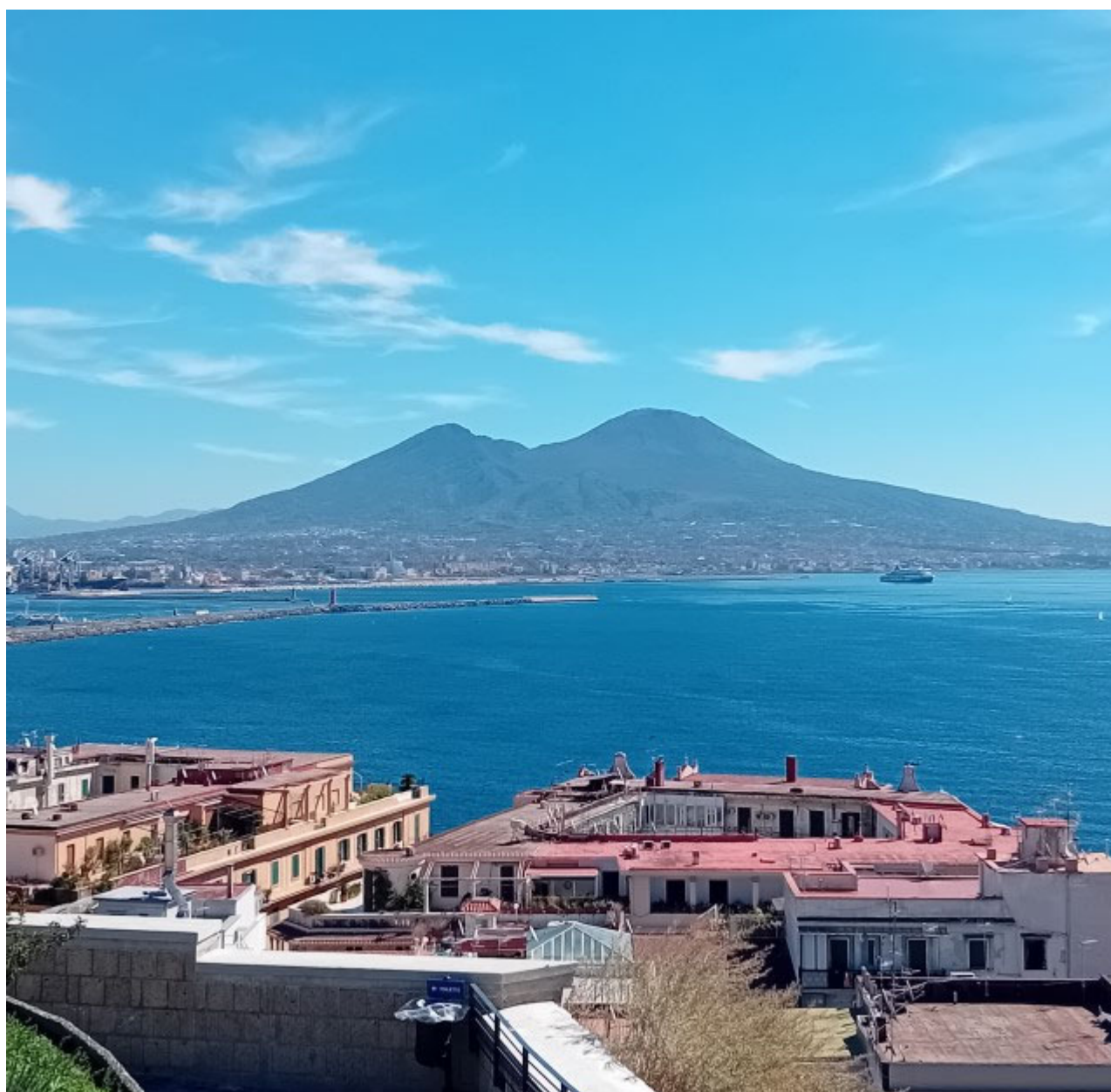


Abstract Book

International Conference on Superconducting Quantum Nanodevices and Materials for Coherent Manipulation

19-22 October 2026

Ischia, Italy





Aims and Scope

Quantum computation thrives in part thanks to the insight won in basic studies of superconductivity. The COST Action superqumap.eu, wishes to devote the last meeting to gather with experts in quantum computation and present the results obtained during the four years that the Action has been running. This meeting will include invited talks by Action members and talks by experts in quantum technologies based on superconducting and magnetic devices.

The COST Action Superqumap

The COST Action [SUPERQUMAP](#) is organized by researchers from all European countries and includes collaborators all over the world. Superqumap started in October 2021 and will continue until October 2026. Superqumap will significantly shape research in superconductivity by a series of instruments provided by the well proven COST Action system. These includes [two meetings a year](#), [short term scientific missions](#) and [support](#) to attend meetings organized by other entities in the same field. The [management committee](#) includes researchers from 29 countries, which share the common goal of advancing in the objectives of the Action. The approach is completely open to any researcher that can contribute to the objectives of the Action in [any country](#).

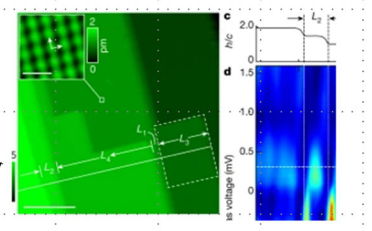
The Action superqumap aims to harness the results obtained recently in superconductivity and build a collaborative effort to provide radically new approaches to superconducting based quantum devices. Research has three main objectives:

- To synthesize, characterize, model and understand superconducting materials and devices using a collaborative approach including techniques and capabilities available all over Europe.
- To improve our understanding of superconductors at interfaces and in combination with other systems such as magnets and insulators.
- To achieve a disruptive advance in superconducting devices for quantum technologies.

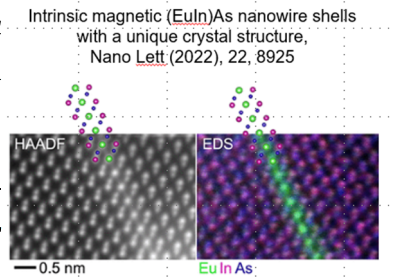
The work is organized in three work packages, which aid in shaping the meetings and networking activities in which researchers mutually benefit from complementary knowledge to advance in the objectives of the Action.

- Work package 1: Quantum materials
 - Obtain topological and triplet superconductivity by tuning correlations and the properties at interfaces.
 - Understand the relationship between electronic correlations, magnetism and unconventional superconducting properties.

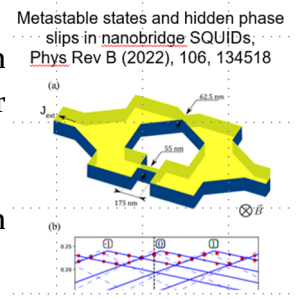
Quantum well states at the surface of a heavy-fermion superconductor, Nature (2023), <https://doi.org/10.1038/s41586-023-05830-1>



- Work package 2: New functionalities for sensors and devices
 - Control the degree of disorder in low dimensional and low carrier density superconductors.
 - Achieve a better understanding of electronic behavior between the extreme limits of infinity and zero resistance.
 - Understand transport in hybrid magnetic-superconducting devices and explore the behavior of junctions made of hybrid heterostructures.



- Work package 3: Building Quantum Systems.
 - Create and characterize novel two-level systems in superconducting junctions and devices suitable for quantum computation.
 - Design and test methods for their coherent manipulation in quantum devices.





Organizers

Organizing Committee

Halima Ahmad, University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Davide Massarotti, University of Napoli “Federico II”, Department of Electrical Engineering and Information Technology

Domenico Montemurro, University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Roberta Satariano, University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Nicola Poccia, University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Francesco Tafuri (Co-chair), University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Hermann Suderow (Co-chair), Universidad Autonoma de Madrid

Local Committee

Halima Ahmad, University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Davide Massarotti, University of Napoli “Federico II”, Department of Electrical Engineering and Information Technology

Domenico Montemurro, University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Roberta Satariano, University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Nicola Poccia, University of Napoli “Federico II”, Department of Physics “Ettore Pancini”

Scientific Advisory Committee

The [COST Action Management Committee](#).

Grant Manager and Support

Irene González Martín



Invited Speakers

Name	Organisation
Jan Aarts	Leiden Institute of Physics, Leiden University, The Netherlands
Halima Giovanna Ahmad	University of Napoli "Federico II", Italy
José J. Baldovi	Instituto de Ciencia Molecular, C/Catedrático Beltrán 2, Paterna, Valencia, Spain
Thilo Bauch	Quantum Device Physics Laboratory, Department of Microtechnology and Nanoscience, Chalmers University of Technology: Kemivägen 9, Göteborg, 41296, Sweden
Anna E. Böhmer	Experimental Physics IV, Ruhr-University Bochum
Adrian Crisan	National Institute of Materials Physics, 405A Atomistilor Str., 077125 Magurele, Romania
Szabolcs Csonka	Budapest University of Technology and Economics.
Giorgio Di Battista	Ludwig Maximilian University of Munich.
Oleksandr Dobrovolskiy	Cryogenic Quantum Electronics, EMG and LENA, Technische Universität Braunschweig, Germany.
Vladimir F. Fomin	Institute for Electronic Technologies, Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Helmholtzstraße 20, D-01069 Dresden, Germany.
Manuela Garnica	IMDEA Nanoscience.
Ali Gencer	Ankara University, Superconductor Technologies Application and Research Center, Ankara, Türkiye. Ankara University, Science Faculty, Physics Department, Ankara, Türkiye.
Adbou Hassanien	Jozef Stefan Institute, 39 Jamova, 1000, Ljubljana, Slovenia
Dima V. Geshkenbein	ETH Zurich
Danica Krstovska	Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University, Arhimedova 3, Skopje, 1000, Macedonia.
Chuan Li	MESA+ Institute for Nanotechnology, University of Twente, 7500 AE Enschede, The Netherlands
Florian Lombardi	Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-41296, Göteborg, Sweden
Fernando Luis	Instituto de Nanociencia y Materiales de Aragón (INMA, CSIC-Universidad de Zaragoza), Zaragoza, Spain
Riccardo Manenti	Rigetti Computing



Yurii Naidyuk	B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, Kharkiv, Ukraine
Tomas Novotný	Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic
Jon A. Ortuzar	Quantronics group, Service de Physique de l'État Condensé (CNRS, UMR 3680), IRAMIS, CEA-Saclay, Université Paris-Saclay, 91191 Gif-sur-Yvette, France
Elisabetta Palladino	Dipartimento di Fisica e Astronomia Ettore Majorana, University of Catania, INFN Sez Ct. INFN Sezione di Catania, Via Santa Sofia 64, Catania, Italy.
Cheryl Feuillet-Palma	Laboratoire de Physique et d'étude des Matériaux, ESPCI Paris, CNRS, PSL University, 75005 Paris, France.
Nicola Poccia	Department of Physics "Ettore Pancini", University of Naples Federico II, Complesso Universitario di Monte Sant'Angelo, Via Cinthia 21, 80126 Naples, Italy Leibniz Institute for Solid State and Materials Research Dresden (IFW Dresden), Helmholtzstraße 20, 01069 Dresden, Germany
Dimitri Roditchev	LPED, UMR-8213, ESPCI Paris - PSL, CNRS, Sorbonne University, F-75005 Paris, France.
Peter Samuely	Institute of Experimental Physics, Slovak Academy of Sciences, 04001 Košice, Slovakia
Roberta Satariano	Università degli Studi di Napoli « Federico II »
Alejandro Silhanek	Université de Liège.
M. P. Sørensen	Department of Applied Mathematics and Computer Science, Technical University of Denmark
Asle Sudbø	Norwegian University of Science and Technology.
Hermann Suderow	Universidad Autonoma de Madrid
Joris Van de Vondel	Quantum Solid-State Physics, Department of Physics and Astronomy, KU Leuven, Celestijnenlaan 200D, Leuven, B-3001, Belgium
Andrey A. Varlamov	Institute of Superconductivity and Innovative Materials (SPIN-CNR), Rome, Italy Istituto Lombardo "Accademia di Scienze e Lettere", via Borgonuovo, 25 - 20121 Milan, Italy
Javier E. Villegas	Laboratoire Albert Fert, CNRS, Thales, Université Paris-Saclay, 1 avenue Augustin Fresnel, 91767 Palaiseau, France
Shuqiu Wang	University of Bristol
Junting Zhao	Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark



Dijana Žilić	Ruđer Bošković Institute, Bijenička 54, 10000 Zagreb, Croatia
--------------	--



Program

Time		Monday 19 October	Tuesday 20 October	Wednesday 21 October	Thursday 22 October
8:30		Opening at 14h15 Chair:	Chair:	Chair:	Chair:
			Jan Aarts Vortex pinning in few-layer NbSe ₂	Dima Geshkenbein Pearl-Vortex Tunneling in Magic-Angle Twisted Graphene	Peter Samuely Hierarchy of Pairing and Interlayer Phase Coherence in a Natural Ising Superlattice



08:55			Elisabetta Paladino Circuit Quantum Electrodynamics with two-dimensional material-based Josephson Junctions	Szabolcs Csonka Realization of Andreev-molecules	Joris Van De Vondel Imaging Microwave Fields with a Scanning SQUID
09:20			Halima Giovanna Ahmad The UNINA Superconducting Quantum Computing Centre: first hardware-aware quantum algorithms, progresses and roadmap	Thilo Bauch Nanoscale YBCO Devices for Quantum Sensors and Detectors	Ali Gencer Interface Engineering in IMD-Processed MgB_2 : From Reaction Kinetics to High-Field Superconducting Transport



09:45			Chuan Li Inducing superconductivity in hinge states of Bi-based topological materials	Domenico Montemurro	Evagelia Moshopoulou
10:10		Coffee break			
			<i>Chair:</i>	<i>Chair:</i>	<i>Chair:</i>
10:45			José Baldovi Engineering Spins in Two Dimensions: From Magnonics to Molecular Altermagnets	Nicola Poccia TWISTED VAN DER WAALS CUPRATES: FROM PROTECTED QUBITS TO QUANTUM SENSING	Andrey Varlamov Fluctuation spectroscopy: Emergence of Abrikosov's



					Lattice approaching Hc2
11:10			Alejandro Silhanek Time-Resolved Thermal Susceptibility Mapping via Low-Temperature Scanning Laser Microscopy	Jon Ortuzar Hybridizing fermionic Andreev modes with bosonic circuit modes	Roberta Satariano Ferromagnetic Tunnel Josephson Junctions: A Route Towards Scalable Quantum Architectures
11:35			Manuela Garnica Microscopic Insights into Magnetically Doped Topological Insulators	Shuqiu Wang Spectroscopic imaging of intrinsic topological superconductivity in UTe ₂	Dimitri Roditchev Microscopic structure of the vortex cores in granular niobium:

Emergent phenomena in quantum materials and devices for unconventional superconducting systems



					A coherent quantum puzzle
12:00			Junting Zhao Phase Engineering in Ferromagnetic Josephson Junctions based on Epitaxial Al/EuS/2DEG Triple Hybrids	Abdou Hassanien Competition between Kondo screening and exchange coupling of spin states on Armchair Graphene Nanoribbons	Hermann Suderow STM in quantum materials
12:25			Idan Ofek Imaging Current Flow in the Electrically	François Martinet Magnetization Dynamics of Superconducting	Closing, Lunch Box and departure



			Induced Hidden State of 1T-TaS ₂	YBa ₂ Cu ₃ O _{7-δ} /Ni ₈₀ Fe ₂₀ Bilayers Under DC Current Injection	
12:35			Klinti Sinojmeri	Francesca Calloni Phase dynamics and transport properties in tunnel ferromagnetic Josephson junctions	
12:50		Lunch			
14:15		<i>Chair:</i>	<i>Chair:</i>	<i>Chair:</i>	
		Welcome by F. Tafuri			
14:25		Anna Böhmer Single-crystal growth and superconducting	Javier Villegas Dimensionality of vortex matter in the	Floriana Lombardi	



		properties in the Sr-Bi-Se system	superconducting infinite-layer nickelates	Nanoscale YBCO Devices for Quantum Sensors and Detectors	
14:50		Yurii Naidyuk Yanson Point-Contact Spectroscopy: What can we learn from it	Fernando Luis Wiring up molecular spins with superconducting circuits for quantum applications Nanowires Out of Equilibrium	Riccardo Manenti Scalable quantum computers with chiplet technology	
15:15		Cheryl Feuillet Palma Reversible control of superconductivity in NbN thin film	Giorgio Di Battista Transport studies and quantum sensing with magic-angle twisted bilayer graphene	Mads Peter Sørensen Bifurcation Phenomena in the Anisotropic BCS gap Equation	



15:40		Coffee break			
		Chair:	Chair:	Chair: Sara López-Paz	
16:10		Nathan Abezgaux Architecture and Vibration Characterization of a Low-Vibration 0.9K Dilution Refrigerator for Scanning SQUID-on-Tip Microscope	Alessandro Sarno Variational quantum circuits for hardware-aware transpilation	Pablo García Talavera Band structure and defects in FeSe under high magnetic fields	
16:20		Celia González-Sánchez Signatures of edge states in antiferromagnetic van	Deepti Rana Gate-tunable anomalous phase shift in ferromagnetic	Zlatomir Zhelev Ab initio-calculated double-electron exchange amplitudes and modulation of superfluid density by apical oxygen distance in in Bi ₂ Sr ₂ CaCu ₂ O _{8+x} as	



		der Waals Josephson junctions	hybrid Josephson junctions	crucial experiment for the pairing mechanism	
16h30		Vivek Kumar Nonlinear Microwave Dynamics in a Superconducting Nb Resonator			
16:40		Asle Sudbø Beyond Cooper-pairs: Higher order fermionic condensates	Oleksandr Dobrovolskiy Current decrowding and vortex trapping in superconducting 3D nanostructures	Kimberly Modic	



17:05		Adrian Crisan Interaction between vortex matter and Eu^{2+} spins in $\text{EuRbFe}_4\text{As}_4$ magnetic superconductor. Anomalous paramagnetic Meissner-like effect.	Tomas Novotny Generation of Autonomous Quantum Resources by Dissipative Quantum Systems	Danica Kristova The unconventional superconductivity of Sr_2RuO_4 — a new perspective on an old mystery	
17:30		Cocktail	Vladimir Fomin From quantum rings to three-dimensional nanoarchitectures: interplay between the quantum paradigm and topology	Dijana Zilic Low-dimensional magnetism in selected metal-organic frameworks and their intermediate compounds	
17:55			MC Meeting	Free Dinner in Ischia	

Emergent phenomena in quantum materials and devices for unconventional superconducting systems



18:45		Free Dinner in Ischia	Free Dinner in Ischia		
-------	--	-----------------------	-----------------------	--	--



Abstracts- Invited



Vortex pinning in few-layer NbSe₂

J. Zhang¹, S. Bhattacharyya¹ and J. Aarts^{1*}

¹Leiden Institute of Physics, Leiden University, The Netherlands.

*Presenting author: aarts@physics.leidenuniv.nl

Single crystalline NbSe₂ is well known to contain few defects, and the vortex lattice (VL) will be pinned through a collective mechanism. For crystals with a thickness in the micron range, the collective pinning is 2D in character, and vortex lattice melting can be observed. Decreasing the thickness d , the typical pinning critical current increases, suggesting that surface pinning takes over from bulk pinning [1]. We have confirmed this behavior in our current study. However, in the few-layer regime we find deviations from the inverse-thickness scaling, suggesting that the nature of the superconductivity of the surface layer has changed. This is reminiscent of the behavior of the Pearl length when NbSe₂ transits into the few-layer regime [2], although the magnetic fields at which these various experiments are performed, are widely different. This will be discussed.

[1] J. Kopp, D. J. Huntley and R. F. Frindt, Critical Currents in NbSe₂: Evidence for Surface Pinning, *Can. Jn. of Physics* **50**, 2840 (1972).

[2] N. Fridman *et al.*, Anomalous thickness dependence of the vortex Pearl length in few-layer NbSe₂, *Nature Comm* **16**, 2696 (2025).



The UNINA Superconducting Quantum Computing Centre: first hardware-aware quantum algorithms, progresses and roadmap

H. G. Ahmad^{1*}, C. Cosenza¹, V. Stasino¹, A. Sarno¹, A. Pizza¹, A. P. Italiano¹, F. Tafuri¹, and D. Massarotti²

¹University of Napoli “Federico II”, Department of Physics “Ettore Pancini”, via Cinthia, 80126 Napoli, Italy.

²University of Napoli “Federico II”, Department of Electrical Engineering and Information Technology, via Claudio, 80125 Napoli, Italy.

*Presenting author: halimagiovanna.ahmad@unina.it

The engineerable quantum macroscopic and artificial nature of superconducting quantum platforms [1], also recognized by the recent Nobel prize to Clarke, Martinis and Devoret, has favored noticeable advancements towards both quantum utility in the Noisy and Intermediate Scale Quantum (NISQ) era and quantum error correction for fault-tolerant quantum computing [2-5]. Nevertheless, the incredibly fast development of superconducting quantum computers prevents their use as “black boxes” to unlock their full potential in the NISQ era [6]. In this work, we discuss the strategy pursued to build the UNINA superconducting quantum computing center, the milestones to achieve an open and upgradable modular multi-node quantum computing system made of a 64-qubit superconducting Quantum Processing Unit (sQPU) (“Partenope”) and a 25-qubit sQPU (“Ligea”), and our roadmap. We will focus on the experimental study of quantum coherent processes in superconducting quantum processors with an increasing number of qubits, e.g., the study of quantum computational resources such as the well-known superposition, entanglement, and the more advanced and less standard magic, a computational resource that provides true quantum advantage [7,8]. We demonstrate that a full knowledge of the hardware at hand, especially regarding the impact of noise in superconducting quantum devices, is a tool to develop quantum algorithms in the NISQ era under realistic conditions. We do so by discussing the very first quantum algorithms run by the UNINA group, e.g., in use-case applications in quantum finance [9] and quantum optimization.

[1] M. Devoret *et al.*, *Phys. Rev. Lett.* **53**, 1260 (1984).

[2] F. Arute *et al.*, *Nature* **574**, 505–510 (2019)

[3] Y. Kim *et al.*, *Nature* **618**, 500–505 (2023)

[4] Google Quantum AI and Collaborators. *Nature* **638**, 920–926 (2025).

[5] Google Quantum AI and Collaborators. *Nature* **646**, 825–830 (2025).

[6] A. Sarno *et al.*, under review (2026).

[7] H. G. Ahmad *et al.*, under editorial consideration. arXiv:2511.15576 (quant-ph) (2026).

[8] V. Stasino *et al.*, under preparation

[9] H.G. Ahmad *et al.*, *IEEE Transactions on Quantum Engineering* **7**, 3103316-3103316, 2026, Art no. 3103316.



Engineering Spins in Two Dimensions: From Magnonics to Molecular Altermagnets

José J. Baldoví^{1*}

¹*Instituto de Ciencia Molecular, C/Catedrático Beltrán 2, Paterna, Valencia, Spain*

Presenting Author: j.jaime.baldovi@uv.es

The recent isolation of two-dimensional (2D) magnets offers tantalizing opportunities for spintronics, magnonics and quantum technologies at the limit of miniaturization. [1] In this presentation, I will provide an overview of our recent results on this fascinating topic. First, we will take advantage of the outstanding deformation capacity of 2D materials to answer the question: Can we use strain engineering to control spin waves propagation? [2] For that, we will focus on the magnetic properties of the air-stable 2D magnetic semiconductor CrSBr, investigating their evolution under mechanical strain using first-principles. Then, we will introduce the modulation of the magnetic properties, magnon dispersion and spin dynamics of this 2D magnet after the deposition of sublimable organic molecules, molecular spin qubits and spin-crossover molecules in a journey towards molecular controlled magnonics. [3, 4, 5] We will delve into the origin of the high T_C of Fe_3GaTe_2 [6] and, finally, we will introduce a coordination-driven chemical strategy to realize altermagnetic spin splitting in 2D metal-organic frameworks, enabling the rational design of 2D molecular materials with tunable altermagnetic properties for next-generation spintronic devices.[7,8,9]

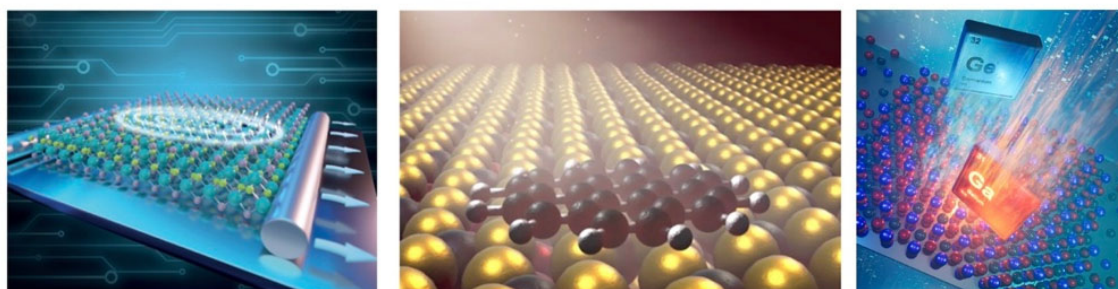


Figure 1: Artistic representation of (left) magnon straintronic device showing the chemical structure of CrSBr; (center) an irradiated coronene molecule on the surface of a 2D magnetic material; (right) formation of a Fe_3GaTe_2 single-layer representing the enhancement of T_C with respect to Fe_3GeTe_2 .

- [1] B. Huang *et al.*, *Nature*, 546, 270–273 (2017).
- [2] D. L. Esteras, A. Rybakov, A.M. Ruiz, J.J. Baldoví, *Nano Lett.*, 22, 8771–8778 (2022).
- [3] A. M. Ruiz, G. Rivero-Carracedo, A. Rybakov, S. Dey, J.J. Baldoví, *Nanoscale Adv.*, 6, 3320–3328 (2024).
- [4] S. Dey, G. Rivero-Carracedo, A. Shumilin, C. Gonzalez-Ballester, J.J. Baldoví, *Nano Lett.*, 25, 10457–10464 (2025).
- [5] A. Shumilin, S. Dey, D. Coltuneac, L. Stoleriu, J.J. Baldoví, *Adv. Mater.* 38(51), e23690 (2026).
- [6] A.M. Ruiz, D.L. Esteras, D. López-Alcalá, J.J. Baldoví, *Nano Lett.*, 24, 7886–7894 (2024).
- [7] D. López-Alcalá, A.M. Ruiz, A. Shumilin, J.J. Baldoví, *J. Am. Chem. Soc.* 148(25), 25415–25425 (2026)
- [8] D. López-Alcalá, A. Shumilin, J.J. Baldoví, *J. Am. Chem. Soc.* 148(26), 27008–27022 (2026).
- [9] D. López-Alcalá, A.M. Ruiz, A. Shumilin, J.J. Baldoví, *J. Am. Chem. Soc.* DOI: 10.1021/jacs.6c15502 (2026).



Nanoscale YBCO Devices for Quantum Sensors and Detectors

T. Bauch^{1*}, A. Garibaldi¹, N. A. Herraiz¹, E. Tralbaldo¹, A. Kalaboukhov¹, R. Arpaia¹, J. F. Schneidman², D. Winkler¹, F. Lombardi¹

¹Quantum Device Physics Laboratory, Department of Microtechnology and Nanoscience, Chalmers University of Technology: Kemivägen 9, Göteborg, 41296, Sweden

²Institute of Neuroscience and Physiology, Sahlgrenska Academy, The University of Gothenburg: Box 430, Gothenburg, 40530, Sweden

*Presenting Author: bauch@chalmers.se

Recent advances in nano-patterning of high critical-temperature (high- T_c) superconductors have enabled simpler, more versatile, and highly sensitive quantum devices, such as SQUID magnetometers, THz mixers, and single photon detectors. Conventional approaches using bicrystal and step-edge Josephson junctions, developed in the 1980s and 1990s, rely on complex epitaxy and multilayer structures that limit performance and design flexibility. Our nanoscale Dayem bridges [1] and novel grooved Dayem-bridge (GDB) [2] process addresses these limitations, offering an effective alternative. We present SQUID magnetometers based on GDBs that match or exceed the low-noise performance of conventional SQUIDs at moderate temperatures (~ 77 K). This enables applications like magnetoencephalography (MEG) with sensor placement within 1 mm of the scalp, capturing stronger neuromagnetic signals and improving imaging resolution [3]. Additionally, we demonstrate THz harmonic frequency mixing using a YBCO nanobridge with cross section 70×50 nm² integrated with a spiral broadband antenna. At 1.2 THz ($\times 12$ mixing), with ~ 1 μ W input and operating at 77 K and 60 K, the device achieved a 20 dB SNR at 1 Hz bandwidth [4]. These results highlight the suitability of nanowire-based devices for high-frequency detection. Finally, we report dark count observation in ultra-thin (10 nm) YBCO nanowire single photon detectors below 20K [5]. The high critical current density leads to hysteretic current voltage characteristics (IVCs), enabling bistable switching and revealing fluctuation induced dark pulses. This marks a milestone toward developing YBCO based quantum detectors for high temperature operation.

[1] Nawaz S. *et al.*, Microwave Response of Superconducting YBa₂Cu₃O₇ Nanowire Bridges Sustaining the Critical Depairing Current: Evidence of Josephson-like Behavior, *Phys. Rev. Lett.* **110**, 167004 (2013).

[2] Tralbaldo E. *et al.*, Grooved Dayem Nanobridges as Building Blocks of High-Performance YBa₂Cu₃O₇ - δ SQUID Magnetometers, *Nano letters* **19**, 1902 (2019).

[3] Pfeiffer C. *et al.*, A 7-Channel High- T_c SQUID-Based On-Scalp MEG System, *IEEE Transactions on Biomedical Engineering* **67**, 1483 (2020).

[4] N. Alcalde-Herraiz *et al.*, THz Mixing of High-Order Harmonics Using YBa₂Cu₃O₇ - δ Nanobridges, *Appl. Phys. Lett.* **128**, 082601 (2026).

[5] Ejrnaes M. *et al.*, Observation of dark pulses in 10nm thick YBCO nanostrips presenting hysteretic current voltage characteristics, *Supercond. Sci. Technol.* **30**, 12LT02 (2017).



Single-crystal growth and superconducting properties in the Sr-Bi-Se system

Max Brückner¹, Jule Kirschke¹, Ashiwini Balodhi¹, Paula Obladen², Edwin Herrera², Isabel Guillamón², Christoph Flathmann³, Liran Wang⁴, Frédéric Hardy⁴, Christian Liebscher³, Hermann Suderow², Elena Hassinger⁴, Andreas Kreyssig¹, and Anna E. Böhmer^{1*}

¹*Experimental Physics IV, Ruhr-University Bochum*

²*Laboratorio de Bajas Temperaturas y Altos Campos Magnéticos, Unidad Asociada UAM-CSIC, Condensed Matter Physics Center (IFIMAC), Instituto Nicolás Cabrera (INC), Departamento de Física de la Materia Condensada, Universidad Autónoma de Madrid*

³*Faculty of Physics and Astronomy, Ruhr-University Bochum*

⁴*Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology*

*Presenting Author: boehmer@physik.ruhr-uni-bochum.de

Bi₂Se₃ is a topological insulator in which Sr-intercalation has been reported to induce superconductivity with an unexpected two-fold anisotropy of the upper critical field, H_{c2} , in the basal plane. SrBi₂Se₄ is a recently discovered quasi-one dimensional superconductor that offers a promising platform for exploring exotic superconductivity in low-dimensional systems. We study the formation of the two phases from the melt and examine different single-crystal growth conditions. Using self-flux growth, we obtain free-standing single crystals. We present the characterization of superconductivity of high-quality SrBi₂Se₄ via transport, heat capacity and tunneling spectroscopy measurements. The hexagonal SrBi₂Se₄ is found to be a bulk superconductor below $T_c = 2.6$ K, with an anisotropic H_{c2} of approximately 6 T along the c axis, and approximately 1.5 T in the plane.

We acknowledge support from the European Research Council through Project 101040811, Distort-to-Grasp, and from the Deutsche Forschungsgemeinschaft (DFG) under CRC/TRR 288 (Project A02).



Interaction between vortex matter and Eu^{2+} spins in $\text{EuRbFe}_4\text{As}_4$ magnetic superconductor. Anomalous paramagnetic Meissner-like effect.

Adrian Crisan^{1,*}, Alina M. Badea (Ionescu)¹, Ion Ivan¹, Armando Galluzzi² and Massimiliano Polichetti²

¹National Institute of Materials Physics, 405A Atomistilor Str., 077125 Magurele, Romania

²Department of Physics “E.R. Caianiello”, University of Salerno, Via Giovanni Paolo II, 132, 84084 Fisciano, Italy

*Presenting Author: acrisan652@gmail.com

Magnetic superconductor $\text{EuRbFe}_4\text{As}_4$ is a quite unique system in which macroscopic superconductivity and magnetic ordering coexist, with interesting interactions between Abrikosov vortices and Eu^{2+} spins that were investigated mostly by static (DC) magnetization measurements. Our aim is to study the dynamic interactions between the two sub-systems using AC susceptibility measurements in a wide range of temperatures and superimposed DC fields. In low DC fields, the magnetic transition at 15 K is clearly visible. We have observed very little difference between the AC susceptibility in different cooling regimes, but large difference for different field orientation. For field perpendicular to the superconducting planes, we have observed an anomalous dependence just below the critical temperature, which is absent in the parallel field orientation. We explained the anomaly by the interplay between the sample dimensions and the temperature dependence of the London penetration depth which may allow the paramagnetic Meissner-like response to be detected in the temperature dependence of the AC susceptibility. We stress that the newly reported phenomenon reflects an AC-susceptibility manifestation of a field-stabilized critical state rather than a thermodynamic phase. In addition, we have observed a paramagnetic AC response in the normal phase, in both field orientations, indicative of interactions between Eu^{2+} spins and flux lines. The anomaly was also observed in the temperature dependence of third harmonic susceptibility. From frequency and AC field amplitude dependence of the out-of-phase AC susceptibility we have also determined the critical current density and pinning potential.



Realization of Andreev-molecules

S. Csonka^{1*}

¹ Budapest University of Technology and Economics.

*Presenting author: csonka.szabolcs@ttk.bme.hu

Topological superconductivity provides a promising platform to realize fault tolerant quantum hardware. The simplest topological superconducting system is the Kitaev-model, which is a chain of localized sites where neighboring ones are coupled by superconducting pairing and direct tunneling. Since state-of-the-art semiconducting nanostructures allows to create artificial atoms and tunnel couple them or interconnect by superconductors, the basic ingredients are available to build up artificial chains, which we call superconducting artificial molecule, or Andreev-molecule. Very recently various realizations of such chains have been reported where the sites are coupled in different ways, e.g. via superconducting vacuum, superconducting bound state, or superconducting artificial atom. We will present experimental realization of two types of Andreev-molecules: i) the analog of H_2 molecule, where two artificial atoms are tunnel coupled via a superconducting vacuum [1] and ii) the analog of H_2O molecule, where two artificial atoms are coupled via a 3rd superconducting atom [2].

[1] O. Kürtössy *et al.*, *Nano Lett.* **21**, 7929 (2021).

[2] O. Kürtössy *et al.*, *Nano Lett.* **26**, 8, 2797 (2026).



Transport studies and quantum sensing with magic-angle twisted bilayer graphene

G. Di Battista^{1*}

¹Ludwig Maximilian University of Munich.

*Presenting author: giorgio.dibattista@lmu.de

Magic-angle twisted bilayer graphene (MATBG) hosts a rich phase diagram arising from the interplay of flat bands, electronic correlations, and topology. However, microscopic device details, including twist-angle inhomogeneity and strain, can produce substantial device-to-device variability, obscuring which features are universal and which are sample-specific. In this talk, I will present recent advances in MATBG fabrication that improve twist-angle control and device homogeneity [1], together with a systematic transport study of 18 devices fabricated using the same protocol [2]. Comparison across the ensemble reveals two highly reproducible metallic states that are difficult to resolve in individual devices. In particular, we identify a dome-shaped metallic region directly above the superconducting domes. Its filling range, characteristic temperature scale, and magnetic-field response coincide with those of the “outer gap” recently observed spectroscopically, suggesting a common electronic origin. Finally, I will discuss the potential of MATBG for quantum sensing, enabled by its low carrier density and ultralow electronic heat capacity [3]. In a proof-of-principle experiment, we use a voltage-biased MATBG device near its superconducting transition to detect individual infrared photons [4]. The absorption of a single photon triggers the breakdown of superconductivity, demonstrating the exceptional sensitivity of MATBG and its potential as a platform for moiré-based quantum sensing.

[1] J. Díez-Mérida *et al.*, “High-yield fabrication of bubble-free magic-angle twisted bilayer graphene devices with high twist-angle homogeneity,” *Newton* **1**, 100007 (2025).

[2] G. Di Battista *et al.*, In preparation

[3] G. Di Battista *et al.*, “Revealing the Thermal Properties of Superconducting Magic-Angle Twisted Bilayer Graphene,” *Nano Letters* **22**, 6465–6470 (2022).

[4] G. Di Battista *et al.*, “Infrared Single-Photon Detection with Superconducting Magic-Angle Twisted Bilayer Graphene,” *Science Advances* **10**, eadp3725 (2024).



Current decrowding and vortex trapping in superconducting 3D nanostructures

O. Dobrovolskiy^{1*}

¹*Cryogenic Quantum Electronics, EMG and LENA, Technische Universität Braunschweig, Germany.*

**Presenting author: oleksandr.dobrovolskiy@tu-bs.de*

3D shaping provides a powerful route to control current flow and vortex dynamics in superconducting nanoarchitectures. Using time-dependent Ginzburg-Landau modeling, we show that curved and constricted superconducting geometries redistribute current, suppress geometric current crowding, and enable field-tunable critical currents approaching the depairing limit. Curvature additionally converts a uniform magnetic field into a spatially nonuniform normal component, creating reconfigurable pinning landscapes that allow the number and position of trapped vortices to be controlled by field orientation. The resulting asymmetric vortex nucleation and trapping give rise to non-reciprocal critical currents and superconducting diode effects, while finite thickness enables intrinsically 3D vortex processes, including apex-mediated vortex entry and filament splitting. These results establish 3D geometric engineering as a general strategy for controlling current distributions, vortex nucleation, pinning, and transport in superconducting nanodevices.

- [1] I. Bogush, O. Dobrovolskiy, Geometry-induced current decrowding in superconducting 3D constrictions, arXiv:2609.08349.
- [2] I. Bogush, V. Fomin, O. Dobrovolskiy, Trapping magnetic flux quanta in superconducting 3D caps, arXiv:2610.xxxxx.



From quantum rings to three-dimensional nanoarchitectures: interplay between the quantum paradigm and topology

V. M. Fomin^{1,2*}

¹*Institute for Electronic Technologies, Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Helmholtzstraße 20, D-01069 Dresden, Germany.*

²*Department of Physics and Engineering, Moldova State University, str. A. Mateevici 60, MD-2009 Chişinău, Republic of Moldova.*

*Presenting author: v.fomin@ifw-dresden.de

Quantum rings are a state-of-the-art class of high-tech nanostructures, which provide a unique playground for the quantum-mechanical paradigm and topological physics [1]. I will discuss several recent theoretical and experimental advances concerning the interplay between the quantum paradigm and topology as manifested in systems ranging from quantum rings to three-dimensional nanoarchitectures. The free-electron confinement model is applied to obtain an analytical description of the structure and topology, in reciprocal space, of free electrons confined in a quantum ring. A larger number of topological transitions is found in a quantum ring compared to the case of a thin film. It is possible to deduce analytical formulae for the electronic DOS, for the Fermi energy, and, subsequently, for the superconducting critical temperature, as a function of the geometric parameters. The exactly solvable mathematical model features two topological transitions in the Fermi surface upon shrinking the quantum ring size either along its axis of revolution or in the plane orthogonal to it. These topological transitions are manifested through a kink and a discontinuity in the density of states of the quantum ring. The superconducting critical temperature varies non-monotonically with the dominant confinement size and exhibits a prominent maximum, whereas it is a monotonically increasing function of the other, non-dominant, length scale. Effects of a bias electric current are investigated in a spin-triplet superconducting ring in a magnetic field. The bias current can stabilize a half-quantum-flux state via couplings to the Zeeman field and the dipole-type spin-orbit interaction. The latter effect becomes active when the magnetic field is tilted from the ring axis. The emergence of the half-quantum-flux state is manifested as a field-induced half-quantum shift in the Little-Parks oscillation in the critical current. [3]. An interplay between the double-connectedness of a quantum ring, leading to the occurrence of a geometric phase, and the topology inherent in the unconventional superconducting materials, opens up a novel perspective to understand the nature of superconductivity in them and to design new quantum-interference devices. In superconductor open nanotubes and nanohelices, a topological transition between the vortex and phase-slip regimes determines the transport characteristics revealing a nontrivial topology of superconducting screening currents [4]. In a densely packed W–C nanoarray fabricated using FIBID [5], in addition to vortex pinning, periodic magnetoresistance oscillations may be associated with magnetic flux quantization effects and interference of circulating supercurrents within the periodic structure. In direct written superconductor W–C nanobridges, a strong anisotropy of the critical magnetic field gives rise to the reconfigurable coexistence of superconducting and normal states. In this regime of nano-superconductivity, the vortex state can be designed and manipulated by geometric confinement [6]. These findings highlight the potential of three-dimensional nanoarchitectures as a prospective platform for quantum technologies [7]. I acknowledge support from the COST Action CA21144 (SuperQuMap) and ZIH TU Dresden.

[1] V. M. Fomin (Editor), *Physics of Quantum Rings*, 3rd edition, Springer Nature Switzerland, Cham, 2025, 621 p.



- [2] E. Landrò, V. M. Fomin, A. Zacccone, *Eur. Phys. J. B* **98**, 7 (2025).
- [3] K. Aoyama, *Phys. Rev. B* **108**, L060502 (2023).
- [4] R. Córdoba, V. M. Fomin, Curved 3D Superconducting Nanoarchitectures: Vortex Physics, to be published in P. Gentile, D. Makarov, C. Ortix (Editors), Effects of Curvature in Condensed Matter Physics, Springer Nature Switzerland, Cham, 2027.
- [5] A. Arroyo-Fructuoso, G. Hlawacek, V. M. Fomin, R. Córdoba, *APL Quantum* **3**, 016108 (2026).
- [6] E. Zhakina *et al.*, *Adv. Funct. Mater.* **35**, 2506057 (2025).
- [7] O. Dobrovolskiy *et al.*, *Sup. Sci. Technol.* **39**, 023502 (2026).



Microscopic Insights into Magnetically Doped Topological Insulators

M. Garnica^{1*}

¹IMDEA Nanoscience.

*Presenting author: manuela.garnica@imdea.org

Magnetic topological insulators (MTIs) constitute a versatile platform to explore the interplay between non-trivial band topology and magnetic order. The introduction of magnetic dopants enables the breaking of time-reversal symmetry (TRS), leading to the opening of a gap in the Dirac-like topological surface states (TSS). This gap is a key requirement for realizing exotic quantum phenomena such as the quantum anomalous Hall effect (QAHE), characterized by dissipationless edge transport. Despite significant progress, achieving robust QAHE at elevated temperatures remains a central challenge [1]. In this talk, I present a comparative study of different approaches to induce and control magnetism in topological insulators, focusing on both intrinsically magnetic systems and externally doped compounds. In particular, we investigate the antiferromagnetic topological insulator $\text{Mn}_2\text{Bi}_4\text{Te}_7$ [2], as well as rare-earth-doped Bi_2Te_3 [3] and Sb_2Te_3 . Using a combination of surface-sensitive techniques, including angle-resolved photoemission spectroscopy (ARPES) and scanning tunneling microscopy (STM), we analyze how magnetic order and dopant incorporation influence the TSS. These findings open a viable pathway toward achieving the QAHE and integrating MTIs into spintronic technologies.

[1] J. Liu and T. Heshedal, *Advanced Materials* **35**, 2102427 (2021).

[2] M. Garnica *et al.*, *npj Quantum Materials* **7**, 7 (2022).

[3] B. Muñiz Cano *et al.*, *Advanced Materials* **38**, 51 (2026): e10877.



Interface Engineering in IMD-Processed MgB₂: From Reaction Kinetics to High-Field Superconducting Transport

A. Gencer^{1,2*}, C. Guo³, F. Almokdad⁴, F. Ervuz¹, H. Koralay⁵, Y. Oznal^{1,8}, S. Safran^{1,2}, S. Salahi⁶, A. Seçkin⁷, K. Sonmez^{1,4}, S. C. Taskin¹, D. Wang³, and Y. Ma³

¹Ankara University, Superconductor Technologies Application and Research Center, Ankara, Türkiye.

²Ankara University, Science Faculty, Physics Department, Ankara, Türkiye.

³Chinese Academy of Sciences, Institute of Electrical Engineering, Key Laboratory of Applied Superconductivity, Beijing 100190, Peoples Republic of China.

⁴Ankara University, Graduate School of Natural and Applied Sciences, Ankara, Türkiye.

⁵Gazi University, Science Faculty, Physics Department, Ankara, Türkiye.

⁶Gazi University, Department of Metallurgical and Materials Engineering, Ankara, Türkiye.

⁷Gazi University, Basic and Engineering Sciences Central Laboratory Application and Research Center (GUTMAM), Ankara, Türkiye.

⁸Ankara University, Elmadag Vocational School, Electronics and Automation Department, Ankara, Türkiye.

*Presenting author: Ali.Gencer@science.ankara.edu.tr

MgB₂ superconducting wires continue to attract interest for high-field applications because of their relatively high critical temperature, low raw-material cost, and potential for scalable conductor fabrication. In the Internal Mg Diffusion (IMD) process, the diffusion of Mg and the formation of a dense and homogeneous MgB₂ layer strongly influence the final superconducting performance. In this study, thin metallic coatings applied to the central Mg source were investigated as low-temperature activators to control the Mg–B reaction and improve the microstructural and superconducting properties of IMD-processed MgB₂ wires. Monofilamentary wires were first fabricated using Mg rods coated with 200 nm Cu, Sn, and Ag layers in order to compare the effects of different metallic activators on Mg diffusion and MgB₂ phase formation. Following this comparison, Cu was further investigated by varying the coating thickness from 200 to 800 nm to examine its influence on reaction kinetics and the possibility of promoting MgB₂ formation at reduced heat-treatment temperatures and reaction times. The role of carbon addition was also considered, with 4% C-coated B showing improved critical current density at fields below 7 T, while higher carbon content provided an advantage in transport measurements at 10 T. The reaction behavior and microstructural evolution of the fabricated wires were examined by differential thermal analysis (DTA), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS). Their superconducting properties were evaluated through resistance–temperature measurements under magnetic fields up to 9 T, allowing the field-dependent superconducting transition, upper critical field (H_{c2}), and irreversibility field (H_{irr}) to be assessed. Transport critical-current measurements were additionally carried out at 4.2 K and 10 T. Among the monofilamentary conductors, the 200 nm Cu-coated wire exhibited the highest transport J_c , reaching 3.9×10^4 A/cm². Based on the optimized Cu-assisted IMD approach, the fabrication process was subsequently extended to a seven-filament architecture. The resulting multifilamentary MgB₂ wires achieved transport J_c values of up to 1.2×10^5 A/cm² at 4.2 K and 10 T. These results demonstrate that controlled modification of the Mg surface can effectively influence MgB₂ formation and high-field current-carrying performance, while the successful transition from monofilamentary to multifilamentary conductors highlights the potential of the approach for scalable, high-performance MgB₂ wire development.



Competition between Kondo screening and exchange coupling of spin states on Armchair Graphene Nanoribbons

Stefan Šćepanović^{1,3}, Amina Kimoche², Jovan Mirković³ and Abdou Hassanien^{1*}

¹ Jozef Stefan Institute, 39 Jamova, 1000, Ljubljana, Slovenia

² Institute of Physics and Astronomy, University of Potsdam, 14476, Potsdam, Germany

³ Faculty of Sciences, University of Montenegro, 81000, Podgorica, Montenegro

*Presenting Author: abdou.hassanien@gmail.com

Inducing magnetic states in 7-atom wide armchair graphene nanoribbon (7-AGNR) leverage its potential not only for fundamental interest but also for applications such as spintronics and quantum information processing. With a low decoherence channel, 7-AGNR can be used as a platform to realize delocalized magnetic states and manipulate their coupling strength. Using scanning tunneling microscopy methods, we explore two different strategies to achieve these goals; namely via hydrogen abstraction or molecular magnets bonded to the terminus or physisorbed in the bulk of 7-AGNRs. At the terminus, we observe two delocalized Kondo resonances that decay asymptotically along the armchair direction and across the ribbon width. The tunnelling spectroscopy measurements reveal a nonvanishing local density of states associated with Kondo effect in region between the peripheral atoms, suggesting the presence of exchange coupling and potential spin ordering. Although thermal decoherence weakens the signal intensity, temperature dependence shows that the interaction effects remain detectable at a relatively high temperature of 14 K. At the bulk of AGNR, the interaction of two spin states can be manipulated through coupling with microenvironment. We demonstrate this by using self-assembly of physisorbed quantum magnets on 7-AGNR and 14-AGNR. As the coupling strength of the two delocalized moments could be tuned by electric field, this system offers great potential for quantum information processing.

- [1] Šćepanović, S., Kimouche, A., Mirković, J. *et al.* Delocalized spin states at zigzag termini of armchair graphene nanoribbon. *Sci Rep* 14, 11641 (2024).
- [2] Hassanien, A., Robust Contact by Direct Formation of C-Au Bond in Suspended Armchair Graphene Nanoribbon. *Phys. Status Solidi RRL*, 18: 2470030 (2024)
- [3] Šćepanović S., López-Alcalá D., Baldoví José J., Vahl A., Hassanien A. *Phys. Status Solidi RRL*. ; 19:e2500203. (2025)
- [4] Hassanien A, Kondo Screening and Coupling of Spin States on Graphene Nanoribbon, *physica status solidi (RRL) Rapid Research Letters*, 0, e70249. (2026)



Pearl-Vortex Tunneling in Magic-Angle Twisted Graphene

M. Perego¹, P. Koopmann¹, C. Galante Agero¹, A. Mestre Torà¹, A. O. Denisov¹, T. Taniguchi², K. Watanabe²,
D. V. Geshkenbein^{1*}, G. Blatter¹, T. Ihn¹, and K. Ensslin¹

¹ETH Zurich.

²National Institute for Materials Science, Tsukuba, Japan.

*Presenting author: dimagesh@phys.ethz.ch

Planar Josephson junctions made from atomically thin films exhibit poor transverse screening, causing the magnetic-field dependence of the Josephson current $I_c(B)$ to deviate from the standard Fraunhofer pattern of conventional junctions. Given the weak screening, the junction is highly sensitive to Pearl vortices in the leads. Vortices alter the phase pattern and affect the Josephson current. The importance of thermal and quantum fluctuations can be quantified through the superfluid density ρ_s and the sheet resistance R . The low carrier density and large effective mass associated with flat electronic bands result in a small ρ_s and a large R , which enhance fluctuation effects in both the thermal and quantum regimes. These properties make graphene particularly well suited to study vortex dynamics. Fluctuations can cause vortices to jump in and out of the leads, leading to shifts in the Fraunhofer-like pattern, as observed in recent experiment [1]. Our model quantitatively explains these jumps, whose timescale depends on magnetic field, current, temperature, and superfluid stiffness. At low temperatures Pearl vortices can tunnel through the edge barriers [2].

[1] M. Perego *et al.*, *Nature Communications* **16**, 10259 (2025).

[2] M Perego *et al.* *Physical Review Letters* **137** (7), 076001 (2026).



The unconventional superconductivity of Sr_2RuO_4 — a new perspective on an old mystery

D. Krstovska^{1*}, A. Skeparovski¹, E. Steven², E. S. Choi³

¹Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University, Arhimedova 3, Skopje, 1000, Macedonia.

²Emmerich Research Center, Pluit Karang Permai 12 B9 Barat no 1 and 2, DKI Jakarta, 14450, Indonesia.

³Department of Physics, National High Magnetic Field Laboratory, 1800 East Paul Dirac Drive, Tallahassee, 32310, Florida, USA

*Presenting author: danica@pmf.ukim.mk

By combining complex transport measurements with thermodynamic torque magnetometry, we uncover a field-induced 3D–2D dimensional crossover near 7 T in the normal state of the unconventional superconductor Sr_2RuO_4 . Beyond this field, the reactive transport channel surpasses the dissipative component ($|X| > R$) in a macroscopically phase-locked regime. This shift is driven by the quasi-1D β Fermi surface sheet acting as an orbital gatekeeper; quenching its out-of-plane hopping allows the 2D γ pocket to govern global chemical potential oscillations $\Delta\mu$. Consequently, the real (R) and reactive (X) transport response functions synchronize into a temperature-independent $\pi/2$ phase shift relative to de Haas-van Alphen oscillations. Even at 1.43 K, thermal smearing fails to suppress multi-orbital $\gamma \pm \alpha$ cross-modulation sidebands, which exhibit amplitudes on par with the primary γ frequency. This failure of linear scaling highlights a synchronized multi-band normal state preceding multi-component superconductivity. In the low-field limit, this multi-orbital network manifests as a phase-rotated negative resistance baseline ($R < 0$) and discrete torque switching steps, pointing to time-reversal symmetry breaking driven by avalanche dynamics in chiral domains.

[1] Y. Maeno, S. Yonezawa, A. Ramires, *J. Phys. Soc. Jpn.* **93**, 062001 (2024).

[2] E. Steven, D. Krstovska, D. Suarez, T. Berliani, E. Jobiliong, E. S. Choi, *Sensors and Actuators A: Physical* **368**, 115133 (2024).



Inducing superconductivity in hinge states of Bi-based topological materials

Biplab Bhattacharyya¹, Stijn R. de Wit¹, Zhen Wu¹, Yingkai Huang⁵, Feike van Veen¹, Jara Vliem², Femke Witmans³, Mark S. Golden⁵, Daniel Vanmaeckelberg⁴, Alexander Brinkman¹, and Chuan Li^{*}

¹ MESA+ Institute for Nanotechnology, University of Twente, 7500 AE Enschede, The Netherlands

² Institute of Physical and Theoretical Chemistry, University of Tübingen, D-72076 Tübingen, Germany

³ II. Physikalisches Institut, Universität zu Köln, D-50937 Köln, Germany and

⁴ Debye Institute for Nanomaterials Science, Utrecht University, 3584 CC Utrecht, The Netherlands

⁵ Van der Waals–Zeeman Institute, IoP, University of Amsterdam, Amsterdam 1090 GL, The Netherlands

* Email: chuan.li@utwente.nl

Higher-order and low-dimensional topological states provide promising platforms for realizing unconventional superconductivity, but establishing robust superconducting coupling to these boundary modes remains challenging. Here, we investigate proximity-induced superconductivity in two complementary topological material platforms, $\text{Bi}_{0.97}\text{Sb}_{0.03}$ and ultrathin $\text{Bi}_{0.97}\text{Sb}_{0.03}$ nanoplates, with a common focus on superconducting transport mediated by low-dimensional hinge or edge states. In $\text{Bi}_{0.97}\text{Sb}_{0.03}$, a higher-order topological insulator (HOTI), Josephson interferometry reveals strongly enhanced supercurrent along sample boundaries and step edges, consistent with transport through multiple hinge channels. The coexistence of topological hinge states and additional non-topological edge modes is further reflected in the current-phase relation and temperature dependence of the Josephson current [1]. In ultrathin $\text{Bi}_{0.97}\text{Sb}_{0.03}$ nanoplates, thickness-induced hybridization of the top and bottom surface states provides access to a regime where transport can become dominated by one-dimensional boundary states [2]. By integrating these nanoplates into Josephson junctions, we probe the proximity coupling of these boundary modes and their contribution to the supercurrent. Together, these results demonstrate a general route toward inducing and detecting superconductivity in low-dimensional boundary states of topological materials. The ability to engineer superconducting hinge and edge channels across distinct material platforms provides a basis for studying unconventional Josephson transport and for developing topological superconducting devices.

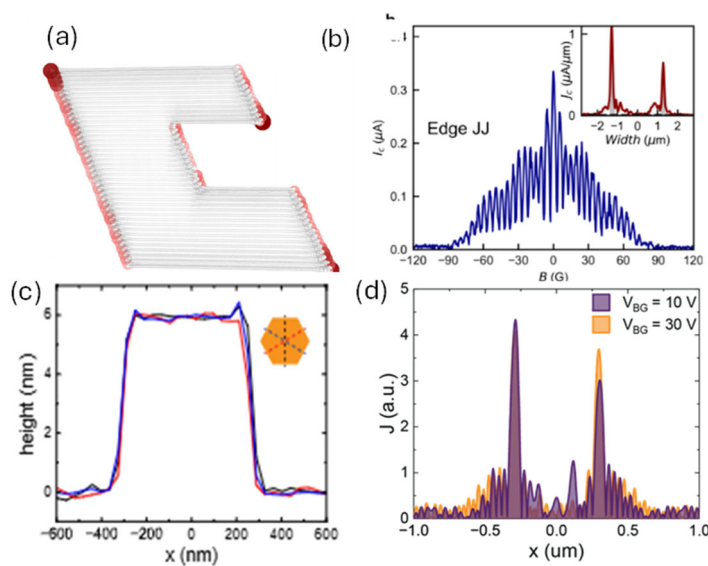




Figure 1: Edge current in Bi-based materials.

(a) tight-binding calculation for a $\text{Bi}_{0.97}\text{Sb}_{0.03}$ infinite slab with a discontinuous side facet. An extra mode is apparent. (b) critical current as a function of magnetic field $I_c(B)$. Insert: converted current density distribution $j(x)$. (c) AFM scan profile of a 6 nm $\text{Bi}_{0.97}\text{Sb}_{0.03}$ nanoplate. (d) current distribution in a nanoplate junction.

- [1] Bhattacharyya, et al. *ACS Nano* **20**, 21636 (2026).
- [2] Liu, C.-X. et al. *Phys. Rev. B* **81**, 041307 (2010)



Engineering the Cuprate Ground State with Designer Substrates

Floriana Lombardi

*Department of Microtechnology and Nanoscience, Chalmers University of Technology,
SE-41296, Göteborg, Sweden*

Despite decades of intense research, the microscopic mechanism of high-temperature superconductivity in the cuprates remains unresolved. A central obstacle is the limited tunability of these materials: unlike many two-dimensional systems, the charge carrier density in cuprate superconductors is fixed during synthesis, making it difficult to continuously access and manipulate competing electronic phases using conventional gating approaches. In this talk, I show that substrate engineering provides a powerful alternative route to control the electronic ground state of cuprates, enabling access to new phases and reshaping their interplay with superconductivity. Focusing on nm thick $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ films, I demonstrate that substrates with a nanofaceted surface morphology, formed by high-temperature surface reconstruction induce electronic nematicity and a unidirectional charge-density wave, stabilizing a novel ground state distinct from that of thicker films and bulk crystals. Remarkably, these interfacial effects lead to a strong enhancement of superconductivity: the onset temperature increases by more than 20 K, and the upper critical magnetic field is enhanced by more than 50 T at fixed doping. Together, these results establish substrate engineering as a powerful strategy for tuning quantum phases in cuprates and for designing high-performance superconducting materials.



Wiring up molecular spins with superconducting circuits for quantum applications

F. Luis^{1*}

¹ Instituto de Nanociencia y Materiales de Aragón (INMA, CSIC-Universidad de Zaragoza), Zaragoza, Spain

*Presenting author: fluis@unizar.es

Scaling up quantum processors remains very challenging, even for today's most successful platforms, on account of the need of mitigating and, eventually, correcting errors. Magnetic molecules provide some competitive advantages, due to their exquisite reproducibility and the ability of tuning their relevant properties, or even scaling up, by chemical design [1,2]. Exploiting them calls for a solid-state platform able to initialize, control and read-out the molecular spins, and of establishing the communication channels between remote spins that are need for scalability [3-5]. Here, we focus on results obtained with circuits based on lumped element superconducting LC resonators (LERs). Their relevant properties, resonance frequency ω_r and quality factor Q , can be widely tuned without affecting the transmission through the readout line. We realize resonator arrays, consisting of 2 to 7 mutually coupled LERs. Couplings between different resonators have been engineered by circuit design and by their mutual distances. I'll illustrate with examples from recent experiments how these devices allow performing magnetic resonance of a molecular sample at different frequencies [6] and studying the quantum hybridization of molecular spins with different photon modes. In addition, they introduce coherent communication between remote spins [7], thus paving the way for scaling up quantum computing with molecular based spin qubits and for introducing additional functionalities in a hybrid architecture.

- [1] G. Aromí, D. Aguilà, P. Gamez, F. Luis, and O. Roubeau, *Chem. Soc. Rev.*, 2012, 41, 537.
- [2] A. Gaita-Ariño, F. Luis, S. Hill, and E. Coronado, *Nature Chem.* 11, 301 (2019).
- [3] M. D. Jenkins, D. Zueco, O. Roubeau, G. Aromí, J. Majer and F. Luis, *Dalton Trans.* 45, 16682-16693 (2016).
- [4] S. Carretta, D. Zueco, A. Chiesa, Á. Gómez-León, and F. Luis, *Appl. Phys. Lett.*, 118, 240501 (2021).
- [5] A. Chiesa, S. Roca, S. Chicco, M.C. de Ory, A. Gómez-León, A. Gomez, D. Zueco, F. Luis, and S. Carretta, *Phys. Rev. Applied* 19, 064060 (2023).
- [6] C. del Río, S. Roca-Jerat, P. Pakulski, J. L. García-Palacios, M. C. Pallarés, J. Sesé, D. Pinkowicz, A. Lostao, D. Zueco, and F. Luis, *Low Temp. Phys.* 52, 865 (2026).
- [7] C. del Río, M. Rubín-Osanz, D. Rodríguez, S. Roca-Jerat, M. C. Pallarés, J. A. de Sousa, P. Pakulski, J. L. García Palacios, D. Granados, D. Pinkowicz, N. Crivillers, A.I Lostao, D. Zueco, A. Gomez, and F. Luis, *Phys. Rev. X Quantum* (2026), accepted for publication. arXiv preprint arXiv:2602.18103.



Scalable quantum computers with chiplet technology

R. Manenti^{1*}

¹Rigetti Computing

*Presenting author: riccardo@rigetti.com

The seminar will start with the theoretical motivations behind quantum computing, including a brief overview of some fundamental results in computational complexity theory. I will then address the challenges of scaling quantum computers, presenting the approaches adopted by Rigetti including our proprietary chiplet technology. The presentation will conclude with an overview of the development roadmap, spanning both the growth in qubit count and improvements in gate fidelity. These steps will be crucial for achieving quantum advantage.



Yanson Point-Contact Spectroscopy: What can we learn from it.

Y. Naidyuk^{1*}

¹*B. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine, Kharkiv, Ukraine*

**Presenting author: naidyuk@ilt.kharkiv.ua*

In my presentation, I will provide a pedagogical overview of Yanson point-contact spectroscopy (PCS) and its extensive capabilities for investigating charge-transport processes at the nanoscale. Specifically, I will explain how measuring non-linear conductance in microscopic contacts enables the observation of electron interactions with phonons and other quasiparticles. I will demonstrate how such contacts allow for the study of the Kondo effect, crystal electric field excitations, spin fluctuations, two-level systems in disordered materials, and more. I will also discuss various experimental techniques for fabricating these contacts—such as the "needle-anvil" and "break-junction" methods—which achieve atomic-scale dimensions. Finally, I will highlight the extreme physical conditions within the contact region (high current density, strong electric fields, and high pressure) that facilitate the investigation of unique phenomena, including resistive switching, enhanced or induced superconductivity, and the manifestation of charge-density waves.



Generation of Autonomous Quantum Resources by Dissipative Quantum Systems

T. Novotný^{1*}, A. Slobodeniuk¹, K. Kawa^{2,1}, and R. Filip³

¹*Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic*

²*Institute of Physics, The Czech Academy of Sciences, Prague, Czech Republic*

³*Department of Optics, Palacký University, Olomouc, Czech Republic*

*Presenting author: tomas.novotny@matfyz.cuni.cz

Theory of open quantum systems, i.e., systems coupled to thermal bath(s) in the quantum regime [1] despite of its age still constitutes a vivid research field addressing various aspects of the general question how the dissipative coupling to a bath, which inevitably also brings quantum noise, influences the quantum dynamics of the studied system. The question is particularly important in the context of quantum information setups where quantum resources such as coherence or entanglement should be prevented from the (supposedly) detrimental effects of the noise. However, as it has turned out recently, the sole dissipative coupling of a quantum systems without any further external control (such as driving fields) can, in fact, also be used for generation of such quantum resources, which are then called autonomous. Our contribution addresses two complementary situations for generation of quantum resources – autonomous coherence generated by coupling to an equilibrium quantum bath [2,3] and generation of autonomous quantum entanglement in a nonequilibrium setup [4].

[1] Ulrich Weiss, *Quantum Dissipative Systems*, 4th Edition (World Scientific, Singapore, 2012); H.-P. Breuer and F. Petruccione, *The Theory of Open Quantum Systems* (Oxford University Press, New York, 2002).

[2] Giacomo Guarnieri, Michal Kolář, and Radim Filip, Steady-State Coherences by Composite System-Bath Interactions, *Phys. Rev. Lett.* **121**, 070401 (2018); A. Purkayastha, G. Guarnieri, M. T. Mitchison, R. Filip, and J. Goold, Tunable phonon-induced steady-state coherence in a double-quantum-dot charge qubit, *npj Quantum Information* **6**, 27 (2020).

[3] Artur Slobodeniuk, Tomáš Novotný, and Radim Filip, Extraction of autonomous quantum coherences, *Quantum* **6**, 689 (2022); Synthesizing and multiplexing autonomous quantum coherences, *Quantum* **8**, 1386 (2024).

[4] Bradley Longstaff, Michael G. Jabbour, and Jonatan Bohr Brask, Impossibility of bosonic autonomous entanglement engines in the weak-coupling limit, *Phys. Rev. A* **108**, 032209 (2023).



Hybridizing fermionic Andreev modes with bosonic circuit modes

J. A. Ortuzar^{1*}

¹*Quantronics group, Service de Physique de l'État Condensé (CNRS, UMR 3680), IRAMIS, CEA-Saclay, Université Paris-Saclay, 91191 Gif-sur-Yvette, France*

**Presenting author: jon.ortuzar.a@gmail.com*

A Josephson junction shunted by a large inductance, commonly obtained by an array of Josephson junctions, operates in a high-impedance environment where the junction phase couples not to a single mode, but to a dense set of linear electromagnetic modes, hence, the measured spectrum is a forest of hybridized states. Within this context, we study a gatemonium: a fluxonium-type circuit whose weak link is a semiconducting (InAs) nanowire junction, so that the Josephson coupling can be tuned in situ by a gate voltage. Such a weak link hosts fermionic degrees of freedom that hybridize with the bosonic circuit modes. This raises the central question of this work: how can the signatures of the fermionic modes be extracted from a spectrum dominated by the multimode environment? Employing a renormalization-group-inspired low-energy diagonalization method we are able to fit the measured spectrum as a function of gate and flux. We show that characterizing the electromagnetic circuit and tracking the evolution of its modes is not a preliminary step but an integral part of understanding the qubit itself.



Circuit Quantum Electrodynamics with two-dimensional material-based Josephson Junctions

V. Varrica^{1,2,3}, G. Falci^{1,2}, E. Paladino^{1,2*}, and F. Pellegrino^{1,2,3}

1 Dipartimento di Fisica e Astronomia Ettore Majorana,, University of Catania, INFN Sez Ct.

2 INFN Sezione di Catania, Via Santa Sofia 64, Catania, Italy.

3 Centro Siciliano di Fisica Nucleare e Struttura della Materia, Via Santa Sofia 64, Catania, Italy.

**Presenting author: elisabetta.paladino@dfa.unict.it*

In the context of hybrid superconductorsemiconductor systems, Josephson junctions based on twodimensional materials, such as graphene, offer promising opportunities because of their scalability and gatetunable electronic properties. In this work, we investigate the inductive coupling between a quantum LC resonator and a superconducting loop embedding a short, ballistic, planar Josephson junction, with the graphene based case as a representative example. Within a mean field formalism, we analyze how the properties of the global system depend on the light-matter interaction coupling, the Fermi level of the twodimensional material, and temperature. Our findings reveal that the current-phase relation can show features indicative of spontaneous timereversal symmetry breaking [1]. Moreover, we investigate the same system as a possible solidstate implementation of a Dicke-like quantum battery where Andreev bound states naturally act as noninteracting, energetically non-degenerate two-level systems, and the setup allows for both single photon and two photon resonant processes. The coupling between the LC-circuit flux and the supercurrent through the junction gives rise to peculiar longitudinal interaction terms that have no counter part in the conventional Dicke model. These additional couplings can enhance energy storage for a proper range of parameters [2].

[1] V. Varrica, G. Falci, E. Paladino, F. Pellegrino, Hybrid lightmatter excitations and spontaneous time-reversal symmetry breaking in twodimensional Josephson Junctions, Phys. Rev. B 114, 115401 (2026) DOI: 10.1103/npcs-dllq.

[2] V. Varrica, G. Gemme, F. Pellegrino, E. Paladino, M. Sassetti, D. Ferraro, Quantum Batteries in two-dimensional material-based Josephson Junctions, arXiv:2605:22582.



Reversible control of superconductivity in NbN thin film

D. Yakovlev¹, S. N. Kozlov¹, M. Vernet¹, Z. Velluire-Pellat¹, S. Zanna¹, Q. Li¹, A. Jouan¹, J. Biscaras¹, Y. Todorov¹, A. Gurevich¹, M. Filoche¹, D. Roditchev¹, and C. Feuillet-Palma^{1*}

¹*Laboratoire de Physique et d'étude des Matériaux, ESPCI Paris, CNRS, PSL University, 75005 Paris, France.*

**Presenting author: cheryl.palma@epsci.psl.eu*

The high carrier density and short screening length of metals make any electrostatic control of their electronic properties very difficult. Here, we demonstrate the reversible control of both electrical resistance and superconducting properties of thin NbN films deposited on lime glass.

Heating the samples up to 390 K results in a high mobility of Na-ions which migrate under externally applied electric fields and modify the inter-grain coupling in NbN. This leads to a controllable modification of the film resistances by several orders of magnitude along with strong variations of their superconducting properties. The most resistive films even undergo a superconductor-insulator transition.

Our finding paves a new way for controllable and reversible tuning of electronic properties of granular metallic films. I will discuss the mechanism in terms of inter-grain coupling.



TWISTED VAN DER WAALS CUPRATES: FROM PROTECTED QUBITS TO QUANTUM SENSING

N. Poccia^{1,2*}

¹Department of Physics “Ettore Pancini”, University of Naples Federico II, Complesso Universitario di Monte Sant’Angelo, Via Cinthia 21, 80126 Naples, Italy

²Leibniz Institute for Solid State and Materials Research Dresden (IFW Dresden), Helmholtzstraße 20, 01069 Dresden, Germany

*Presenting author: nicola.poccia@unina.it

Van der Waals (vdW) heterostructures are emerging as compact qubit platforms: all-vdW NbSe₂–hBN transmons reach $T_1 \approx 55 \mu\text{s}$, with dephasing limited by charge noise, not materials [1]. Atomically thin high-temperature superconductors have meanwhile become a fast-growing field. Monolayer Bi₂Sr₂CaCu₂O_{8+ δ} retains the bulk T_c [2], thinning to two unit cells strongly enhances superconductivity and vortex fluctuations [3], and single-CuO₂-plane Bi₂Sr₂CuO_{6+ δ} reveals the superconductor–insulator transition [4]. Cryogenic stacking below -90°C made twisted cuprate junctions possible, with d-wave angular dependence and second-harmonic coupling near 45° [5]. Nitrogen-vacancy relaxometry has since imaged chiral $d \pm id'$ edge modes with a $\sim 4 \text{ meV}$ topological gap persisting up to $T_c \approx 86 \text{ K}$ [6]. The flowermon, a capacitively shunted twisted junction, is predicted to be intrinsically protected against relaxation, charge dephasing and nodal quasiparticles, but awaits experimental realization [7,8]. The key obstacle is integrating this fragile interface into circuits. Cryogenically transferred silicon-nitride nanomembrane circuits address it, preserving Josephson coupling comparable to the best reported junctions [5,9], and a simplified top-down recipe makes such devices affordable and scalable [10]. Bi₂Sr₂CaCu₂O_{8+ δ} flakes couple strongly to microwave resonators ($Q \approx 3 \times 10^4$) but host an off-resonant two-level-system bath [11], which capping and circuit design can reduce [11,12]. The same sensitivity that makes these orders fragile makes them powerful sensors: Raman fingerprints the twist angle [13], and ultrafast optics resolve charge-order dynamics in NbSe₂ [14]. vdW superconductors thus reach beyond quantum computing, into sensing and the hybrid frontier where quantum circuits probe correlated matter and correlated matter defines new circuit elements.

- [1] S. Park et al., arXiv:2609.14230 (2026).
- [2] Y. Yu et al., Nature 575 (2019) 156.
- [3] S. Y. F. Zhao et al., Phys. Rev. Lett. 122 (2019) 247001.
- [4] H. Luo et al., Nature (2026), doi:10.1038/s41586-026-10857-1.
- [5] S. Y. F. Zhao et al., Science 382 (2023) 1422.
- [6] S. Li et al., arXiv:2609.13070 (2026).
- [7] V. Brosco et al., Phys. Rev. Lett. 132 (2024) 017003.
- [8] T. Confalone et al., Adv. Quantum Technol. 8 (2025) 2500203.
- [9] T. Confalone et al., Small 21 (2025) e06520.
- [10] T. Confalone et al., arXiv:2608.14158 (2026).
- [11] H. Jin et al., Nano Lett. 25 (2025) 3191.
- [12] Y. Lee et al., arXiv:2609.00964 (2026).
- [13] F. Lo Sardo et al., Adv. Phys. Res. (2025), doi:10.1002/apxr.202500108.
- [14] S. Kumbhakar et al., arXiv:2603.03980 (2026).



Microscopic structure of the vortex cores in granular niobium: A coherent quantum puzzle

D. Roditchev^{1*}

¹LPEM, UMR-8213, ESPCI Paris - PSL, CNRS, Sorbonne University, F-75005 Paris, France.

*Presenting author: dimitri.roditchev@espci.fr

In homogeneous type-II superconductors, each Abrikosov vortex has a tiny core where the superconducting gap $\Delta(r)$ is known to smoothly vanish towards the 2π -phase singularity on the scale of the coherence length ξ . The cores host quantized quasiparticle energy levels known as Caroli-de Gennes-Matricon (CdGM) bound states [Caroli et al., Phys. Lett. v. 9, 307 (1964)]. In pure materials, the spectrum of the low-lying CdGM states has the characteristic level spacing $\sim (\Delta_0^2)/E_F$, where E_F is the Fermi energy and Δ_0 is the bulk superconducting gap. In disordered superconductors, the CdGM states shift and broaden due to scattering. Here, we show [1], both experimentally and theoretically, that the situation is completely different in granular Nb films, which are commonly used in superconducting electronics. In these films, in which the grains are smaller than ξ , the gap $\Delta(r)$ in the quasiparticle spectrum reduces towards the vortex core centres by discrete jumps at the grain boundaries and, for some vortices, does not vanish. The bound states adapt to the local environment and appear at unexpectedly high energies. Both $\Delta(r)$ and bound states form a puzzle-like spatial structure, elements of which are whole grains. We also discovered a very slow regime of vortex motion that we were able to track with the sub-nanometer precision over hours after the initial perturbation of the vortex lattice. This regime, related to the granular structure of the system, resembles the viscous motion of glass. Our discovery shakes up the established understanding of the quantum vortex and encourages a reconsideration of the vortex motion and pinning mechanisms in granular superconductors.

[1] V. S. Stolyarov, V. Neverov, A. V. Krasavin, D. I. Kasatonov, D. Panov, D. Baranov, O. V. Skryabina, A. S. Melnikov, A. A. Golubov, M. Yu. Kupriyanov, A. A. Shanenko, T. Cren, A. Yu. Aladyshkin, A. Vagov, D. Roditchev, Microscopic structure of the vortex cores in granular niobium: A coherent quantum puzzle, <https://arxiv.org/abs/2601.20486>.



Hierarchy of Pairing and Interlayer Phase Coherence in a Natural Ising Superlattice

P. Szabó¹, T. Samuely², J. Kačmarčík¹, F. Košuth¹, L. Cario³, P. Samuely¹

¹*Institute of Experimental Physics, Slovak Academy of Sciences, 04001 Košice, Slovakia*

²*Faculty of Science, P. J. Šafárik University, 04001 Košice, Slovakia*

³*Institut des Matériaux de Nantes Jean Rouxel, Nantes, France*

Bulk layered Ising superconductors combine strong spin–orbit protection with weak interlayer coupling [1-3], offering a platform in which superconducting pairing and global phase coherence may develop on distinct energy and temperature scales. Here we investigate the misfit-layer compound $(\text{LaSe})_{1.14}(\text{NbSe}_2)$, a bulk natural superlattice of electronically quasi-two-dimensional NbSe_2 sheets separated by insulating LaSe spacers. Using direction-selective scanning tunnelling spectroscopy, we resolve two superconducting gaps associated with different momentum-space sectors: a small, fragile $\Delta_\Gamma \sim 0.14$ meV detected by out-of-plane tunnelling, and a larger, robust gap, $\Delta_K \sim 0.22$ meV detected by in-plane tunnelling into the K/K' -derived states [4]. We show a hierarchy of superconducting pairing and interlayer phase coherence. As temperature falls below roughly 1.3 – 1.4 K, superconducting gap Δ_K opens within the NbSe_2 layers, the interlayer c -axis resistance $\rho_{\parallel c}$ increases peaking at 1.2 K. At lower temperatures, coherent Cooper-pair tunnelling develops between the layers, causing $\rho_{\parallel c}$ to collapse to zero near 1.1 K. This coincides with the initial tendency of Δ_Γ , probed by c -axis tunnelling, to close at the same temperature. However, interband coupling to the stronger K -pocket condensate keeps the Γ -pocket proximitized and phase-locked, so its observed closing temperature instead follows the bulk $T_c \approx 1.3$ K. Specific-heat measurements on the same crystal reveal a bulk superconducting anomaly near $T_c = 1.25$ K. The effect of in-plane and out of plane magnetic field on tunnelling spectra will be discussed as well. Our results connect multigap Ising superconductivity to interlayer Josephson coherence and identify $(\text{LaSe})_{1.14}(\text{NbSe}_2)$ as a natural platform for studying the hierarchy of pairing, intralayer superconductivity, and three-dimensional phase locking.

[1] P. Samuely et al., Phys. Rev. B **104**, 224507 (2021).

[2] T. Samuely et al., Phys. Rev. B **108**, L220501 (2023).

[3] D. Volavka et al., Phys. Rev. Lett. **136**, 016002 (2026).

[4] A. Palacio-Morales et al., [arXiv:2609.15446](https://arxiv.org/abs/2609.15446).



Ferromagnetic Tunnel Josephson Junctions: A Route Towards Scalable Quantum Architectures

R. Satariano^{1*}, R. Ferraiuolo², H. G. Ahmad¹, C. Cosenza¹, F. Calloni¹, E. Raja¹, D. Gatta¹, G. Serpico¹, D. Montemurro¹, N. Poccia¹, G. P. Pepe¹, A. Bruno², F. Tafuri¹, and D. Massarotti⁴

¹*Dipartimento di Fisica Ettore Pancini, Università degli Studi di Napoli Federico II, c/o Complesso Monte Sant'Angelo, via Cinthia 26, I-80126 Napoli, Italy.*

²*QuantWare, Elektronikaweg 10, 2628 XG Delft, The Netherlands.*

³*Consiglio Nazionale delle Ricerche—ISASI, Via Campi Flegrei 31, I-80078 Pozzuoli, Italy.*

⁴*Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione, Università degli Studi di Napoli Federico II, I-80125 Napoli, Italy.*

*Presenting author: roberta.satariano@unina.it

Superconductivity and ferromagnetism are competing orders, yet their coexistence in a Josephson junction yields some of the richest physics at the superconductor/ferromagnet (S/F) interface [1], including the generation of $0-\pi$ phase transitions [2] and of spin-triplet correlations [3]. These phenomena have established magnetic Josephson junctions (MJJs) as a unique platform for superconducting spintronics [4, 5] and superconducting digital electronics [6]. However, the dissipation of metallic ferromagnetic barriers has long confined MJJs to the role of passive π -phase shifters in superconducting quantum hardware [7, 8]. A new generation of low-dissipation MJJs has changed this paradigm: barriers built from insulating ferromagnets [9], or from multilayered insulator–thin superconductor–ferromagnet (IsF) stacks [10, 11], combine magnetic switching with low quasiparticle dissipation, promoting the magnetic junction to an active element in quantum circuits [12,13]. This enables an alternative way of controlling the Josephson energy in the so-called ferro-transmon design: rather than being set by persistent flux currents, it is stored in the non-volatile magnetic state of the F barrier and addressed by short magnetic-field pulses. Since the barrier retains its state after the pulse, each operating point can be held with no static bias, removing the wiring and dissipation overhead of flux control and offering a distinct route to scalability. Here, we demonstrate submicrometer tunnel SIsFS JJs, fabricated in a Manhattan-style configuration and designed to operate within the energy scale of transmon qubits [14]. Integrating such a junction into a transmon design, we obtain a coherence relaxation time $T_1 \approx 10 \mu\text{s}$, matching a standard transmon fabricated as a reference. By showing that a ferromagnetic barrier can be embedded in a transmon without degrading coherence, these results open the way to new readout and control schemes for superconducting quantum architectures based on magnetic-field pulses [13].

[1] A. I. Buzdin et al., Rev. Mod. Phys. 77, 935(2005).

[2] A. A. Golubov et al., Rev. Mod. Phys. 76, 411 (2004).

[3] F. S. Bergeret et al., Rev. Mod. Phys. 77, 1321(2005).

[4] M. Eschrig, Reports on Progress in Physics 78, 10 (2015).

[5] J. Linder and J. W. A. Robinson, Nat. Phys. 11, 307 (2015).

[6] I. I. Soloviev et al. Beilstein Journal of Nanotechnology 8, 2689 (2017).

[7] A. K. Feofanov et al., Nat. Phys. 6, 593 (2010).

[8] S. Kim et al., Commun. Mater. 5, 216 (2024).

[9] D. Massarotti et al. Nat. Commun. 6, 7376 (2015).

[10] A. Vettoliere et al., Appl. Phys. Lett. 120, 262601 (2022).

[11] H. G. Ahmad et al., Appl. Phys. Lett. 124, 232601 (2024).

[12] H. G. Ahmad et al., Phys. Rev. B 105, 214522 (2022).

[13] Ferromagnetic coupler, European Patent No. EP EP4769240A1 (2026).



[14] R. Satariano et al., Appl. Phys. Lett. 127, 252601 (2025).



Time-Resolved Thermal Susceptibility Mapping via Low-Temperature Scanning Laser Microscopy

A. Silhanek^{1*}

¹Université de Liège.

*Presenting author: asilhanek@uliege.be

We present a multiharmonic lock-in detection approach that utilizes the inverse Fast Fourier Transform to reconstruct the time evolution of thermal susceptibility with high spatial resolution. We implement the method on a custom-built, modular scanning laser microscope designed for operation in low working-distance optical cryostats and thoroughly calibrated for spatial accuracy. A demonstrative case study using a superconducting resonator highlights this technique's ability to generate thermal images on time scales much shorter than the intrinsic scanning speed, enabling dynamic thermal characterization with high spatial fidelity. The proposed technique of low-temperature time-resolved scanning laser microscopy offers unique opportunities to explore superconducting devices, 2D materials, hybrid planar structures, and other low-dimensional systems.



Bifurcation Phenomena in the Anisotropic BCS gap Equation

M. P. Sørensen^{1*}, T. Schneider², N. Lazarides³, P.L. Christiansen⁴

¹ *Department of Applied Mathematics and Computer Science, Technical University of Denmark*

² *Physik-Institut, Universität Zürich, Switzerland*

³ *Abu Dhabi Polytechnic, United Arab Emirates*

⁴ *Department of Physics, Technical University of Denmark*

*Presenting author: mpso@dtu.dk

A classical BCS strategy has been employed for the study of anisotropic superconductors using a phenomenological pairing mechanism without reference to a specific microscopic pairing mechanism. A simple tight-binding model of layered high-temperature superconductors is used in the BCS gap equation having s-, d- and mixed s- and d-wave symmetries. Nearest neighbor intralayer pairing interaction is used with slightly different strength in the x and y direction. This break of symmetry leads to perturbed bifurcation patterns in the BCS gap equation resulting in marked changes in the physical properties of the superconducting state. We explore the superconducting properties of anisotropy and the influence on electron specific heat, spin susceptibility, photoemission, Josephson tunneling and others.

[1] P.N. Spathis, M.P. Sørensen, P.L. Christiansen and N. Lazarides. Perturbed Bifurcations in the BCS Gap Equation. *Physical Review B*, vol 45(13), 1992, pp. 7360-7367.

[2] T. Schneider, and M.P. Sørensen. Single Particle Tunneling and Photoemission Spectra in Anisotropic Layered High-Temperature Superconductors. *Zeitschrift für Physik B-Condensed Matter* 80, 1990, pp. 331-337.

[3] H. De Raedt, T. Schneider, and M.P. Sørensen. Superconductivity in Hubbard Models Coupled to non-Fermionic Degrees of Freedom. *Zeitschrift für Physik B-Condensed Matter* 79, 1990, pp. 327-332.

[4] N. Lazarides and M.P. Sørensen. Gap anisotropy and tunneling currents. *Mathematics and Computers in Simulation* 40, 1996, pp. 271-280.



Beyond Cooper-pairs: Higher order fermionic condensates

A. Sudbø^{1*}

¹Norwegian University of Science and Technology.

*Presenting author: asle.sudbo@ntnu.no

Superconductivity is conventionally understood as the condensation of Cooper pairs, each composed of two electrons. But must the hierarchy of fermionic condensation stop at pairing? In multicomponent systems, fluctuations may destroy the coherence of the individual pair fields while preserving order in composite combinations involving four or more electrons. This opens the possibility of phases such as charge-(4e) superconductivity and electrically neutral counterflow order.

I will introduce the physical mechanism behind these higher-order condensates, emphasizing the role of vortex proliferation and the fractionalization of composite vortices. I will also discuss their characteristic experimental signatures, including altered magnetic-flux quantization, thermodynamic transitions without conventional superconducting coherence, and unusual Josephson effects. Candidate platforms range from multiband and pair-density-wave superconductors to moiré materials and engineered Josephson systems. These developments suggest that the familiar Cooper-pair condensate may be only the first member of a much richer hierarchy of fermionic quantum states of matter.



STM in quantum materials

Hermann Suderow

Universidad Autonoma de Madrid

**Presenting author: hermann.suderow@uam.es*

Scanning tunnelling microscopy (STM) and quasiparticle interference (QPI) techniques have provided detailed insight into the dispersion and symmetry of electronic states by probing spatial modulations of the local density of states (LDOS). However, these approaches predominantly reveal the amplitude of electronic wavefunctions, while the associated phase information is typically inferred indirectly through symmetry considerations, or by analysing the properties of singularities of a coherent ground state. I will review here approaches to try to visualize phase singularities of the electronic wavefunction in quantum materials using STM and present an example in a magnetic semiconductor. This is probably the first case, outside graphene, where phase singularities have been successfully visualized. I will discuss the prospects opened to study quantum phenomena in quantum materials. Furthermore, I will discuss the observation of two-dimensional superconductivity on Fermi arcs in a Weyl superconductor.



Imaging Microwave Fields with a Scanning SQUID

S. Vervoort¹, L. Nulens¹, J. Baumgarten², D. Boltje³, J. DeVine³, A. V. Silhanek², J. Van de Vondel^{1*}, K. Lahabi^{3,4}

¹*Quantum Solid-State Physics, Department of Physics and Astronomy, KU Leuven, Celestijnenlaan 200D, Leuven, B-3001, Belgium*

²*Experimental Physics of Nanostructured Materials, Q-MAT, Université de Liège, Allée du 6 Août 19, Sart Tilman B-4000, Belgium.*

³*QuantaMap BV, 2333 CG Leiden, The Netherlands.*

⁴*Huygens-Kamerlingh Onnes Laboratory, Leiden University, 2300 RA Leiden, The Netherlands*

*Presenting author: joris.vandevondel@kuleuven.be

Precise characterization of local electromagnetic environments is essential for understanding microwave-driven quantum devices and condensed-matter systems, where microscopic variations can strongly influence microwave coupling and device performance. Scanning superconducting quantum interference (SQUID) devices have demonstrated exceptional sensitivity to local magnetic fields [1,2]. Here, we extend this capability toward local characterization of microwave fields at GHz frequencies.

We demonstrate the working principle by employing a scanning SQUID to probe a superconducting coplanar waveguide (CPW) resonator, a well-defined and widely used platform for microwave-based condensed-matter and quantum-device experiments. The scanning SQUID enables simultaneous, in situ imaging of topography, DC magnetic fields [3], and local microwave fields within a single scanning probe platform. We demonstrate local detection of the power-dependent CPW resonance, in agreement with conventional transmission measurements, and spatially resolve the microwave field distribution across the resonator. This provides a local analogue of conventional microwave transmission measurements and, similar to the point-spread function obtained in DC field measurements [4], establishes the spatial resolution of the local microwave response.

These results demonstrate the working principle of scanning SQUID-based local GHz measurements and establish a route toward spatially resolved electromagnetic characterization of superconducting and magnetic systems and microwave quantum devices.

[1] D. Vasyukov, et al. A scanning superconducting quantum interference device with single electron spin sensitivity. *Nature Nanotech* 8, 639–644 (2013).

[2] T. Weber, et al. Advanced SQUID-on-lever scanning probe for high-sensitivity magnetic microscopy with sub-100-nm spatial resolution. *Phys. Rev. Appl.* 24, 054041 (2025).

[3] M. Rog, et al. Tapping-Mode SQUID-on-Tip Microscopy with Proximity Josephson Junctions. *Nano Lett* 5, 1608–1615 (2026).

[4] J. Ullmann, et al. Spatial resolution and point spread function of high-resolution scanning SQUID microscopy probes. *arXiv.2607.17414* (2026).



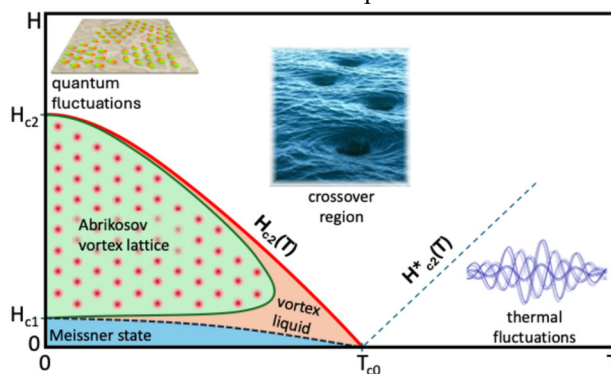
Fluctuation spectroscopy: Emergence of Abrikosov's Lattice approaching H_{c2}

A.A. Varlamov^{1,2*}

¹*Institute of Superconductivity and Innovative Materials (SPIN-CNR), Rome, Italy*

²*Istituto Lombardo "Accademia di Scienze e Lettere", via Borgonuovo, 25 - 20121 Milan, Italy*

Superconducting (SC) fluctuations, identified in the late 1960s, are a central topic in superconductivity due to their manifestation in diverse phenomena and their ability to reveal fundamental properties of the superconducting state. Interest in these effects grew with the discovery of cuprate high-temperature superconductors (HTSs), where fluctuations extend over a wide temperature range owing to short coherence lengths and low electronic dimensionality, leading to anomalous normal-state behavior.



Within the Ginzburg–Landau framework and diagrammatic approaches based on BCS theory, SC fluctuations—along with quantum corrections such as weak localization—have provided powerful tools to study disordered electron systems, granular metals,

Josephson structures, and artificial superlattices. A key feature of SC fluctuations is their strong dependence on temperature and magnetic field near the superconducting transition. This enables their separation from other contributions and allows extraction of microscopic parameters, including the critical temperature and zero-temperature critical field. Their sensitivity to phase-breaking processes also makes them an effective probe, forming the basis of fluctuation spectroscopy [1,2]. My review outlines the physics of SC fluctuations, from thermodynamic fluctuations near the critical temperature to quantum fluctuations near the upper critical field, and summarizes experimental, microscopic, and numerical results across the phase diagram. In particular, I discuss the emergence of the Abrikosov lattice in the normal phase of type-II superconducting film as the magnetic field approaches the upper critical field in the quantum fluctuation regime [3]. This regime features large, long-lived clusters of rotating fluctuation Cooper pairs which act as precursors to Abrikosov vortex lattice and can be detected via the high-frequency electromagnetic response above the upper critical field [4].

[1] Anatoly Larkin, Andrei Varlamov, “Theory of Fluctuations in Superconductors” OUP Oxford, (2009), 432 pages.

[2] A. A. Varlamov, A. Galda, and A. Glatz, “Fluctuation spectroscopy: From Rayleigh-Jeans waves to Abrikosov vortex clusters”, *Rev. Mod. Phys.* **90**, 015009 (2018).

[3] V. M. Galitski, and A. I. Larkin, “Superconducting fluctuations at low temperature”, *Physical Review B* **63**, 174506 (2001).

[4] Hang Zhou, Zhanghai Chen, A. A. Varlamov, Andreas Glatz, and Yuriy Yerin, “Microwave Signature of the Emerging Abrikosov Lattice Above H_{c2} ”, preprint



Dimensionality of vortex matter in the superconducting infinite-layer nickelates

D. Sanchez-Manzano¹, V. Humbert¹, D. Zhang¹, A. Gutiérrez-Llorente¹, A. Raji², A. Gloter², M. Bibes³, J. Santamaría⁴, L. Iglesias¹, Javier E. Villegas^{1,*}

¹Laboratoire Albert Fert, CNRS, Thales, Université Paris-Saclay, 1 avenue Augustin Fresnel, 91767 Palaiseau, France

²Laboratoire de Physique de Solides, CNRS, Université Paris-Saclay, Orsay, France.

³Synchrotron SOLEIL, L'Orme des Merisiers, Gif sur Yvette, France.

⁴GFMC, Dpto. de Física de Materiales, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, 28040 Madrid, Spain

*Presenting author: javier.villegas@cnrs-thales.fr

Characterizing the dimensionality of the superconducting state in infinite-layer (IL) nickelates is essential for understanding its nature. Most studies have addressed this by examining the anisotropy of the upper critical fields. However, the dominance of Pauli paramagnetic effects over orbital effects complicates the interpretation of these experiments in terms of dimensionality. Here, we approach the question from a different perspective by mapping the vortex phase diagram. We show that superconducting Pr_{0.8}Sr_{0.2}NiO₂ thin films with low disorder exhibit a vortex liquid-to-glass transition of a quasi-two-dimensional (2D) nature. In contrast, increasing disorder drives a crossover into a pure 2D state. This demonstrates that pure bidimensionality is an extrinsic property, resulting from the decoupling of NiO₂ planes due to enhanced disorder. Our findings establish disorder as a key control parameter of superconductivity in IL nickelates and suggest that it resides within the NiO₂ planes, providing two fundamental insights for understanding these materials.

We acknowledge funding from the European EIC Pathfinder Grant No. 101130224 “JOSEPHINE” and Cost Action CA21144 “SUPERQUMAP”.



Spectroscopic imaging of intrinsic topological superconductivity in UTe₂

S. Wang^{1*}

¹ University of Bristol

*Presenting author: shuqiu.wang@bristol.ac.uk

A distinctive identifier of nodal intrinsic topological superconductivity (ITS) would be the appearance of an Andreev bound state on crystal surfaces parallel to the nodal axis, in the form of a topological quasiparticle surface band (QSB) appearing only below the superconducting transition temperature. Moreover, the theory shows that specific QSB characteristics observable in tunneling to an s-wave superconductor can distinguish between chiral and non-chiral ITS order parameter. To search for such phenomena in UTe₂, s-wave superconductive scan-tip scanning tunneling microscopy (STM) imaging was employed. It reveals an intense zero-energy Andreev conductance maximum at the UTe₂ (0–11) crystal termination. The development of the zero-energy Andreev conductance peak into two finite-energy particle-hole symmetric conductance maxima as the tunnel barrier is reduced and then signifies that UTe₂ superconductivity is non-chiral. Quasiparticle interference imaging (QPI) for an ITS material should be dominated by the QSB for energies within the superconductive energy gap, so that bulk characteristics of the ITS can only be detected excursively. Again using a superconducting scan-tip, the in-gap quasiparticle interference patterns of the QSB of UTe₂ were visualized. Specifically, a band of Bogoliubov quasiparticles appears as a characteristic sextet of interference wavevectors, showing that QSB dispersions $k(E)$ occur only for energies below the superconducting energy gap and only within the range of Fermi momenta projected onto the (0–11) crystal surface. In combination, these phenomena are consistent with a bulk exhibiting spin-triplet, time-reversal conserving, odd-parity, a-axis nodal, B3u symmetry in UTe₂.



Phase Engineering in Ferromagnetic Josephson Junctions based on Epitaxial Al/EuS/2DEG Triple Hybrids

J. Zhao^{1*}

¹ *Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark*

**Presenting author: shuqiu.wang@bristol.ac.uk*

In this talk, we introduce epitaxial triple hybrids consisting of a semiconducting two-dimensional electron gas (2DEG), a ferromagnetic insulator (EuS), and superconducting Al thin films. This platform enables us to investigate the phase of planar ferromagnetic Josephson junctions with different geometries. First, scanning transmission electron microscopy reveals highly crystalline sub-nanometer films and high-quality interfaces. Second, transport measurements show an anomalous Fraunhofer pattern at the onset of the superconducting window, which we attribute to the coexistence of 0- and π -segments within the junction, supported by theoretical modeling. Finally, we probe the junction phase using SQUID devices, where the current-phase relation reveals an abrupt 0- π transition. Our results establish a new hybrid platform with potential applications in superconducting spintronics.



Low-dimensional magnetism in selected metal-organic frameworks and their intermediate compounds

D. Žilić^{1*}

¹ Ruđer Bošković Institute, Bijenička 54, 10000 Zagreb, Croatia

*Presenting author: dzilic@irb.hr

Metal-organic frameworks (MOFs) are porous coordination polymers consisting of metal centers or metal clusters connected with organic ligands. They have broad applicability in chemistry, physics, and materials science, including magnetism.

M(II)-MOF-74 compounds are characterized by a honeycomb structure with large pores that can host different guest molecules. Metal cations M(II) form six 1D oxo-chains on the pore corners with weak interchain interactions, thereby simply realizing the 1D Ising model. Magnetic MOF-74 materials show interesting phenomena such as magnetic ordering, metamagnetic behavior, spin crossover, and changing magnetic behavior upon solvent exchange in the pores.

Here, we focus on monometallic Cu(II)- and bimetallic Cu(II)/Zn(II)-MOF-74 compounds obtained through different synthetic pathways. Additionally, intermediate compounds obtained through mechanochemical MOF synthesis show interesting properties. Magnetic properties were investigated using static magnetization measurements and X-band and high-field/high-frequency ESR spectroscopy over a broad temperature and magnetic-field range.

This work was supported in part by the Croatian Science Foundation under the project number HRZZ-IP-2022-10-9292 and HrZZ-IP-2025-02-5083.

- [1] S. Muratović, B. Karadeniz, T. Stolar, S. Lukin, I. Halasz, M. Herak, G. Mali, Y. Krupskaya, V. Kataev, D. Žilić, K. Užarević, J. Mater. Chem. C 8 (2020) 7132.
- [2] S. Muratović, V. Martinez, B. Karadeniz, D. Pajić, I. Brekalo, M. Arhangeliskis, M. Mazaj, G. Mali, M. Etter, T. Frišić, Y. Krupskaya, V. Kataev, D. Žilić, K. Užarević, Inorg. Chem. 61 (2022) 18181.



Abstracts- Contributed



Architecture and Vibration Characterization of a Low-Vibration 0.9K Dilution Refrigerator for Scanning SQUID-on-Tip Microscope

N. Abezgauz^{1*}, Y. Anahory¹

¹ *The Racah Institute of Physics, The Hebrew University of Jerusalem, Jerusalem*

**Presenting author: nathan.abezgauz@mail.huji.ac.il*

Scanning nano-SQUID-on-tip (SOT) microscopy provides unprecedented magnetic and thermal sensitivity for investigating local phenomena in quantum materials. However, constructing and operating a scanning SOT microscope at ultra-low temperatures (0.9K) presents rigorous engineering challenges, primarily due to the system's extreme susceptibility to mechanical vibrations. This work details the technical architecture of a low-vibration dilution refrigerator designed specifically for SOT operation, alongside a comprehensive characterization of instrumental vibrations within our scanning probe setup.



Phase dynamics and transport properties in tunnel ferromagnetic Josephson junctions

F. Calloni^{1*}, R. Satariano¹, R. Ferraiuolo², H.G. Ahmad¹, D. Gatta¹, E. Raja¹, R. Vidyasagar¹, G. Santo¹, G. Serpico¹, D. Montemurro¹, N. Poccia^{1,4}, A. Vettoliere³, G. Ausanio¹, C. Granata³, L. Parlato¹, G.P. Pepe¹, A. Bruno², F. Tafuri¹, D. Massarotti⁵

¹Dipartimento di Fisica "Ettore Pancini", Università degli Studi di Napoli "Federico II", 80126, Napoli, Italy

²QuantWare, 2628 XG, Delft, The Netherlands

³Consiglio Nazionale delle Ricerche-ISASI, I-80078, Pozzuoli, Italy

⁴Leibniz Institute for Solid State and Materials Research Dresden, (IFW Dresden), Dresden, 01069, Germany.

⁵Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione, Università degli Studi di Napoli Federico II, Napoli, I-80125, IT.

*Presenting author: francesca.calloni@unina.it

Magnetic Josephson junctions (MJJs) are key structures in the field of superconducting spintronics [1,2] and digital superconducting circuits [3,4]. However, MJJs based on Superconductor-Ferromagnet Superconductor (SFS) trilayers present high dissipation, which limits their integration into highly coherent circuits. In this panorama, ferromagnetic tunnel Josephson junctions aim to combine the inherently low dissipation of tunnel junctions with the intrinsic memory behavior of magnetic layers. In this work, we present a systematic experimental investigation of the phase dynamics, dissipation, and temperature-dependent transport properties of superconductor–insulator–thin superconductor–ferromagnet–superconductor (SISFS) Josephson junctions based on Nb and Al electrodes [4,5]. By varying the thickness of the intermediate superconducting (s) layer and following the evolution down to 10 mK, we identify three distinct transport regimes: a tunnel-dominated SIS-like regime, a temperature-driven crossover, and a complex weak-link regime [6]. By scaling lateral dimensions down to the submicrometric regime, Al-based devices exhibit parameters comparable to state-of-the-art superconducting qubits, displaying clear signatures of quantum phase diffusion consistent with standard transmon qubits. Switching current distribution measurements confirm the extracted junction parameters [8]. These results provide key design guidelines: Nb junctions with sufficiently thick s-interlayers are well suited for high-speed cryogenic memory elements and tunable parametric amplifiers[9], while Al junctions emerge as ideal candidates for coherent, scalable superconducting quantum circuits [8].

[1] Jacob Linder and Jason W. A. Robinson. Superconducting spintronics. *Nature Physics*, 11(4):307–315, 2015.

[2] Norman O. Birge and Nathan Satchell. Ferro magnetic materials for Josephson π junctions. *APL Materials*, 12(4):041105, 04 2024.

[3] S. Kim et al. Superconducting flux qubit with ferromagnetic Josephson π -junction operating at zero magnetic field. *Communications Materials*, 5:216, 2024.

[4] R. Satariano, A.F. Volkov et al. Nanoscale spin ordering and spin screening effects in tunnel ferromagnetic Josephson junctions. *Communications Materials*, 5(67), 2024.

[5] H. G. Ahmad et al. "Phase dynamics of tunnel Al-based ferromagnetic Josephson junctions" *Appl. Phys. Lett.* 124, 232601 (2024); doi: 10.1063/5.0211006

[6] R. Satariano et al. "Transport regimes in tunnel ferromagnetic Josephson junctions." under review, 2026.

[7] Calloni, F., Satariano, R. et al. Phase Dynamics and Dissipation in Tunnel Ferromagnetic Josephson Junctions. *J Supercond Nov Magn* 39, 148 (2026). <https://doi.org/10.1007/s10948-026-07236-2>

[8] R. Satariano et al. "Submicrometer tunnel ferromagnetic Josephson junctions with transmon energy scale". *Applied Physics Letters*, 127(25):252601, 12 2025.

[9] M. Esposito et al. , "Josephson parametric amplifier based on tunnel ferromagnetic Josephson junction," Italian Patent Application No. 102025000020416, filed Aug. 4, 2025; approved Feb. 9, 2026.



Signatures of edge states in antiferromagnetic van der Waals Josephson junctions

C. González-Sánchez^{1,2,3*}, I. Sardinero^{4,2}, J. Cuadra^{1,2,3}, A. Spuri⁵, J. A. Moreno^{1,2}, H. Suderow^{1,2,3}, E. Scheer⁵, P. Bursat^{4,2,3}, A. Di Bernardo⁵, R. Seoane Souto⁶, and E. J. H. Lee^{1,2,3}

¹*Departamento de Física de la Materia Condensada, Universidad Autónoma de Madrid, 28049 Madrid, Spain.*

²*Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, 28049 Madrid, Spain.*

³*Instituto Nicolás Cabrera, Universidad Autónoma de Madrid, 28049 Madrid, Spain.*

⁴*Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid, 28049 Madrid, Spain.*

⁵*Department of Physics, University of Konstanz, Universitätsstraße 10, 78464 Konstanz, Germany.*

⁶*Instituto de Ciencia de Materiales de Madrid (ICMM), Consejo Superior de Investigaciones Científicas (CSIC), Sor Juana Inés de la Cruz 3, 28049 Madrid, Spain.*

*Presenting author: celia.gonzalezs@uam.es

The combination of superconductivity and magnetic textures represents a promising approach to explore unconventional superconducting phenomena, including new correlated and topological phases [1, 2]. Van der Waals (vdW) materials constitute an ideal platform to explore the interplay between these two ordering states of matter [3, 4, 5]. Here, we show that the combination of superconductivity in NbSe₂ with the antiferromagnetic spin texture of NiPS₃ leads to the formation of a few localized transport channels. For cases where two such channels are formed, a single NbSe₂/NiPS₃/NbSe₂ junction behaves as a superconducting quantum interference (SQUID) device, whose oscillations are observed for in-plane magnetic fields up to at least 6 T. Microscopic modeling of the antiferromagnet/superconductor (AF/S) vdW interface shows that these channels likely arise at the edges of the sample, owing to the interplay between superconductivity and the spin texture of NiPS₃. Our findings highlight the potential of vdW superconducting heterostructures with AFs as platforms for engineering and probing novel superconducting phenomena.

[1] H. Idzuchi et al., Nat. Commun. 12, 5332 (2021).

[2] J. L. Lado and M. Sgrist, Phys. Rev. Lett. 121, 037002 (2018).

[3] K. Kang et al., Nano Lett. 22, 5022–5028 (2022).

[4] L. Ai et al., Nat. Commun. 12, 6580 (2021).

[5] S. Kezilebieke et al., Nature 588, 424–428 (2020).



Nonlinear Microwave Dynamics in a Superconducting Nb Resonator

Vivek Kumar^{1*}, Lukas Nulens¹, and Joris Van de Vondel¹

¹Quantum Solid-State Physics, Department of Physics and Astronomy,
KU Leuven, Celestijnenlaan 200D, Leuven, B-3001, Belgium

*Presenting Author: vivek.kumar@kuleuven.be

We investigate nonlinear microwave dynamics in a superconducting Nb resonator incorporating an array of integrated superconducting loops [1]. The structure enables the combined application of microwave fields with DC and AC currents, providing a platform to study nonlinear interactions between them. By combining microwave pumping with low-frequency AC modulation, we probe the nonlinear response through microwave transmission and spectrum analysis. We focus on frequency-conversion processes arising from the resonator's nonlinear response, specifically four-wave mixing (χ^3) [2] and symmetry-broken three-wave mixing (χ^2) [2]. We examine their scaling dependence on pump power [3], DC bias current, and temperature to distinguish the underlying nonlinear mechanisms contributing to the observed sideband response. This approach allows us to explore the nonlinear dynamics of resonators with engineered inductive nonlinearity and identify the precise operational regimes under which specific mixing channels dominate.

[1] L. Nulens, D. A. D. Chaves, O. J. Y. Harb, J. E. Scheerder, N. Lejeune, K. Brahim, B. Raes, A. V. Silhanek, M. J. Van Bael and J. Van de Vondel 2024 Noninvasive Readout of the Kinetic Inductance of Superconducting Nanostructures. *Nano Lett.* 24 (36): 11149–11155.

[2] M. Khabipov, V. Gaydamachenko, C. Kissling, R. Dolata and A. B. Zorin 2022 Superconducting microwave resonators with non-centrosymmetric nonlinearity. *Supercond. Sci. Technol.* 35: 065020.

[3] J. Li, P. Barry, T. Cecil, M. Lisovenko, V. Yefremenko, G. Wang, S. Kruhlov, G. Karapetrov and C. Chang 2024 Flux-coupled tunable superconducting resonator. *Phys. Rev. Appl.* 22 (1): 014080



Development of Multi-Doped ZnO Thin Films as Functional Quantum Materials

M. Kılıç¹, T. Özdal¹, H. Kavak^{1*}

¹ Çukurova University, Physics Department, Adana, 01330, Turkey

*Presenting author: hkavak@cu.edu.tr

Zinc oxide (ZnO) thin films have a broad range of functional properties and high potential in optical, electrical, and magnetic devices such as light-emitting diodes, spintronic devices, and solar cells. The precise engineering of electronic, optical, and magnetic degrees of freedom in wide-bandgap semiconductors is vital for the development of oxide-based quantum materials. This study reports the synthesis and comprehensive characterization of multi-element (In, Cu, N, Al, K, Na) doped zinc oxide (ZnO) thin films fabricated via a scalable sol-gel spin coating technique. The various processing conditions were studied to obtain thin films with optimal quality. The structural parameters of the films were calculated using XRD data. The optical properties were studied using transmission and absorption data. The electrical properties were also investigated using a Hall effect measurement system. Additionally, ZnO thin films based homo and heterojunctions were fabricated and tested. These results provide critical insights into modulating quantum states in wide-bandgap oxides, paving the way for scalable, energy-efficient topological quantum devices and non-volatile spin memory systems.



Phase-dependent in-gap states in a quantum spin liquid Josephson junction

C. Lee^{1*} and J. L. Lado¹

¹*Correlated Quantum Materials group, Department of Applied Physics, Aalto University*

**Presenting Author: curie.lee@aalto.fi*

Introducing quantum-disordered magnetic systems, such as quantum spin liquids, into Josephson junctions offers new opportunities to explore the interplay between superconductivity and strong quantum fluctuations. However, the influence of the superconducting phase difference on many-body excitations and in-gap states in such junctions remains largely unexplored.

In this work, we investigate a Josephson junction consisting of a one-dimensional quantum spin liquid described by the Hubbard model, sandwiched between two conventional s-wave superconductors. By calculating the phase-dependent many-body energy spectrum, we characterize the evolution of low-energy excitations arising from electron-electron interaction. In particular, we show that in-gap states associated with interfaces[1] acquire a phase-dependent dispersion in the Josephson geometry. We further investigate the local single-electron, spin, and pair-fluctuation spectral functions to reveal how distinct many-body excitations appear in different dynamical response channels. The single-electron response probes spin-doublet states, while the local spin and pair-fluctuation responses reveal phase-dependent spin-triplet and excited-singlet states, respectively. These results demonstrate that the superconducting phase difference influences not only electronic excitations but also spin and pair excitations across the junction.

Furthermore, we identify symmetry-protected level crossings and a 4π -periodic spectral flow in the many-body singlet spectrum. Our findings elucidate the phase-dependent many-body excitation structure of Josephson junctions incorporating quantum-disordered magnetic barriers and highlight superconducting phase differences as a means of probing their correlated excitations.

[1] J. L. Lado and M. Sigrist, “Solitonic in-gap modes in a superconductor-quantum antiferromagnet interface,” *Phys. Rev. Res.* 2, 023347 (2020).



Magnetization Dynamics of Superconducting $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}/\text{Ni}_{80}\text{Fe}_{20}$ Bilayers Under DC Current Injection

F. Martinet^{1*}, S. Carreira¹ and J. E. Villegas¹

¹Laboratoire Albert Fert, CNRS, Thales, Université Paris-Saclay, 1 avenue Augustin Fresnel, 91767 Palaiseau, France

*Presenting author: francois.martinet@cnrs-thales.fr

Superconductor/ferromagnet (S/F) hybrids combine two antagonistic orders, and how they can act on each other is a central question for superconducting spintronics [1]. Ferromagnetic resonance (FMR) is a sensitive probe of this interplay. In $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}/\text{Ni}_{80}\text{Fe}_{20}$ (YBCO/Py) bilayers, for instance, the magnetization dynamics of Py change when YBCO becomes superconducting, as this modifies its capacity to act as a spin sink [2]. Current-induced effects in S/F structures, on the other hand, have been studied mostly in s-wave systems [3]. Here we ask a further question: can a current flowing in the superconductor act on the magnetization dynamics of an adjacent ferromagnet ?

We measure the FMR of YBCO/Py bilayers between 1 and 30 GHz while injecting a dc current of up to ± 100 mA in the plane of the bilayer, above and below $T_c \approx 80$ K. In the superconducting state, the lineshape changes and the resonance field becomes current-dependent above a threshold current and symmetrically under current reversal. Most strikingly, the shift of the resonance field is of opposite sign at the two frequencies: at 20 GHz it drops by ≈ 10 Oe above $|I| \approx 45$ mA, whereas at 12 GHz it increases by ≈ 12 Oe. Neither an Oersted field nor heating alone would produce such a dependent effect.

The mechanism remains open: the Meissner-screened field of the supercurrent, pair breaking, spin-triplet correlations, magnetoelectric coupling [4], or dissipation near the critical current. We will discuss how the threshold-like current dependence, its symmetry under current reversal, and its temperature and frequency dependence constrain these scenarios.

We acknowledge funding from French ANR through grants No. PEPR SPIN ANR-22-EXSP-0007 “SPINMAT,” and No. ANR-24-EXSP-0012 “SUPERSPIN”; the European EIC Pathfinder Grant No. 101130224 “JOSEPHINE” and Cost Action CA21144 “SUPERQUMAP”;

[1] C. Bell et al., Phys. Rev. Lett. 100 (2008) 047002; K.-R. Jeon et al., Nat. Mater. 17 (2018) 499.

[2] S. J. Carreira et al., Phys. Rev. B 104 (2021) 144428.

[3] M. Müller et al., Phys. Rev. Lett. 126 (2021) 087201.

[4] V. Plastovets and A. Buzdin, Phys. Rev. B 110 (2024) 144521.



Band structure and defects in FeSe under high magnetic fields

Pablo García Talavera ^{1*}, Miguel Águeda Velasco¹, Jose Antonio Moreno¹, Juan Schmidt^{2,3,4}, Sergey L. Bud'ko^{2,3}, Paul C. Canfield^{2,3}, Isabel Guillamón¹, Edwin Herrera Vasco¹, Hermann Suderow¹

¹Laboratorio de Bajas Temperaturas y Altos Campos Magnéticos, Departamento de Física de la Materia Condensada, Instituto Nicolás Cabrera and Condensed Matter Physics Center (IFIMAC), Unidad Asociada UAM-CSIC, Universidad Autónoma de Madrid, Madrid, E-28049, Spain

²Department of Physics and Astronomy, Iowa State University, Iowa, 50011, USA.

³Ames National Laboratory, Iowa State University, Iowa, 50011, USA.

⁴Departamento de Física, FCEyN, Universidad de Buenos Aires, Buenos Aires, 1428, Argentina.

*Presenting Author: pablo.garcia@uam.es

The electronic properties of iron-based superconductors present notorious features that emerge at low energies, including orbital-dependent mass renormalization, nematicity and shallow bands. However, their huge upper critical fields make it very difficult to measure the band structure of the normal phase for energies of the order of the superconducting gap. FeSe is a stoichiometric iron-based superconductor with a critical field of about 16 T. Here we apply magnetic fields up to 20 T and study the electronic properties of FeSe. We focus on the band structure and orbital-sensitive renormalization, as well as on the electronic properties around defects.



Imaging Current Flow in the Electrically Induced Hidden State of 1T-TaS₂

D. Yahav¹, A. Yazdi², I. Ofek^{2*}, H. Bae³, T. R. Devidas², B. Yan^{3,4}, E. Maniv¹, B. Kalisky²

¹ Ben-Gurion University, Israel

² Bar-Ilan University, Israel

³ Weizmann, Israel

⁴ The Pennsylvania State University, Pennsylvania, USA

*Presenting author: idanofek98@gmail.com

1T-TaS₂ is a layered quantum material that exhibits a rich charge-density-wave phase diagram and an electrically induced metastable metallic hidden state at low temperatures. Despite extensive study, the microscopic nature of this state and the pathway through which current flows remain unresolved. We use scanning SQUID together with electrical transport to directly image the spatial distribution of current in electrically pulsed 1T-TaS₂ devices. We find that the current is strongly confined to narrow conduction channels in the *ab* plane, while extending broadly along the *c* axis. These channels can also form within the crystal interior and shift as the pulse amplitude is increased. Our measurements suggest that the dominant conduction pathway is associated with the evolving boundary between the insulating commensurate CDW and metallic mosaic-CDW states, providing a spatial picture of how the hidden state forms and evolves under electrical excitation.



Gate-tunable anomalous phase shift in ferromagnetic hybrid Josephson junctions

D. Rana^{1*}, O. S. Kurapati¹, N. M. S. R. N. Vanjarapu¹, J. Zhao¹, J. B. F. Wolters¹, A. L. R. Manesco¹, S. D. Escribano², E. Prada², and S. Vaitiekėnas¹

¹Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark

²Instituto de Ciencia de Materiales de Madrid (ICMM), Consejo Superior de Investigaciones Científicas (CSIC), E-28049 Madrid, Spain

*Presenting Author: deepti.rana@nbi.ku.dk

We report phase-sensitive measurements of a ferromagnetic InAs/EuS/Al Josephson junction embedded in an asymmetric SQUID with an InAs/Al reference junction.. Sweeping the axial magnetic field produces a continuous and hysteretic displacement of the SQUID interference pattern, corresponding to an anomalous phase shift, with a finite separation between opposite field-sweep directions persisting at zero applied field. The anomalous phase is strongly tunable by electrostatic gating, with global back-gate and local plunger-gate control producing distinct phase responses. Cross-sectional electrostatic calculations reveal a corresponding redistribution of the semiconductor wave functions and variation of the effective Rashba spin–orbit coupling. The observed behaviour is consistent with the interplay between broken time-reversal symmetry induced by the ferromagnetic EuS and inversion-symmetry breaking associated with spin–orbit coupling in the InAs nanowire. These results demonstrate a remanent and electrically tunable Josephson phase bias in a ferromagnetic semiconductor–superconductor hybrid, establishing a platform for controllable phase-biased and nonreciprocal superconducting transport.



Variational quantum circuits for hardware-aware transpilation

A. Sarno^{1*}, C. Cosenza¹, V. Stasino¹, P. Mastrovito¹, M. el Bakraoui², C. Bésain², F. Cibrario³, V. Zaffaroni³, G. Ranieri³, R. Bertilone³, L. Chabbra², D. Corbelleto³, F. Tafuri¹, D. Massarotti⁴, and H. G. Ahmad¹

¹*Dipartimento di Fisica “Ettore Pancini”, Università degli Studi di Napoli Federico II, Via Cinthia, 80126 Napoli, Italy.*

²*G2Q Computing, 20154 Milano, Italy.*

³*Intesa Sanpaolo, 10121 Torino, Italy.*

⁴*Dipartimento di Ingegneria Elettrica e delle Tecnologie dell’Informazione, Università degli Studi di Napoli Federico II, Via Claudio 21, 80125 Napoli, Italy.*

**Presenting author: alessandro.sarno@unina.it*

Executing quantum algorithms on Noisy Intermediate-Scale Quantum (NISQ) devices requires addressing strict physical constraints, including limited coherence times, single- and two-qubit gate imperfections, State Preparation and Measurement (SPAM) errors, restricted connectivity, and crosstalk [1, 2, 3]. To overcome these limitations, precise low-level gate synthesis and systematic calibration are essential to gain high fidelity operations [4, 5]. However, state-of-the-art algorithmic synthesis largely relies on standard, hardware-agnostic compilers to translate logical operations into native gate sets often generating deep circuits with high gate overheads, which fail to adapt to low-level hardware noise and cause significant performance degradation due to decoherence [6]. To bridge this gap, we propose an integrated, hardware aware transpilation framework that combines low-level control pulse engineering in superconducting transmon qubits with in-situ variational tuning of single-qubit rotation angles. This hybrid approach directly counteracts systematic hardware imperfections and mitigates depolarizing noise [7]. As a practical benchmark testbed, we validate our calibration and transpilation workflow on algorithms relevant to Quantum Finance, developed in collaboration with industry partners. Specifically, we implement multi-qubit Gaussian distribution state preparation and a 3-qubit Quantum Gaussian Conditional-Independence (GCI) model for Credit Risk Analysis [8, 9]. Experimental results on the first 25-qubit transmon-based superconducting processor in Italy demonstrate that our hardware-aware framework tailored on specific topology of the processor significantly reduces circuit depth and execution time, thus establishing as a viable methodology for deploying optimized NISQ algorithms in financial applications.

[1] Frank Arute et al. In: Nature 574.7779 (2019), pp. 505–510. doi: 10.1038/s41586-019-1666-5.

[2] Youngseok Kim et al. In: Nature 618.7965 (2023), pp. 500–505. doi: 10.1038/s41586-023-06096-3.

[3] Paul V. Klimov et al. In: Nature Communications 15.1 (2024), p. 2442. doi: 10.1038/s41467-024-46623-y.

[4] P. Krantz et al. In: Applied Physics Reviews 6.2 (June 2019), p. 021318. doi: 10.1063/1.5089550.

[5] V. Negirneac et al. In: Phys. Rev. Lett. 126 (22 June 2021), p. 220502. doi: 10.1103/PhysRevLett.126.220502.

[6] Yunong Shi et al. In: Proceedings of the IEEE 108.8 (2020), pp. 1353–1370. doi: 10.1109/JPROC.2020.2994765.

[7] Halima Giovanna Ahamad et al. In: IEEE Transactions on Quantum Engineering (2026). doi:10.1109/TQE.2026.3691176.

[8] Ashley Montanaro. In: Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences 471.2181 (Sept. 2015), p. 20150301. doi: 10.1098/rspa.2015.0301

[9] Stefan Woerner et al. In: npj Quantum Information 5.1 (Feb. 2019), p. 15. doi: 10.1038/s41534019-0130-6.



Modeling Superconducting Circuits with Neural Stochastic Differential Equations

L. Soták^{1*}, A. Ryabov², T. Novotný¹ and M. Žonda¹

¹*Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, Ke Karlovu 5, Praha 2 CZ-121 16, Czech Republic*

²*Department of Macromolecular Physics, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 747/2, Praha 8 CZ-180 00, Czech Republic*

*Presenting author: l.sotak03@gmail.com

Superconducting circuits containing Josephson junctions are important for both fundamental research and applications ranging from precision metrology to quantum technologies. Even relatively simple circuits exhibit rich nonlinear dynamics, including phase slips and switching between different dynamical regimes [1]. Such systems are often well described by the resistively and capacitively shunted junction (RCSJ) model and its extensions. However, reliable models of more complex and noisy circuits are often difficult to formulate. In this work, we employ neural stochastic differential equations [2], a machine-learning approach that combines known physical models with neural networks to describe such systems. The neural network learns the missing contributions to the dynamics, including stochastic effects, while preserving consistency with the underlying physics. The approach is sufficiently flexible to describe different circuit architectures and may provide a general framework for modeling complex superconducting circuits. As a proof of concept, we apply the method to RCSJ models with different Josephson potentials [3,4] and a more complex circuit.

[1] M. Žonda, W. Belzig, T. Novotný, Phys. Rev. B 91 (13), 134305 (2015)

[2] X. Li, T.-K. L. Wong, R. T. Q. Chen, D. Duvenaud, Proc. Mach. Learn. Res. 108, 3870-3882 (2020)

[3] M. Žonda, W. Belzig, E. Goldobin, T. Novotný, Phys. Rev. B 110 (5), 054306 (2024)

[4] F. Dominguez, F. Hassler, G. Platero, Phys. Rev. B 86, 140503(R) (2012)



Ab initio-calculated double-electron exchange amplitudes and modulation of superfluid density by apical oxygen distance in $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+x}$ as crucial experiment for the pairing mechanism

Zlatomir Z. Zhelev^{1*}, Todor M. Mishonov¹, and Albert M. Varonov¹

¹*Georgi Nadjakov Institute of Solid State Physics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee, BG-1784 Sofia, Bulgaria*

**Presenting Author: zlatomir.zhelev04@gmail.com*

We present a simple cluster method for calculation of the double electron superexchange J_{dd} and the s-d exchange J_{sd} amplitudes between different Cu. Ab initio calculated hopping amplitudes t , single site energies ϵ and Coulomb repulsion U based on well-known atomic wave functions are used in this calculation. The results are applied to the CuO_2 plane of superconducting cuprates. It is found that J_{dd} has almost exact analytical solution through a Dyson-like correction. In addition, the performed analytic perturbative fourth order expansion of J_{dd} in the regime $U/t \gg 1$ reproduces the numerical perturbative analysis of the same order of Psiachos [D. Psiachos, *Annals of Physics*, Vol. 360 (2015) 33–43]. The calculated set of parameters reproduces the depth of the modulation of the superfluid density induced by modulation of apical oxygen distance δ studied with SJTM by O'Mahony et al. [S. M. O'Mahony, W. Ren, W. Chen, Y. X. Chong, X. Liu, H. Eisaki, S. Uchida, M. H. Hamidian, and J. C. S. Davis, *On the electron pairing mechanism of copper-oxide high temperature superconductivity*, *Procs. Nat. Acad. Sci.*, Vol. 119(37), e2207449119 (2022)]. Up to now except for the concurrence of predictions from strong correlation theory, this phenomenon has no alternative explanation other than the s-d pairing exchange amplitude.