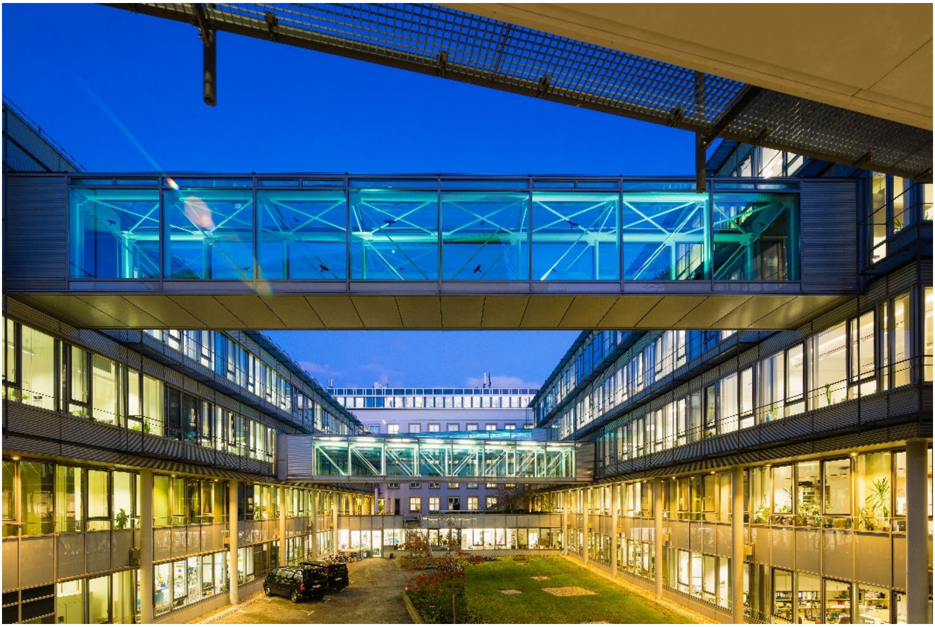

Indo-German Workshop on Quantum Sensing with Quantum Materials: Present and Future

IFW Dresden, 30 June – 3 July 2026

Organizers:

Tanusri Saha-Dasgupta, S.N. Bose Center for Basic Sciences

Bernd Büchner, IFW Dresden

Co-organizers:

Aparajita Singha, Technische Universität Dresden

Saquib Shamim, S.N. Bose Center for Basic Sciences

Leibniz Institute for Solid State and Materials Research Dresden

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Dresden University of Technology

IGSTC INDO-GERMAN SCIENCE AND TECHNOLOGY CENTRE

This event is sponsored by the Indo-German Science and Technology Centre through their Workshop Programme

Welcome to Dresden!

Venue: IFW Dresden, Helmholtzstrasse 20, 01069 Dresden
Opening day 30 June: Lecture Hall (A1E.10)
1-3 July: D2E.27

Access with public transportation: Tramway 3 and 8, stop “Nürnberger Platz”, Bus 66 “Mommsenstrasse”, Bus 85 “Helmholtzstrasse”. Single tickets can be bought on the tram or bus (€3.60), or in the FAIRTIQ app. 4-trip tickets can be bought using the yellow machines at selected stops (€13). If you only travel between IFW and the main train station you can use a 4-short-trip (Kurzfahrten) ticket (€8.40). More information on transportation, time tables and fares: https://www.dvb.de/en-GB/ .

Accommodation:Hotel Ibis Zentrum Dresden, **Prager Str. 5**, 01069 Dresden

Meals: (invited speakers only)
Lunch takes place at the IFW Dresden Restaurant. Please use the provided vouchers.
The conference dinner will take place on **July 1** at **6.30 pm** at the restaurant **Lila Soße**, **Alaunstraße 70**, 01099 Dresden. The restaurant is located in the Kunsthofpassage, a network of interconnected courtyards between Alaun St. and Görlitzer St. that is one of the best-know cultural and architectural attractions in the Dresden Neustadt. The restaurant is a representative of the “junge deutsche Küche” (new German cuisine) offering a modern reinterpretation of German and Central European dishes. The restaurant is easily reached from Tramway 8 (stop Louisenstrasse): walk up Louisen St. and turn left in Alaun St. Follow Alaun St. for ~200 m and you will find the entrance to the Kunsthofpassage on your right-hand side.

Internet access
WLAN :“QSQM” (no password), or “eduroam” (using your eduroam credentials).

Tuesday, 30 June - IFW Lecture Hall (A1E.10)	
08:30	Registration
09:00	**Opening Session – Chair: Büchner**
	Welcoming words **Bernd Büchner**, Scientific Director, IFW Dresden **Gerhard Rödel,** Head Office Manager, DRESDEN-concept **Sohag Sen**, First Secretary (Commerce) and Head of Chancery, Embassy of India **Kusumita Arora**, Director, Indo-German Science and Technology Center
	Designing 2D materials with novel quantum functionality by computation **Tanusri Saha-Dasgupta,** S.N. Bose National Centre for Basic Sciences, Kolkata
10:30	Coffee break (Atrium)
11:00	**Session 2 - Quantum materials – Chair: Fulga**
	From Properties to Structures: DiffCrysGen as a Lightweight and Efficient Conditional Diffusion Model for AI-Driven Inverse Materials Design **Prasenjit Sen,** Harish-Chandra Research Institute, Allahabad
	Topological surface superconductivity in $PtBi_2$ **Jeroen van den Brink,** IFW Dresden
	Unconventional Surface Superconductivity of t-$PtBi_2$ **Christian Hemker-Hess,** Bergische Universität Wuppertal
13:00	Lunch break (IFW Restaurant)
14:00	**Session 3 - Quantum Materials – Chair: Janson**
	Spins and orbitals in the 2D Ising magnet Li_2FeSiO_4 **Rüdiger Klingeler,** Heidelberg University
	Strain-induced Orbital Ordered Ferromagnetic State and Enhanced Magnetoresistance in $Pr_{0.67}Sr_{0.33}MnO_3$ **Tuhin Maity,** Indian Institute of Science Education and Research Thiruvananthapuram
	Utilizing frustrated magnets for milli-Kelvin refrigeration and a Quantum NanoLab **Philipp Gegenwart,** Universität Augsburg
16:00	Coffee break (Atrium)
16:30	**Discussion panel (closed session, only invited speakers) – Room A2E.04** **Moderator: Büchner/van den Brink**
17:30	End of the day's programme

Wednesday 1 July – Room D2E.27	
09:00	**Session 4 - Quantum Sensing – Chair: Alfonsov**
	Quantum sensing and imaging with NV centers in diamond **Kasturi Saha,** Indian Institute of Technology Bombay
	Spin pumping with novel quantum material **Subhankar Bedanta**, National Institute of Science Education and Research Bhubaneswar
	Spin qubits in diamond for quantum sensing **Nabeel Aslam,** Leipzig University
11:00	Coffee break
11:30	**Session 5 - Quantum Materials – Chair: Nogueira**
	Visualising vortex liquids and inverse melting in superconducting thin films **Pratap Raychaudhuri,** Tata Institute of Fundamental Research, Mumbai
	Tuning the Uncertainty between Charge and Phase: From Dynamical Coulomb Blockade to Dissipationless Cooper Pair Tunneling **Christian Ast,** Max-Planck-Institut für Festkörperforschung, Stuttgart
12:50	Lunch
14:00	**Session 6 - Quantum Materials – Chair: Efremov**
	What limits the critical temperature for superconductivity in quantum materials **Milan Allan**, Ludwig-Maximilians-Universität München
	Nucleation and Enhancement of Superconductivity Under Tip-induced Strain fields **Goutam Sheet**, Indian Institute of Science Education and Research Mohali
	Sensing vortex correlations using Noise **Saquib Shamim,** S.N. Bose National Centre for Basic Sciences, Kolkata
16:00	Coffee break
16:30	**Discussion panel (closed session, only invited speakers) – Room A2E.04** **Moderator: Saha-Dasgupta**
17:30	End of the day's scientific programme
18:30	Workshop dinner (invited speakers) – Lila Soße, Alaunstrasse 70

Thursday, July 2nd– Room D2E.27	
09:00	**Session 7 - Quantum Sensing: Search for Alternatives – Chair: Sarkar**
	Entanglement-Assisted Quantum Sensing with Correlated Nuclear Spin Clusters **T.S. Mahesh**, Indian Institute of Science Education and Research Pune
	Localization and coherent control of 25 nuclear spins in Silicon Carbide **Vadim Vorobyov**, University of Stuttgart
	Planar scanning probe microscopy - the art of low-level flight at the nanoscale **Friedemann Reinhard**, University of Rostock
11:00	Coffee break
11:30	**Session 8 - Quantum Sensing: Search for Alternatives – Chair: Singha**
	Spin-based quantum sensing: from material science and physics, to applications in biology and chemistry **Elke Neu-Ruffing**, RPTU Kaiserslautern-Landau
	Counting photons with all-2D hybrids **Arindam Ghosh**, Indian Institute of Science, Bengaluru
12:50	Lunch
14:00	**Session 9 - Quantum Sensing: Search for Alternatives – Chair: Lubk**
	Spin Defects in hexagonal Boron Nitride for Sensing Applications **Vladimir Dyakonov,** Julius Maximilian University of Würzburg
	NV-magnetometry: Challenges and Opportunities for Quantum Sensing Experiments **Aparajita Singha**, Technische Universität Dresden
	Nonlinear nanomechanical resonators approaching the quantum ground state **Chandan Samanta**, Indian Institute of Science Education and Research Bhopal
16:00	Coffee break
16:30	**Discussion panel (closed session, only invited speakers) – Room A2E.04** **Moderator: Singha**
17:30	End of session

Friday, July 3rd– Room D2E.27	
09:00	**Session 10 – Bridging the gap between academia and industry – Chair: Büchner**
	Christian Osterkamp, Diatope GmbH, Ulm
	Gayathri H.N. Murthy, Quan2D Technologies, Bengaluru
	Malllikarjun Karra, QuBeats, Nostradamus Technologies Private Limited, Hyderabad
10:30	Coffee break
11:00	**Discussion panel (closed session, only invited speakers) – Room A2E.04 Moderator: Singha**
12:30	End of Worskhop

ABSTRACTS

Designing 2D materials with novel quantum functionality by computation

Tanusri Saha-Dasgupta, S. N. Bose National Centre for Basic Sciences

In this talk, I will demonstrate how computer engineered 2D materials derived from known bulk compounds, can be a host for exhibiting intriguing Quantum functionalities. I will discuss two examples. In the first example [1], we will explore the robust half-metallicity and topological properties in square-net potassium manganese chalcogenides. Our study puts these compounds in the class of topological half-metals with appreciable values of anomalous Hall conductivity, opening up the application possibility in topological quantum spintronics. In the second example [2], we will discuss the giant Rashba effect and nonlinear anomalous Hall conductivity in a two-dimensional molybdenum-based Janus structure. The ab initio calculated electronic structure of these Janus structures, show giant Rashba effect with Rashba coefficients as large as 4 ~ eV Ao. Interestingly, the same Janus structures are shown to be potential candidates to exhibit nonlinear anomalous Hall conductivity owing to the nonzero Berry curvature on the nonequilibrium Fermi surface. Our computational study predicts that such

Janus structures can be promising platform for exploring intertwined quantum phenomena in a single two-dimensional system.

[1] Koushik Pradhan, Prabuddha Sanyal, and Tanusri Saha-Dasgupta, Phys. Rev. B 107, 155115
[2] Shiladitya Karmakar, Rajdeep Biswas, and Tanusri Saha-Dasgupta, Phys. Rev. B 107, 075403

From Properties to Structures: DiffCrysGen as a Lightweight and Efficient Conditional Diffusion Model for AI-Driven Inverse

Prasenjit Sen, Harish-Chandra Research Institute

Mapping desired properties to material structures represents the final frontier of advanced materials design for emerging technologies. Traditionally, materials discovery has relied on trial-and-error experimentation - a process that is slow and costly, consuming significant resources with no guarantee of success. While machine learning-accelerated property prediction has helped narrow the experimental search space, recent advances in generative AI have opened entirely new possibilities: the ability to directly design materials possessing a precisely specified set of properties for a target application.

Earlier generative approaches - Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) - though straightforward to implement, carry well-known limitations. GANs are prone to mode collapse, while VAEs suffer from posterior collapse and a tendency to generate a disproportionately large fraction of low-symmetry crystal structures. Diffusion-based models have emerged as a compelling alternative, overcoming these shortcomings and yielding significantly higher-quality crystal structures.

While many sophisticated diffusion models have been proposed in the literature, I will present the one developed in our group, built around a minimalist design philosophy. DiffCrysGen — a lightweight yet powerful model — achieves generation throughputs up to two orders of magnitude faster than leading baseline models. Building on this foundation, DiffCrysGen+, its extension to conditional generation, produces materials satisfying pre-specified target properties at an accelerated rate, making both models valuable tools for high-throughput inverse materials design. I will illustrate their capabilities through concrete examples drawn from the design of advanced functional materials.

Topological surface superconductivity in $PtBi_2$

Jeroen van den Brink, Institute for Theoretical Solid State Physics, IFW Dresden

Most superconducting materials are well-understood and conventional in the sense that the pairs of electrons that cause the superconductivity by their condensation have the highest possible symmetry. Famous exceptions are the enigmatic high-Tc cuprate superconductors. Nodes in their superconducting gap are the fingerprint of their unconventional character and imply superconducting pairing of d-wave symmetry. Here, using angle-resolved photoemission spectroscopy, we observe that the Weyl semimetal PtBi2 harbors nodes in its superconducting gap, implying unconventional i-wave pairing symmetry. At temperatures below 10K, the superconductivity in PtBi2 gaps out its topological surface states, the Fermi arcs, while its bulk states remain normal. The nodes in the superconducting gap that we observe are located exactly at the center of the Fermi arcs, and imply the presence of topologically protected Majorana cones around this locus in momentum space. From this, we infer theoretically that robust zero-energy Majorana flat bands emerge at surface step edges. This not only establishes PtBi2 surfaces as unconventional, topological i-wave superconductors but also as a promising material platform in the ongoing effort to generate and manipulate Majorana bound states.

Unconventional Surface Superconductivity of t- $PtBi_2$

Christian Hemker-Hess, Bergische Universität Wuppertal

The Weyl semimetal t-$PtBi_2$ (trigonal) recently emerged as an interesting host of unconventional and potentially topological superconductivity. Sizable superconducting gaps up to about 20 meV have been observed in scanning tunneling spectroscopy (STM/STS) [1] and ARPES [2,3]. The data suggest surface superconductivity emerging from the Weyl Fermi arc states while the bulk states remain normal. The order parameter has been reported to possess nodes, suggestive of topological i-wave superconductivity [3]. Here we present STM/STS data of the quasiparticle interference (QPI) in both the superconducting and the normal state as well as temperature dependent measurements of the superconducting gap. Our data clearly reveal that i) the states which are gapped out by superconductivity indeed are located at the Fermi arcs, and ii) the large superconducting gaps correspond to a high critical temperature Tc up to about 50 K. Thus $PtBi_2$ indeed qualifies as a truly unconventional and topological superconductor.

1. S. Schimmel et al., Nature Communications 15, 9895 (2024)
2. A. Kuibarov et al., Nature 626, 294 (2024)
3. S. Changdar et al., Nature 647, 613-618 (2025)

Spins and orbitals in the 2D Ising magnet Li_2FeSiO_4

Rüdiger Klingeler, Heidelberg University

We report the high-pressure optical growth and detailed investigation of Li_2FeSiO_4 single crystals by means of magnetisation, specific heat, thermal expansion and magnetostriction, Mössbauer spectroscopy, neutron diffraction, and high-frequency ESR studies, some of which in static/pulsed magnetic fields up to 35/60 T, as well as numerical studies. The material is a quasi-2D Ising magnet evolving long-range magnetic order at 17 K showing the crossover from 2D-Ising to a 3D-Ising behavior above T_N, i.e., in the paramagnetic short-range spin-ordered phase. By means of Grüneisen analysis, we separate the thermodynamic signatures of the orbital degrees of freedom and quantify the lowest orbital energy gap and its pressure dependence. Studies of the antiferromagnetic resonance branches show that the anisotropy gap of closes in magnetic fields || easy axis of 16 T which is associated with the complete suppression of magnetic order down to the lowest temperature. Notably, a re-entrant spin ordered phase appears above 16 T which is reminiscent of the phase diagram of a generic uniaxial 2D magnet. Our results extend the available model materials of quasi-2D magnetism to a high-spin S = 2 system with tetrahedrally coordinated Fe^{2+} ions, thereby illustrating how magnetic order evolves in a 2D Ising-like system with orbital degrees of freedom.

Strain-induced Orbital Ordered Ferromagnetic State and Enhanced Magnetoresistance in $Pr_{0.67}Sr_{0.33}MnO_3$

Tuhin Subhra Maity, Indian Institute of Science Education and Research Thiruvananthapuram

As the global demand for data processing and storage continues to increase, there is an urgent need for highly efficient, next-generation, low-power electronic devices. Present technologies rely on charge transport, which is inherently associated with Joule heating and high energy consumption. This motivates the exploration of energy-efficient alternatives such as spintronics. In this context, magnetoresistance (MR) plays a key role in enabling magnetic sensing and data storage technologies. Among various material systems, mixed-valence rare-earth perovskite manganites are promising due to the strong coupling between spin, charge, lattice, and orbital degrees of freedom, leading to emergent phenomena such as colossal magnetoresistance (CMR), metal–insulator transitions (MIT), and charge/orbital ordering. However, controlling and enhancing magnetotransport in thin films remains challenging, as epitaxial strain alters the balance between competing interactions.

In this work, we study $Pr_{0.67}Sr_{0.33}MnO_3$ (PSMO) in bulk and epitaxial thin-film forms and show that biaxial compressive strain reconstructs its ground state. Bulk PSMO exhibits a ferromagnetic metallic state with an MIT coinciding with the Curie temperature, consistent with double-exchange-driven carrier delocalisation. In contrast, the thin film stabilises a ferromagnetic insulating state over the entire temperature range, where transport evolves from

thermally activated conduction to variable-range hopping due to progressive polaron localisation.
Despite being insulating, the thin film shows strong sensitivity to external magnetic fields, with a large negative MR of ~-87% at 100 K. Raman spectroscopy and first-principles calculations reveal that compressive strain stabilises static Jahn-Teller distortions, leading to splitting of Mn eg orbitals, orbital polarisation and ordering, and a reduced electronic bandwidth.
Overall, this work establishes epitaxial strain as an effective route to tune orbital degrees of freedom and spin–lattice coupling, enabling field-tunable functional states and enhanced MR in oxide thin films.

Utilizing frustrated magnets for milli-Kelvin refrigeration and a Quantum NanoLab

Philipp Gegenwart, Universität Augsburg

Accessing milli-Kelvin temperatures is a prerequisite for quantum-matter research and applications in quantum technologies. Adiabatic demagnetization refrigeration (ADR) is a simple and sustainable alternative to ^{3}He/^{4}He dilution refrigeration. Geometrically frustrated rare earth oxides feature important advantages compared to the traditionally utilized hydrated paramagnetic salts for mK-ADR, including higher entropy density, chemical stability and easier fabrication of cooling stages. Recent work on materials optimization and customized ADR platforms for the Quantum Design Physical Property Measurement System is presented. Furthermore, application in an ADR-based ultra-low noise milli-Kelvin UHV scanning probe microscope is presented. Work in collaboration with Marvin Klinger, Tim Treu, Anton Jesche, Taner Esat, Ruslan Temirov and Stefan Tautz. Financial support by BMBF 13N16032 (Quantum NanoLab), BMWK EXIST-Forschungstransfer: „Solidcryo“ and by the German Research Foundation (DFG) through Project 514162746 (GE 1640/11-1) is acknowledged.

Quantum sensing and imaging with NV centers in diamond

Kasturi Saha, Indian Institute of Technology Bombay

Quantum diamond microscopy has emerged as a powerful platform for high-sensitivity magnetic and electric field imaging with nanoscale to wide-field resolution. This talk will discuss recent advances in the development of quantum diamond microscopes operating at both room temperature and low temperature, enabling applications across materials science, spintronics, superconductivity, and biological sensing. I will present progress in instrument design, optical integration, microwave control, cryogenic compatibility, and sensitivity optimization. Particular emphasis will be placed on overcoming technical challenges related to coherence preservation, imaging speed, and spatial resolution. Future directions toward scalable, application-driven quantum imaging systems will also be highlighted.

Spin pumping with novel quantum material

Subhankar Bedanta, National Institute of Science Education and Research Bhubaneswar

Pure spin current is the key factor for development of next generation energy efficient spintronic devices. Spin pumping is an established method to generate spin current via precessing magnetization from a ferromagnetic (FM) layer by microwave driven ferromagnetic resonance. This generated pure spin current gets converted to charge current due to high SOC by inverse spin Hall effect (ISHE). Quantum materials exhibit unique electronic properties, such as strong SOC, topological surface states, or engineered band structures, that enable efficient spin-to-charge conversion. In this context, I will discuss the spin to charge conversion phenomena with the transition metal dichalcogenide MoS_2, topological insulator Bi_2Se_3 and various antiferromagnets. I will also discuss on the ISHE experiments with novel coupled ferrimagnetic systems. Systematic thickness and azimuthal angle dependent measurements were carried out to disentangle various spin rectification effects such as anisotropic magnetoresistance, anomalous Hall effect etc. We demonstrate spin pumping and ISHE in large area magnetron sputtered MoS_2/CoFeB heterostructures. Further, I will review our work on the spin-charge conversion phenomena in Bi_2Se_3/CoFeB systems and antiferromagnetic heterostructures comprising IrMn, NiMn, Mn_2Au, Mn_3Ga, Co_3O_4, RuO_2 etc. Ultra-low damping, long spin propagation and presence of magnon modes in ferrimagnets have attracted attention for coherent spintronic applications. In this regard, I will demonstrate our work on magnetization dynamics in coupled YIG/TmIG epitaxial system and its relevance in spin-charge based experiments.

Spin qubits in diamond for quantum sensing

Nabeel Aslam, Leipzig University

Quantum sensors based on single spins in diamond have emerged as powerful tools for probing matter at the nanoscale. In this talk, I will introduce the fundamental principles behind these sensors and show how they can be used to detect e.g. magnetic fields with unprecedented sensitivity and resolution. A key theme will be the interplay between quantum information and quantum sensing - how concepts like coherence, quantum memory and entanglement, extend the capabilities of spin-based sensors. The talk will highlight advances in nanoscale nuclear magnetic resonance spectroscopy and explore how these techniques are applied to different samples ranging from biological structures to quantum materials. The talk will conclude with a perspective on how quantum sensing can act as a bridge between fundamental research and real-world applications.

Visualising vortex liquids and inverse melting in superconducting thin films

Pratap Raychaudhuri, Tata Institute of Fundamental Research

In a Type II superconductor in the presence of a magnetic field, the magnetic flux disperses in the form of quantized flux tubes that arrange themselves in a periodic structure, called the Abrikosov vortex lattice. While in many ways the vortex lattice behaves like a soft crystalline solid, the melting of this solid into a vortex liquid state is rarely observed in conventional 3-dimensional superconductors. On the other hand, other hand, over the past decade, work carried out in our group showed that vortex liquid states can be readily realised in superconducting thin films, where the 2-dimensional vortex lattice is much more susceptible to thermal fluctuations. In this talk, I will describe how the melting of a 2-dimensional vortex solid can be directly visualised using a low-temperature scanning tunnelling microscope (STM) and elucidate the structure and dynamics of the 2-dimensional vortex liquid. I will also discuss a very rare phenomenon, namely "inverse melting" of the vortex lattice, where the vortex state transforms from a liquid to a solid with an increase in temperature or magnetic field.

References:

1. I. Roy et al., Melting of the Vortex Lattice through Intermediate Hexatic Fluid in an α-MoGe Thin Film, Phys. Rev. Lett. 122, 047001 (2019).
2. R. Duhan et al., Structure and dynamics of a pinned vortex liquid in superconducting α-$Re_xZr_{(x\sim 6)}$ thin film, Phys. Rev. B 108, L180503 (2023).
3. Rishabh Duhan, Subhamita Sengupta, John Jesudasan, Somak Basistha, Pratap Raychaudhuri, Nature Communications 16, 2100 (2025).

Tuning the Uncertainty between Charge and Phase: From Dynamical Coulomb Blockade to Dissipationless Cooper Pair Tunneling

Christian Ast, Max-Planck-Institut für Festkörperforschung

The Josephson effect, the tunneling of Cooper pairs between two superconductors, is one of the most striking manifestations of quantum mechanics on macroscopic scales. It remains a cornerstone of condensed matter physics, underpinning phenomena from macroscopic quantum tunneling to dynamical Coulomb blockade and forming the basic building block of superconducting quantum computing. Josephson junctions also serve as exquisitely sensitive probes of quantum behavior across all energy scales. In the context of scanning tunneling microscopy (STM), the Josephson effect provides a unique window into the electromagnetic environment of the tunnel junction, where improvements in energy resolution open gateways to previously unexplored physics. The STM Josephson junction generally operates in the dynamical Coulomb blockade (DCB) regime, a situation fundamentally different from the well-known dissipationless Cooper pair tunneling observed in planar junctions. In the latter regime, the superconducting phase difference is well defined and can be treated classically, assuming negligible interaction with the electromagnetic environment during tunneling. In the DCB regime, by contrast, the phase fluctuates strongly, must be treated quantum mechanically, and the coupling to the electromagnetic environment can no longer be neglected. So far, these two regimes have remained largely disconnected, as the relevant parameters are difficult to tune experimentally. Here, I will show how we bridge this gap. Leveraging a greatly improved energy resolution and the intrinsic flexibility of the STM to vary the tunneling conductance, we continuously tuned a Josephson junction from the DCB regime into the dissipationless Cooper pair tunneling regime. In doing so, we closed a longstanding gap in the understanding of the Josephson effect, establishing a direct and continuous connection between its dissipative and dissipationless limits.

What limits the critical temperature for superconductivity in quantum materials

Milan Allan, Ludwig-Maximilians-Universität München & Alqem.AI

What causes superconductivity to disappear at the critical temperature T_c in high-temperature superconductors? In my talk, I will discuss two examples. First, I will present the case of underdoped cuprate superconductors, where a pseudogap exists far above T_c. Whether the pseudogap energy is associated with pairing has been a key question debated for decades. Using novel shot-noise experiments, we found that the pseudogap energy is equal to the pairing energy, meaning that pairing persists to very high energies – therefore, superconductivity is limited by coherence [1]. I will also briefly discuss overdoped high-temperature superconductors, where we found that superconductivity breaks down because of the formation of nanometer-sized puddles in a metallic matrix. Again, superconductivity is not limited by the pairing interaction [2].

References
[1] Niu & Ortego, et al. arXiv:2409.15928
[2] Tromp & Benschop, et al. Nature Materials (2023)

Nucleation and Enhancement of Superconductivity Under Tip-induced Strain fields

Goutam Sheet, Indian Institute of Science Education and Research Mohali

Tip-induced and tip-enhanced superconductivity have been observed in a growing number of materials, including topological semimetals, elemental metals, and correlated electron systems. This talk will begin with an overview of these discoveries and the experimental techniques used to study them. I will then discuss our recent work showing that the uniaxial nature of the stress field under a metallic point contact and the confinement of superconductivity to a small region under the tip are essential for understanding these phenomena. A framework based on Hertzian contact mechanics and Ginzburg-Landau theory incorporates these effects and explains a wide range of experimental observations. Using this framework, we predicted tip-induced superconductivity in elemental antimony and yttrium, which was subsequently confirmed by point-contact spectroscopy. I will also present recent measurements on elemental cerium, where superconductivity with transition temperatures above 20 K is observed only under mesoscopic point contacts. These results show that local strain generated by a metallic tip can create superconducting states that do not appear in conventional bulk measurements and establish point-contact strain engineering as a route to realizing superconductivity in quantum materials.

Sensing vortex correlations using Noise

Saquib Shamim, S.N. Bose National Center for Basic Sciences

We report on the statistics of resistance fluctuations across the superconducting transition in FeSe thin films, which lie in the BCS-BEC crossover regime. Low-frequency noise measurements reveal an enhancement of noise magnitude by five orders at low temperatures at the onset of the superconducting transition. The second spectrum of noise reveals unexpectedly large deviations from Gaussianity, thus providing direct evidence of strongly correlated dynamics near the transition, beyond the independent quasi-particle excitations. The non-Gaussian component increases with increasing superconducting critical temperature, establishing a direct link between enhanced correlations and superconducting strength. Our results demonstrate that noise spectroscopy provides a sensitive probe of correlated phase fluctuations and their evolution across the superconducting transition in low-dimensional systems.

Entanglement-Assisted Quantum Sensing with Correlated Nuclear Spin Clusters

T.S. Mahesh, Indian Institute of Science Education and Research Pune

Entangled states, owing to their heightened susceptibility to external perturbations, enable quantum sensors to achieve sensitivities beyond classical limits. Quantum-correlated clusters of nuclear spins provide a versatile testbed for investigating such sensors and for developing broadly applicable methodologies. In particular, star-topology molecules offer a powerful platform for experimental studies of entanglement-assisted sensing via NMR-controlled spin dynamics [1]. After outlining the underlying principles, we introduce Clifford lensing, a protocol for coherently localizing phase information, and demonstrate its implementation in a 19-qubit system, achieving near-optimal sensing under constrained resources [2]. We further investigate sensing through the creation, manipulation, and detection of quantum-correlated clusters comprising up to three thousand nuclear spins in crystalline systems [3]. As a representative application, we show that such clusters enable the sensitive detection of pulse-width fluctuations in radio-frequency control fields at the level of tens of nanoseconds. A key practical consideration in entanglement-assisted quantum sensing is the tradeoff between enhanced phase accumulation and the reduced coherence time of larger entangled states. In this context, we experimentally demonstrate the existence of an optimal entanglement size that maximizes sensing efficiency.

[1] T. S. Mahesh, D. Khurana, Krithika V. R., Sreejith G. J., C. S. S. Kumar, J. Phys. Condens. Matter 33, 383002 (2021)
[2] S. Asthana, C. Alexander, A. K. Srivastava, T. S. Mahesh, S. Vinjanampathy, arXiv:2603.24035
[3] C. Alexander and T. S. Mahesh, Phys. Rev. A 113, 042620 (2026)

Localization and coherent control of 25 nuclear spins in Silicon Carbide

Vadim Vorobyov, University of Stuttgart

t.b.a.

Planar scanning probe microscopy - the art of low-level flight at the nanoscale

Friedemann Reinhard, University of Rostock

Scanning probe magnetometry is one of the most successful applications of NV-diamond quantum technology, but requires sophisticated nanofabricated diamond tips with a single NV center at their apex [1].
We have developed a greatly simplified approach to achieve the same goal, termed planar scanning probe microscopy [2]. Here, a planar bulk diamond with shallow embedded NV centers is used as a sensor, with a planar surface 10 µm to millimeters in size. Surprisingly, such a large sensor can still be approached into 10 nanometer-scale proximity of samples, if it is aligned sufficiently parallel to their surface, a feat which we accomplish by interferometric microscopy.
I will present recent results demonstrating that this technique can achieve scanning-probe NV magnetometry of nanoscale magnetic domains, and that it even has complementary strengths beyond the tip-based technique. For example, multiple NV centers can be employed in parallel in the same scanning probe, which we have recently used to demonstrate vector

magnetometry [3] and which could pave the way to imaging covariance magnetometry.
My talk will also cover a recent result [4] indicating that competitive count rates on the order of 500 x 10^3 photons/s can be obtained from a single NV center in a planar scanning probe, if detection is performed from the back side of the diamond sensor by diamond-adapted optics. Reaching this level of count rate thus does not require nanofabrication, eliminating another reason for using diamond tips as scanning sensors.

[1] Maletinsky ... Loncar, Yacoby, Nat Nano 7, 320 (2012)
[2] Ernst ... Reinhard, ACS Photonics 6, 327 (2019)
[3] Weinbrenner ... Reinhard, IOP Quant. Sci. Technol. 10, 015037 (2024)
[4] Weinbrenner ... Reinhard, Nano Letters 26, 990 (2026)

Spin-based quantum sensing: from material science and physics, to applications in biology and chemistry

Elke Neu-Ruffing, RPTU

Quantum sensors based on spins are useful tools in many areas of science including material science, physics, biology and chemistry. In this talk, I will summarize our works towards optimized sensors for those disciplines. Applications will include e.g. sensing of radicals in chemical reactions or scanning probe magnetometry to investigate nanoscale magnetism. I will also highlight recent work towards proteins as spin-based sensors, enabling for the first time living organisms to produce quantum sensor by themselves.

Counting photons with all-2D hybrids

Arindam Ghosh, Indian Institute of Science, Bangalore

van der Waals heterostructure of graphene and 2D semiconductors such as the transition metal dichalcogenides are known to form exceptionally sensitive detectors of light. The mechanism of this optoelectronic sensitivity is dependent on the transfer of charge across the van der Waals interface, which usually makes the process rather slow. In this talk I shall describe a new architecture of all-2D optoelectronic hybrid, where the graphene layer is coupled to a 3R bilayer of transition metal dichacogenide, where the latter exhibits a ferroelectric instability as a function of an external electric field. We find that such an architecture can not only be used as an extremely sensitive photodetector, with resolution down to 5 photons at temperatures as high as 100 K, but they operate at speed that is limited only by our measurement electronics. I shall explain that a light-driven modulation of internal polarization in the TMDC bilayer explains the unprecedented performance of our photodetectors.

Spin Defects in hexagonal Boron Nitride for Sensing Applications

Vladimir Dyakonov, Julius Maximilian University of Würzburg

Two-dimensional materials have emerged as the new playground for quantum photonics devices. Among them, hexagonal boron nitride (hBN) is an interesting candidate due to its ability to harbor optically active defects generating single photons. In recent years, the negatively charged boron vacancy defect in hBN caught attention for their sensitivity to environmental parameters such as magnetic field, temperature, and pressure, making it interesting for quantum sensing. This spin-1 color center remains the only one with a clearly elucidated structure. Quantum sensing applications of this spin center in hBN require identification of the non-radiative relaxation pathways from the excited triplet states to the ground triplet state, particularly via an intermediate state (IS), and direct determination of their rate constants. In my talk, I will discuss the relaxation dynamics of the IS in the optical pumping cycle in a broad temperature range.

NV-magnetometry: Challenges and Opportunities for Quantum Sensing Experiments

Aparajita Singha, Technische Universität Dresden

Solid-state spin defects such as nitrogen-vacancy (NV) centers in diamond, have emerged as powerful platforms for quantum sensing, enabling

nanoscale measurements of magnetic fields, temperature, strain, and electric fields at both cryogenic temperatures as well as at ambient conditions. My research group focusses on utilizing these quantum sensors for non-invasive probing of isolated magnetic molecules on surfaces, which are difficult to access using other complementary techniques. These efforts naturally require the usage of near surface NV centers (< 10 nm) to gain desired magnetic sensitivity. However, such shallow NV sensors are also infamous for often lacking sufficient stability of their optical and spin properties. We take advantage of our UHV experimental conditions to understand the role of the diamond surface in defining these optical and spin properties for shallow NV sensors, as well as to better engineer the diamond surface with desired surface chemistry.
Another aspect of our current research involves two-dimensional mapping of both static and dynamic magnetization profile of synthetic antiferromagnets, as well as nanoscale devices, using scanning probe NV magnetometer. The key idea here is to identify their local nanoscale properties which are often obscured in conventional transport measurements. After introducing the essential concepts of nanoscale quantum sensing and providing a broad overview of the current research scopes in my experimental group, I will also highlight on the current challenges and the opportunities in this vibrant field of research.

Nonlinear nanomechanical resonators approaching the quantum ground state

Chandan Samanta, IISER Bhopal

A key frontier in nanomechanics is the realization of mechanical nonlinearities in the quantum ground state. This requires engineering a mechanical nonlinearity far beyond what has been realized thus far. In the first part of this talk, I will present a mechanism to boost the Duffing nonlinearity by coupling the vibrations of a nanotube resonator to single-electron tunnelling and by operating the system in the ultrastrong coupling regime. At the lowest temperature, the average vibration amplitude reaches

about 13 times the zero-point motion, with approximately 42% of the thermal energy stored in the anharmonic part of the potential.
In the second part, I will discuss theoretically how such nonlinear platforms can be harnessed to realize nonclassical phonon statistics. I will present phonon antibunching in a hybrid architecture comprising two coupled weakly nonlinear nanomechanical resonators interacting with a two-level system (TLS). This architecture outperforms conventional single-resonator schemes, enabling strong antibunching even in the weak-coupling regime. An auxiliary resonator enhances phonon blockade and provides tunable control via coupling strengths, detunings, and drive phase.

INDUSTRY PARTICIPANTS

Christian Osterkamp, Diatope GmbH

Diatope GmbH focuses on the development and production of high-performance NV-doped diamond materials tailored for emerging quantum technologies. By combining advanced chemical vapor deposition (CVD), isotopic purification with 12C enrichment, and precise defect engineering, the company enables fine control over key sensor parameters such as NV density, depth distribution, layer thickness, and spin coherence properties. A central objective is to achieve high reproducibility and scalability in material fabrication, thereby bridging the gap between laboratory research and industrial deployment.These engineered NV diamond materials are specifically designed for applications in quantum sensing, including high-resolution magnetic field detection, NV microscopy, and novel low-field MRI approaches. Through close collaboration with system and application partners, Diatope continuously refines its materials to meet stringent performance requirements in real-world environments. This talk highlights the concept of “NV diamonds Made in Germany” as a reliable, scalable, and application-driven platform for the next generation of quantum sensor technologies.

Gayathri H.N. Murthy, Quan2D Technologies, Bengaluru t.b.a.

Mallikarjun Karra, QuBeats

QuBeats is a full-stack quantum sensing solutions startup based out of Hyderabad, India. The company develops field-deployable quantum sensors built on a unified atomic vapour-cell platform interrogated by lasers to deliver magnetometry, gyroscopy, atomic timekeeping, and broadband RF sensing from a common set of physics. From this single platform QuBeats builds optically pumped magnetometers reaching femtotesla-to-picotesla sensitivities, Rydberg-atom RF receivers, warm-vapour optical clocks, and integrated positioning-navigation-timing systems for GPS-denied environments, serving defence, space, geoscience, mineral exploration, and biomedical applications.
Looking ahead, QuBeats is interested in leveraging advances in quantum materials—including quantum dots, spintronic systems, and engineered defect platforms—to develop next-generation compact quantum sensors that deliver high sensitivity, scalability, and robust operation in real-world settings.