Book of Abstracts

III Russian-Chinese International School

Superconducting Functional Materials for Advanced Quantum Technologies'25

Moscow Institute of Physics and Technology

(MIPT / PhysTech)

September 22-26, 2025

Dolgoprudny, Russia
2025

Contents

Conference Information

This Conference is organized within the framework of the **Russian Science Foundation** (project No. 23-72-30004) *Superconducting Functional Materials for Advanced Quantum Technologies*.

The School will be held in offline and online formats at the Center for Advanced Mesoscience and Nanotechnology at MIPT.

No registration fee is required.

The conference language is English.

The participants will get Letters of Attendence.

Main topics

- Functional quantum materials based on topologically protected electronic subsystems;
- Physics of magnetic topological insulators, hybrid superconducting-ferromagnetic systems;
- Development of control elements for superconducting quantum circuits and devices;
- Magnetic resonance spectroscopy;
- Topological quantum phenomena in superconducting systems.

Key dates

- Conference dates: September 15-19, 2025
- Submission of abstracts in English by August 30, 2025

Program Commitee:

- Prof. **STOLYAROV Vasily** – Director of the Center for Advanced Mesoscience and Nanotechnology, MIPT (Moscow, Russia)
- Prof. **GOLUBOV Alexander** – Head of the Laboratory of Topological Quantum Phenomena in Superconducting Systems at the Center for Advanced Mesoscience and Nanotechnology, MIPT (Moscow, Russia)
- Prof. **NIKITOV Sergei** – Academician of the Russian Academy of Sciences (RAS); Director of the Kotelnikov Institute of Radio Engineering and Electronics Russian Academy of Sciences (Moscow, Russia)
- Prof. **BOBKOVA Irina** – Head of the Laboratory of Spin Phenomena in Superconducting Nanostructures and Devices at the Center for Advanced Mesoscience and Nanotechnology, MIPT (Moscow, Russia)
- Prof. **MELNIKOV Alexander** – leading researcher of the laboratory of spin phenomena in superconducting nanostructures and devices at the Center for Advanced Mesoscience and Nanotechnology, MIPT (Moscow, Russia)
- Prof. **VAGOV Alexey** – Director of the Center for Quantum Metamaterials, HSE University (Moscow, Russia)
- Dr. **FROLOV Alexander** – head of the laboratory of photoelectron spectroscopy of quantum functional materials at the Center for Advanced Mesoscience and Nanotechnology, MIPT (Moscow, Russia)
- Prof. **GORSHUNOV Boris** – Head of the Laboratory of Terahertz Spectroscopy, MIPT (Moscow, Russia)
- Prof. **LI Jiafang** – deputy director of the School of Physics, Beijing Institute of Technology (Beijing, China)
- Prof. **YU Geliang** – Nanjing University (Nanjing, China)
- Prof. **ALADYSHKIN Alexey** – leading researcher of the Laboratory of Topological Quantum Phenomena in Superconducting Systems at the Center for Advanced Mesoscience and Nanotechnology, MIPT (Moscow, Russia)

Organazing Commitee:

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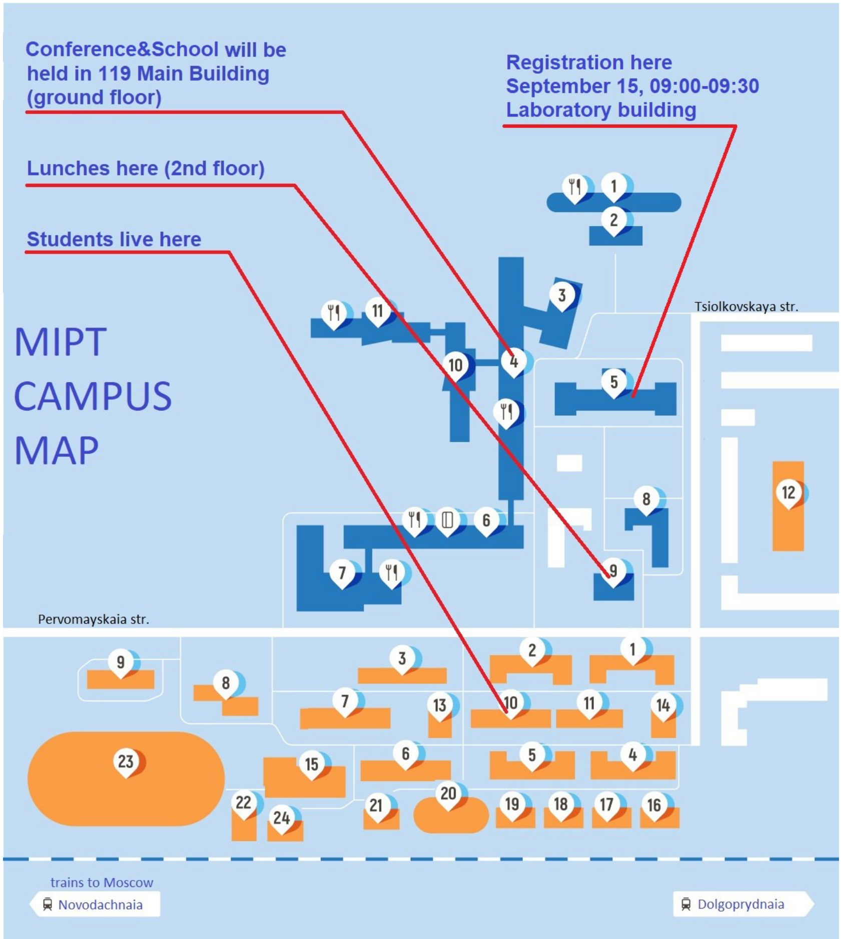

Figure 1: Schematics of the MIPT campus.

Monday, September 22, 2025 Location: Room 119, Main Building, MIPT	
10:00-11:00	**Prof. Mauro DORIA (UFRJ)**
11:00-11:30	**Coffee Break**
11:30-12:30	**Prof. Sergey NIKITOV (IRE RAS, MIPT)**
12:30-14:00	**Lunch at MIPT Cafe**
14:00-15:00	**Prof. Rafael Zadorosny (UNESP)** The Ginzburg–Landau Framework in the Study of Mesoscopic Superconductivity and Vortex Dynamics
15:00-15:30	**Coffee Break**
15:30-16:30	**Prof. Denis VYALIKH (DIPS)** Angle-resolved photoelectrons spectroscopy (ARPES) for investigations of strongly-correlated electrons and exotic magnetism in quasi-two-dimensional 4f systems

Tuesday, September 23, 2025 Location: Room 119, Main Building, MIPT	
10:00-11:00	**Prof. Sergio MAGALHAES (UFRGS)**
11:00-11:30	**Coffee Break**
11:30-12:30	**Prof Hao WU (BIT)** Color-Center Based Quantum Sensing
12:30-14:00	**Lunch at MIPT Cafe**
14:00-15:00	**Prof. Alexey ALADYSHKIN (IPM RAS, MIPT)** Historical and scientific remarks on screening effects in superconductors
15:00-15:30	**Coffee Break**
15:30-16:30	**Prof Junli MA (BIT)** Solar-Thermal Evaporation and Induced Power Generation Performance of Graphene-Based Devices

Wednesday, September 24, 2025 Location: Room 119, Main Building, MIPT	
10:00-11:00	**Prof. Valerii KOSHELETC (IRE RAS)** Superconducting Terahertz Receivers and Oscillators
11:00-11:30	**Coffee Break**
11:30-12:30	**Prof. Alexei Kartsev (HSE)** Magnetism Meets Machine Learning: Computational Pathways to Novel Materials
12:30-14:00	**Lunch at MIPT Cafe**
14:00-15:00	**Dr Dongyu LIU (HSE)** Ab Initio and Machine Learning Methods for (Non-)Adiabatic Molecular Dynamics of Materials
15:00-15:30	**Coffee Break**
15:30-16:30	**Ya-Xin ZHAO (BIT)** Research on novel structures and their electronic states realized in two-dimensional materials

Thursday, September 25, 2025 Location: Room 119, Main Building, MIPT	
10:00-11:00	**Dr. Konstantin MOTOVILOV (MIPT)** From nano- to mesoscale quantum phenomenology in bioorganic materials
11:00-11:30	**Coffee Break**
11:30-12:30	**Dr Daniil RABINOVICH (RQC, MIPT)** Quantum computing in the NISQ era
HSE excursion	

Friday, September 26, 2025 Location: Room 117, BIO Building, MIPT	
10:00-11:00	**Prof. Geliang YU (Nanjing University)**
11:00-11:30	**Coffee Break**
11:30-12:30	**Prof. Fabricio Luiz FAITA (UFRGS)** High-Pressure Effects on the Quantum materials: Challenges and facilities available in Brazil
12:30-14:00	**Lunch at MIPT Cafe**
14:00-15:00	**Prof Wenyong SU (BIT)** Discrete mapping
15:00-15:30	**Coffee Break**
15:30-16:30	**Dr. Sergey BOZHKO (ISSP RAS)** Research on novel structures and their electronic states realized in two-dimensional materials
16:30-17:30	**Dr. Qingmei HU (BIT)**
17:30-19:00 Poster Session	

Monday, September 22

1 Welcoming Address

Dear Colleagues, Guests, and Participants,

On behalf of the Program and Organizing Committees, it is my great pleasure to welcome you to the **III Russian-Chinese International School on Superconducting Functional Materials for Advanced Quantum Technologies 2025**, held at the Moscow Institute of Physics and Technology.

We are delighted to host this gathering of brilliant minds from across the globe, bringing together leading scientists, researchers, and students to discuss the latest breakthroughs and future directions in superconducting materials, quantum devices, and computing systems. The interdisciplinary nature of this School reflects the collaborative spirit essential for tackling the complex challenges at the forefront of modern quantum technology.

Special attention in our School program is paid not only to fundamental and applied aspects of modern superconducting materials, but also to their practical application in creating advanced devices and computing systems. The focus of our discussions spans the full cycle from innovative superconducting materials to practical implementations in quantum computing and devices, including superconducting qubits, quantum processors, single-photon detectors, and other critical components for quantum technologies.

This Book of Abstracts showcases the diverse and high-quality research—from novel superconducting materials to prototypes of quantum devices and computing architectures—that will be presented in the coming days. We are confident that the exchange of ideas and discussions that will take place here will foster new collaborations and inspire innovative research pathways.

We extend our sincere gratitude to all authors for their valuable contributions, to the members of the Program Committee for their diligent work in reviewing the submissions, and to the Organizing Committee for their tremendous efforts in preparing this event. Special thanks are due to the Russian Science Foundation for their support (Project No. 23-72-30004) "Superconducting Functional Materials for Advanced Quantum Technologies." We also gratefully acknowledge the support from the Priority 2030 program, which has enabled the participation of our distinguished colleagues from Brazil.

We wish you all a productive, stimulating, and enjoyable School here in Moscow.

With the highest regards,

Prof. Vasily Stolyarov
Director, Center for Advanced Mesoscience and Nanotechnology
Moscow Institute of Physics and Technology (MIPT)
Chairman of the Program and Organizing Committees

2 A Quantum Plasmonic approach for the topological insulators

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**e-mail:*

Abstract

Several common features are emerging in Condensed Matter Physics bringing new paradigms to the field. They are the Dirac linear spectrum, the Rashba term, the pseudo gap, the presence of narrow and wide bands, the spin-momentum locking, the magnetic monopole behavior of carriers and the topological nature of excitations. Here we propose that the origin of these features is found in some common properties shared by the topological insulators and the type II superconductors. They can be traced back to Abrikosov's 1957 seminal work when the magnetic properties of superconducting alloys were determined from topological excitations, the so-called vortices. Alexey Abrikosov and later Evgeniy Bogomolny have shown that the fundamental structure behind vortices is a set of linear equations and here we assert that the inclusion of the electronic spin into these equations provides the simplest framework to describe the topological insulators. The first of such Abrikosov-Bogomolny equations is a zero helicity condition which is essentially the spin-momentum locking condition [1,2,3] and gives the simplest explanation for the existence of the Dirac linear spectrum. The second one implies a plasmonic nature for the topological insulator state, a consequence of the evanescence of the magnetic field away from the layer. Here we show that the stacking of several topological insulating layers generates a semi-metal spectrum with the onset of a pseudo gap and of several conducting bands associated with different masses. This scenario of coexisting narrow and wide bands may provide a route to obtain a high critical superconducting temperature which makes us conjecture a deep connection between the topological insulators and the high temperature superconductors.

Keywords:

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3 Angle-resolved photoelectrons spectroscopy (ARPES) for investigations of strongly-correlated electrons and exotic magnetism in quasi-two-dimensional $4f$ systems

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Abstract

The photoelectric effect, discovered by H. Hertz in 1887 and later, in 1906, explained by A. Einstein, forms the basis of a variety of spectroscopic techniques known as photoelectron spectroscopy (PES). Among them are ultraviolet photoelectron spectroscopy (UPS), X-ray photoelectron spectroscopy (XPS), angle-resolved photoelectron spectroscopy (ARPES), as well as spin- and time-resolved photoelectron spectroscopies [1]. Nowadays, PES is one of the most extensively used and continuously developing methods, allowing researchers to comprehensively study the electronic structure of molecules, solids, surfaces, and interfaces, and to gain insight into the dynamic and magnetic properties of the studied systems. Furthermore, PES has wide practical implications in fields such as surface chemistry and materials science, and it has significantly contributed to the understanding of fundamental principles in solid-state physics [1,2].

An introduction to photoelectron spectroscopy, with particular emphasis on angle-resolved photoelectron spectroscopy (ARPES), will be provided. Several examples from our own studies [3–15] will then be presented, illustrating how ARPES can be applied to investigate strongly correlated electrons and magnetic phenomena in rare-earth intermetallic materials. For a long time, such materials have attracted considerable interest because of their exotic properties at low temperatures, which include complex magnetic phases, valence fluctuations, heavy-fermion behavior, Kondo physics, and many others. All of these phenomena arise from the interplay between nearly localized 4f electrons and itinerant states.

In that regard, the class of RE compounds RET_2Si_2 (T is transition metal atoms) of the $ThCr_2Si_2$ type structure attracts considerable attention. Besides their unique bulk properties evolving from a delicate interplay of $4f$ and *spd* electrons, these materials serve as toy models for studying exotic physics within the non-centrosymmetric Si-T-Si-RE four layer of the Si-terminated surface. There, the spin-orbit coupling (SOC) can be tuned by choice of suitable transition metal atoms. It gradually increases by exchanging Co ($3d$) for Rh ($4d$) and further for Ir ($5d$). The SOC-based phenomena will be rather weak for Co $3d$ electrons, while they will be greatly enhanced for Ir $5d$ orbitals.

As a competing ingredient, exchange magnetic interaction may be exploited by inserting elementary $4f$ magnets like Gd as the RE component. Because the orbital moment of the Gd $4f$ shell vanishes ($L = 0$), the pure and large spin moment of Gd will be a strong and robust source of magnetic phenomena. A rotation of the $4f$ moments to a certain angle relative to the surface normal may be achieved by coupling to crystal-electric-field (CEF). To make use of notable CEF effects, a non-vanishing orbital moment L is needed, like for instance in Ho or Dy. Then, this option allows to implement an exchange magnetic field with different strength and orientation at the surface, which competes with the Rashba SOC field and creates additional possibilities to manipulate the properties of the 2D electrons within the considered Si-T-Si-RE system. As the next ingredient, the Kondo effect can be introduced by inserting elements with unstable $4f$ shell as Yb or Ce. This gives the opportunity to explore the interplay of the 2D electrons with $4f$ moments within a 2D Kondo lattice in the presence of spin-orbit coupling and a non-centrosymmetric environment.

It will be shown that, in general, such a Si–T–Si–RE system may serve as a beautiful playground for studying the fundamental properties of 2D electrons. These systems can be regarded as a veritable platform, with spin–orbit coupling, Kondo effect, crystal-electric field, and exchange magnetic interactions as the building blocks. Combining them provides the opportunity to design systems for different scenarios and to explore the physics of 2D electrons in the presence of these competing interactions.

Keywords: lanthanide materials, surface magnetism, ARPES, XAS, 4f electrons

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4 The Ginzburg–Landau Framework in the Study of Mesoscopic Superconductivity and Vortex Dynamics

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Abstract

In this lecture, an overview of the Ginzburg–Landau theory will be presented, along with a discretization methodology for the time-dependent Ginzburg–Landau equations applied to the study of equilibrium and non-equilibrium states of vortex matter in mesoscopic superconductors. As application examples, some of the main results obtained by our research group in recent years will be discussed. Firstly, a characteristic size scale that defines the threshold between macroscopic and mesoscopic behaviors will be presented [1]. Additionally, dissipation mechanisms governing mesoscopic superconductors [2,3], vortex dynamics and phase-slip lines in superconducting tapes [4], as well as vortex dynamics under AC magnetic fields [5], will also be addressed.

Keywords: Ginzburg-Landau, vortex dynamics, mesoscopic

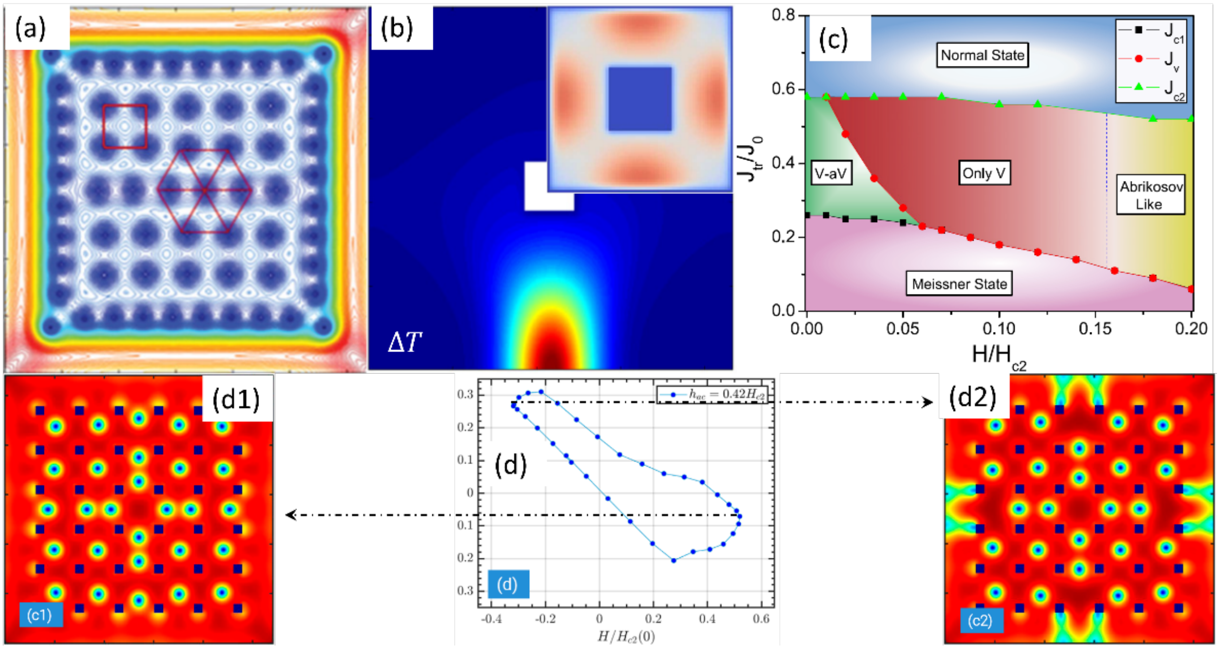

Figure 1: (a) Crossover of the vortex lattice near the macro–meso threshold; (b) temperature variations in vortex motion (darkest red indicates maximum variation, dark blue indicates zero); (c) diagram of vortex dynamics illustrating kinematic vortex behavior and an Abrikosov-like vortex; (d) AC magnetic field excitation, where (d1) shows the vortex configuration after entry and (d2) the onset of vortex exit.

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Tuesday, September 23

5 Historical and scientific remarks on screening effects in superconductors

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Abstract

This talk is primarily educational and aims to provide an overview of both classical [1-10] and recent advances [11-15] in understanding screening effects in superconductors, focusing on measurement technologies and interpretation of key findings.

Keywords: Historical and scientific remarks on screening effects in superconductors

Acknowledgements: This study was supported by the Grant of the Ministry of Science and Higher Education of the Russian Federation (agreement 075-15-2025-010, date 28.02.2025).

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6 Color-Center Based Quantum Sensing

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Abstract

Quantum sensing harnesses the principles of quantum mechanics—such as superposition, entanglement, and coherence—to achieve measurement sensitivities beyond the limits of classical approaches. Among various solid-state platforms, color centers in diamond, in particular the nitrogen-vacancy (NV) center, have emerged as versatile quantum sensors owing to their unique optical addressability, long spin coherence times, and operation under ambient conditions. This course introduces the foundations of quantum sensing, highlighting how quantum states can be exploited to probe physical quantities with high precision. We will discuss the fundamental properties of diamond color centers, including their electronic and spin structure, coherence characteristics, and methods for optical initialization and readout. Finally, the course will explore key applications of diamond-based quantum sensors in magnetometry, thermometry, and electric field detection, as well as their potential roles in biology, materials science, and quantum technologies.

7 Solar-Thermal Evaporation and Induced Power Generation Performance of Graphene-Based Devices

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Abstract

With the increasing population and serious water pollution, the global issues of fossil energy crisis and water scarcity have become one of the most severe challenges faced by human society. Solar-driven interfacial photothermal evaporation, which converts solar energy into thermal energy by photo-thermal conversion materials, is considered a promising technology for efficient freshwater acquisition. Compared with traditional solar evaporation techniques that heat the entire body of water, interfacial solar photothermal evaporation utilizes solar energy more efficiently, as thermal evaporation only occurs at the air-water interface, significantly reducing the conduction heat losses and improving the solar-to-vapor conversion efficiency of the system. Currently, a large amount of research is dedicated to modulating the physicochemical properties of photothermal materials and designing efficient interfacial evaporation systems. However, the low energy utilization efficiency and freshwater production rate in integrated seawater desalination devices remain challenges for solar evaporation technologies. To address these issues, researchers aim to select appropriate photother-

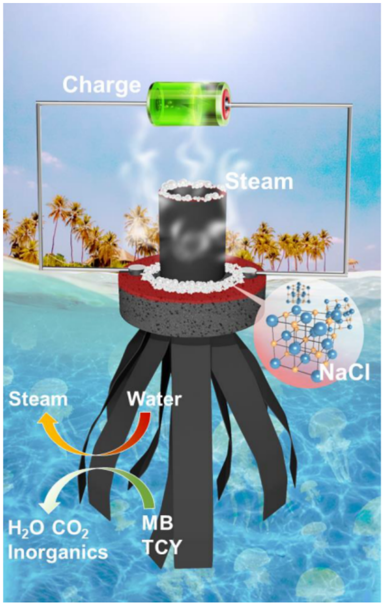

Figure 1: Multifunctional integrated 3D asymmetric nanofluid solar photothermal evaporator for seawater desalination, salt collection, power generation, and photocatalytic degradation.

mal materials and optimize the evaporator structure to enhance solar energy utilization efficiency, meeting the demand for clean water supply. Moreover, by integrating power generation functions into solar photothermal evaporation systems, the solar- mixed system can serve a dual purpose of freshwater production and electricity generation, enabling the system to operate continuously day and night and improving overall energy conversion efficiency. This presentation focuses on two main themes: energy acquisition and conversion, and resource recovery and utilization. Graphene-based materials and their composites are used as photo-thermal materials to design solar-thermal devices for maximizing energy and resource utilization. The key scientific and technical problems of solar evaporation system, such as light absorption, heat loss, water collection and latent heat utilization, are emphatically solved. The combination of water evaporation-induced power generation technology with solar-thermal evaporation technology was proposed, enriching the application field of solar photothermal evaporation technology and maximizing resource utilization.

Wednesday, September 24

8 Superconducting Terahertz Receivers and Oscillators

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Abstract

There are a number of practical applications where devices based on superconducting elements due to their quantum nature, unique set of parameters, and cryogenic operating temperatures significantly outperform devices based on traditional technologies.

Superconducting elements offer an extremely high characteristic frequency and very strong nonlinearity. Superconductor-Insulator-Superconductor (SIS) mixers based on high-quality tunnel junctions are the key elements of the most sensitive sub-THz receivers; their operating frequency has reached 1 THz and noise temperature is restricted only by quantum limit. Many applications require a spectral resolution of $\Delta f/f \sim 10^6$; this can only be achieved with heterodyne receiving systems. The heterodyne mixer down-converts the weak input signal of interest to a lower intermediate frequency (IF) without loss of phase; the spectrum of IF signal is the same as the input one, but is shifted down in frequency by LO frequency. This report presents the results of the SIS receiver developments for the 211–275 GHz and 790-950 GHz frequency ranges with a noise temperature in the double sideband (DSB) mode of approximately 20 K and 200 K, respectively. These designs and achievements are implemented in the development of the receiving systems for the Russian Space Agency mission “Millimetron”, and for the ground- based APEX (Atacama Pathfinder EXperiment) telescope.

One of the most promising areas is the development of superconducting THz generators for integrated receiving systems. Such an application of the AC Josephson effect seems quite natural; however, many developments and studies conducted in dozens of major laboratories worldwide failed for a long time to create a generator with the required parameters. Until recently, it was possible to implement in one device both terahertz generation with the ability to tune the frequency in a wide range and a narrow emission line required for the most practical application only for systems based on long Josephson junctions (LJJ). The report presents the results of the development and study of an integrated local oscillator based on LJJ, conducted at the IREE in recent years, and also describes a new type of superconducting oscillator based on a one-dimensional array of Josephson junctions in a coplanar line.

9 Magnetism Meets Machine Learning: Computational Pathways to Novel Materials

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Abstract

This hands-on workshop introduces participants to one of the most dynamic areas in modern physics and materials science: multiscale computational design and analysis of two-dimensional (2D) magnetic materials [1]. The lecture will cover fundamental computational approaches—density functional theory (DFT) [2], Monte Carlo simulations [1], and molecular dynamics (MD)—and demonstrate how recent advances in machine learning (ML) are transforming these methods. Participants will gain an overview of state-of-the-art atomistic simulation tools such as LAMMPS, VASP/Quantum ESPRESSO [3], and Vampire[1], as well as ML-accelerated interatomic potentials (DeepMD, MLIP) that enhance both accuracy and scalability. Core principles of DFT and ML will be discussed in the context of predicting structural, electronic, and magnetic properties of bulk and nanoscale systems, with applications ranging from skyrmion modeling to thin-film growth (CVD/PVD) and thermoelectric phenomena. Designed for a broad audience—including materials scientists, physicists, and engineers—this workshop aims to equip participants with practical insights and computational skills to address contemporary challenges in materials research.

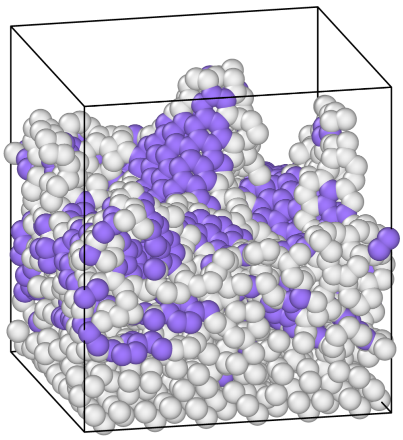

Figure 1: Final atomic configuration obtained using simulated CVD algorithm at 1300 K (grey Si and blue C).

Keywords: DFT, machine learning, 2D magnets, MD

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10 Quantum computing in the NISQ era

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Abstract

Quantum computing leverages principles of quantum mechanics and computational theory to manipulate the states of physical quantum systems in order to solve specific problems. By naturally exploiting purely quantum phenomena such as superposition and entanglement, quantum computers can perform processes that are extremely difficult to simulate classically. This has led many researchers to believe that quantum computers have the potential to be inherently more powerful than any classical computer.

However, in the current era of Noisy Intermediate-Scale Quantum (NISQ) devices, the practical capabilities of quantum computers remain limited. In this talk, we will introduce the fundamental principles and mechanisms of quantum computing, and explore standard algorithms that, under ideal conditions, demonstrate provable quantum advantage over the best-known classical algorithms. We will then discuss the main practical limitations of today's quantum computing technologies and present a recent computational paradigm — variational quantum computing – which can partially mitigate these challenges. Finally, we will address open questions and future directions from both practical and algorithmic perspectives.

11 Ab Initio and Machine Learning Methods for (Non-)Adiabatic Molecular Dynamics of Materials

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Abstract

Adiabatic and non-adiabatic molecular dynamics are powerful approaches for modeling the behavior of electrons and atoms in materials, which determines the performance of many modern technologies such as batteries and solar cells. The simulations usually rely on solving the Schrödinger equation at the ab initio level, which is accurate but costly for large systems, hindering the investigation of realistic conditions. In recent years, machine learning has emerged as a gamechanger to significantly accelerate many calculations. This breakthrough is expected to enable the modeling of many large-scale processes which are unavailable before. This lecture will briefly review the ab initio methods in material studies and introduce some recently developed machine learning interatomic potentials and Hamiltonian models. Some applications will be provided as well. We anticipate that the lecture can show the potential of machine learning in advancing the modern computational materials science.

Keywords: ab initio calculation, machine learning, molecular dynamics, non-adiabatic dynamics

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Thursday, September 25

12 From nano- to mesoscale quantum phenomenology in bioorganic materials

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Abstract

Although many bioorganic systems and materials possess significantly disordered structures, they exhibit a remarkable capacity to facilitate processes in which the quantum properties of their constituent participants are manifest. Well-documented phenomena include electron [1, 2] and proton [3] tunneling, which is observed in many enzymatic catalytic processes. More contentious are proposals regarding coherent superpositions in various energy and electron transfer processes including: (1) excitonic states within biological photosynthetic antennae [4]; (2) superpositions within the singlet-triplet transition of cryptochrome proteins — a process sensitive to weak natural external magnetic fields [5]; (3) generation of delocalized excitonic states during energy dissipation in melanins [6]; (4) UV superradiance from tryptophane-containing biological architectures [7]. This lecture will have two parts. The first will review seminal experimental evidence that substantiates the occurrence of such quantum phenomena in biological systems. The second part will subsequently address contemporary questions concerning the emergence of quantum properties within complex systems [8]. It will also explore current and prospective applications that leverage the unique characteristics of living systems for the development of novel quantum materials [9, 10].

Keywords: bioorganic, superposition, entanglement, tunneling

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13 Research on novel structures and their electronic states realized in two-dimensional materials

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Abstract

Through the development of two-dimensional (2D) material transfer processes, van der Waals (vdW) homo/heterostructures have been controllably constructed based on monolayer graphene. By utilizing scanning tunneling microscopy (STM) atomic-scale tip manipulation technology and scanning tunneling spectroscopy (STS) technology, the detection and regulation of novel quantum states have been realized. The research achievements obtained during the doctoral period include:

1. Combining wet transfer technology to controllably construct twisted bilayer graphene (TBG) homostructures. Using STM tip pulses to achieve controllable adjustment of the interlayer coupling strength of TBG, and observing the low-frequency oscillation behavior of the top-layer graphene [1];

2. Combining polydimethylsiloxane (PDMS)-assisted dry transfer technology to controllably construct tiny angle twisted monolayer-bilayer graphene. Realizing the preparation of submicron-scale rhombohedral stacked graphene, and observing the size-dependent flat band characteristic for the first time [2];

3. Through the controllable construction of graphene-transition metal dichalcogenide (TMDC) heterostructures, the preparation of fractional-layer TMDCs has been achieved for the first time using STM tip manipulation technology. Furthermore, lattice reconstruction phenomena and one-dimensional charge density modulation different from those of monolayer 1T'-WTe_2 have been observed in fractional-layer WTe_2 [3]. This provides a relatively comprehensive platform for the research on novel quantum states based on fractional-layer TMDC materials and their heterojunctions.

Keywords: Scanning tunneling microscopy, graphene, flat band, fractional-layer transition metal dichalcogenides

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Friday, September 26

14 tba

Geliang Yu[1*]

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15 High-Pressure Effects on the Quantum materials: Challenges and facilities available in Brazil

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Abstract

The study of quantum materials under high pressure has proven to be crucial for understanding and manipulating topologically protected electronic states and emergent phenomena in correlated systems. The application of hydrostatic pressure allows controlled modifications of the band structure, inducing topological transitions and favoring the emergence of exotic phases such as Weyl semimetals and topological superconductors. In magnetic topological insulators and superconductor–ferromagnet heterostructures, pressure plays a decisive role in tuning magnetic order and in the coupling between magnetism and superconductivity, enabling the observation of Majorana bound states. Complementarily, the search for new materials for superconducting quantum circuits has benefited from synthesis and characterization under high-pressure conditions, revealing compounds with enhanced critical parameters and greater stability against external perturbations—features that are essential for applications in quantum information processing. Nuclear magnetic resonance and electron paramagnetic resonance spectroscopy under pressure provide unique insights into local electronic correlations, spin anisotropies, and magnetic dynamics, which are fundamental for identifying stable quantum phases. Furthermore, transport and high-pressure X-ray diffraction experiments have demonstrated the ability to induce or suppress superconductivity in materials that are candidates for new quantum states, establishing new routes for designing devices aimed at fault-tolerant quantum computation. In this context, pressure emerges not only as a fine-tuning thermodynamic variable but also as a strategic tool for the discovery and control of novel quantum states of matter. Additionally, a discussion will be made about the facilities available in Brazil, mainly at the Physics Institute of the Federal University of Rio Grande do Sul and at the Sirius EMA beamline.

Keywords: High pressure, Quantum materials, superconductivity, facilities available in Brazil: UFRGS and Sirius.

16 Discrete mapping

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Abstract

A discrete mapping (often just called a "map" in mathematics) is a function that defines the evolution of a system in discrete time steps. Instead of changing continuously (like a flowing river), the system "jumps" from one state to the next at specific, separate intervals (like the ticking of a clock).

Think of it as a rule that tells you:

"If the system is in state X_n at step n, then at the next step $n+1$, it will be in state X_{n+1}."

This is mathematically represented by a recurrence relation: $X_{n+1} = f(X_n)$, Where f is the mapping function.

Famous Example: The Logistic Map equation is: $X_{n+1} = rX_n(1 - X_n)$. Here X_n represents a population (normalized between 0 and 1) at generation n, r is a parameter representing the growth rate. This simple-looking map exhibits incredibly complex behavior, including chaos, for certain values of r. By iterating this map, you can study equilibrium, cycles, and the emergence of chaotic systems. Why Are They Important?

Discrete mappings are powerful because:

– Simplicity: They are often easier to define and simulate on computers than continuous models.

– Complexity from Simplicity: As shown by the Logistic Map, very simple nonlinear rules can generate highly complex and unpredictable (chaotic) behavior, which is essential for modeling real-world phenomena like weather, economics, and biological systems.

– Foundation for Computation: The iterative nature of maps is the foundation of algorithms and computer programming.

In summary, a discrete mapping is a fundamental rule that describes how a system moves from one discrete state to the next, serving as a cornerstone for modeling and understanding complex systems in mathematics, computer science, and physics.

Keywords: Discrete mapping, Square mapping, Logistic map, Fixed point, Stability

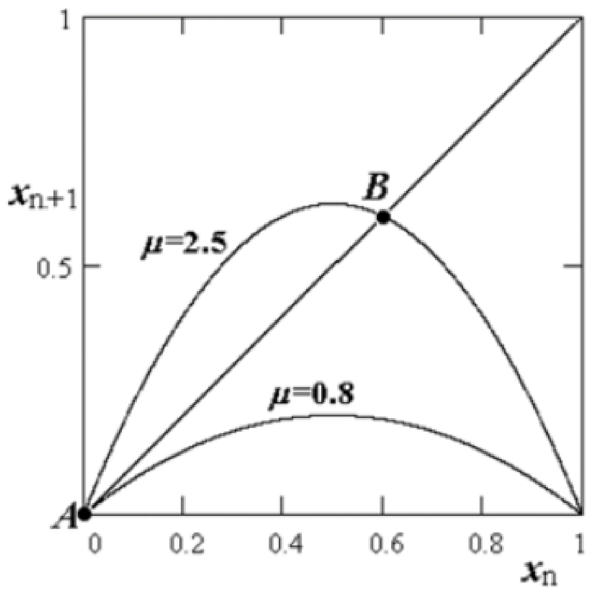

Figure 1: Fixed points of the squaring map.

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17 Scanning tunneling microscopy of molecules, atoms and atomic orbitals

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Abstract

Scanning tunneling microscopy is a powerful tool for investigation of conductive surfaces. In the presentation following topics will be discussed:

1. Principles of STM.

2. STM of thin C_{60} films on WO_2/W(110) surface. Dynamic of individual molecule rotation. Rotational kinetic and phase transition.

3. STM lithography on the MoO_2/Mo(110) surface.

4. Electron orbital resolution in STM and orbital-orbital interaction.

18 Advances in 2D Materials for Infrared Photodetection: Synthesis, Heterostructures, and Device Innovations

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Abstract

Two-dimensional (2D) materials have emerged as transformative candidates for infrared photodetection, boasting exceptional properties including high carrier mobility, tunable bandgaps, and strong light-matter interactions. Despite such great potential, critical challenges persist: achieving broadband spectral responses (for example, covering the ultraviolet to far-infrared range), minimizing dark currents (to below 10^{-10} A), and maximizing on/off ratios (to above 10^3). The report will explore recent advancements in three key areas to address these issues: synthesis techniques of 2D materials, their intrinsic material properties, and the design of innovative heterostructures. Key topics to be discussed include van der Waals heterostructures, photodetection mechanisms, and mixed-dimensional device architectures. Furthermore, we will highlight the current challenges in scalable fabrication of 2D material-based infrared photodetectors, and propose AI-driven material discovery as a promising pathway to accelerate their practical applications in commercial infrared detection.

Keywords: 2D Materials; Infrared Photodetection; Synthesis; Heterostructures

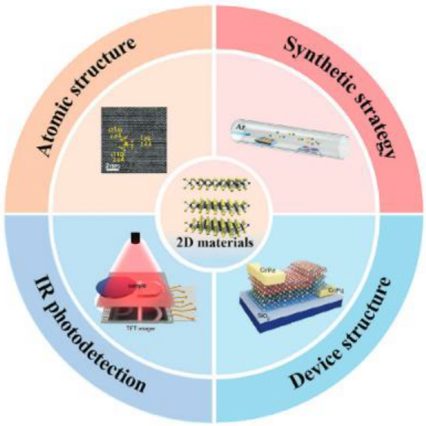

Figure 1: The schematic diagram illustrates the four key aspects of 2D materials in infrared optoelectronic application.

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Submission guide for Mesoscience and Nanotechnology journal

In terms of information and publication support of the **I International Scientific Conference "Advanced Functional Materials for Digital and Quantum Electronics 2025"**, a special issue of the journal *"Mesoscience and Nanotechnology"* (https://jmsn.press) will be organized, in which articles will be published based on the reports presented at the Symposium.

To submit an article, you must complete the following steps:

1. Go to the website of the journal *"Mesoscience and Nanotechnology"* using this link: https://jmsn.press.
2. Click on the **"Submit your article"** button (see Fig. 2).

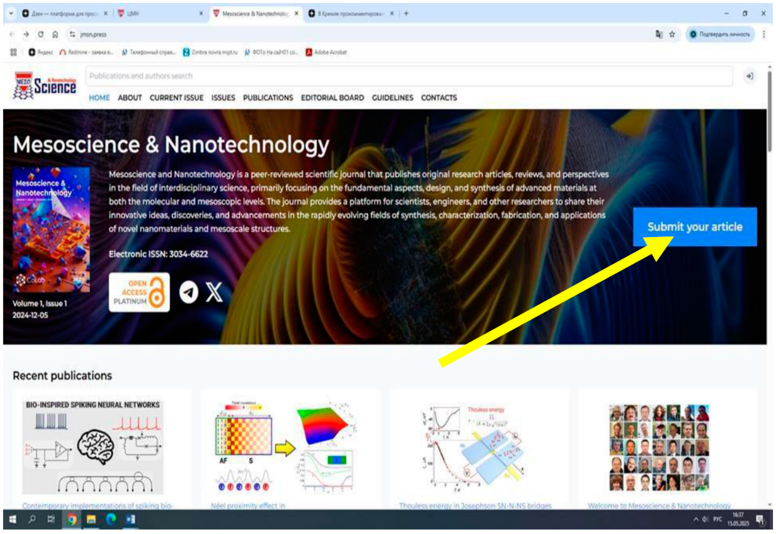

Figure 2: Homepage of the "Mesoscience and Nanotechnology" journal with the submission button

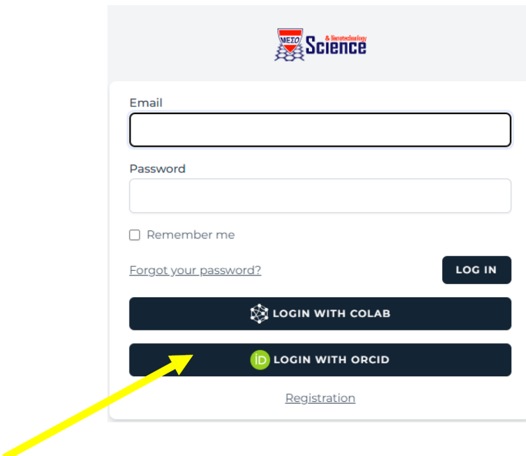

Figure 3: Login page with ORCID authentication option

In the appearing window (Fig. 3), you must select "Login with ORCID" and then follow the standard "ORCID" instructions for uploading articles in any format.

Articles are formed according to the template established by the journal (go to **Guidelines - LaTeX Template**, PDF Template, Word Template).

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