Welcome to the third issue of the Condensed Matter Physics Center (IFIMAC) Newsletter. Last March, IFIMAC received its third consecutive award as a "Maria de Maeztu (MdM) research unit of excellence".

I thank IFIMAC researchers and staff for their hard work and dedication, that have been critical in this collective achievement. This highly competitive recognition will help us to strengthen our internationally recognized reputation in this very active research area that spans from Quantum Materials and Technologies, Nano and Quantum optics, and Nanotechnology, to Soft and Active Matter and Biophysics.

The MdM award will also support our communication strategy, including, among other instruments, this newsletter that summarizes IFIMAC’s main achievements in the last semester.

I invite you to explore its pages and discover some of IFIMAC's researchers and the highlights of our scientific, training and outreach activities.
Nicolás Agraït is retiring after a brilliant career that has left a profound impact on the field of condensed matter physics. In more than three decades of scientific work, he has combined an unwavering dedication to research with a firm commitment to the education and training of new generations of scientists.

Nicolás Agraït obtained a degree in physics from the Universidad Autónoma de Madrid (UAM) in 1981 and a PhD in physics from the Universidad Nacional de Educación a Distancia (UNED) in 1988. In 1991, he joined the Department of Condensed Matter Physics at the UAM as an Assistant Professor. In 1995, he was promoted to Associate Professor and in 2007 he reached the rank of Full Professor. Since 2008, he has also been Associate Senior Researcher at the Institute of Advanced Studies in Nanoscience of Madrid (IMDEA-Nanociencia). From 2017 to 2023, Agraït served as Director of the Department of Condensed Matter Physics, strengthening its reputation as a centre of excellence in research and teaching.

As a lecturer, Nicolás Agraït has taught a wide range of undergraduate physics courses, including fluid physics, computer science, experimental techniques, quantum mechanics and solid state physics. His ability to communicate concepts in a clear and accessible manner has left a lasting impression on his students, many of whom have gone on to successful careers in academia and industry. He's also supervised numerous Bachelor's and Master's theses, giving his students the opportunity to embark on scientific careers. In total, Nicolás has supervised 12 doctoral theses, guiding his students with wisdom and dedication, inspiring curiosity and scientific rigour.

Prof. Nicolás Agraït has been working in the field of scanning probe microscopies since 1989 when he joined the Low Temperature Lab in the UAM. There he built a new scanning tunneling microscope (STM) at low temperatures and studied the transition from the tunneling regime to the contact regime demonstrating the quantization of the conductance in nanometer-sized metals. The development of a singular force sensor enabled him to study plastic deformation processes at the nanometer scale, showing that at this scale plastic deformation processes take place as a sequence of elastic stages alternating with atomic rearrangements. These works had a very high impact.
In 1995, during a research stay at Lawrence Berkeley Lab, he studied surface friction processes in nanometer-sized contacts under ultra-high vacuum conditions. In late 1995, he made fundamental contributions to the understanding of quantum transport in nanometer-sized conductors, such as the relationship between chemical valence and quantum channels, and the discovery of the formation of single atomic chains, the thinnest conducting wire, of which he also measured the mechanical properties and the inelastic scattering of electrons by the atomic vibrations.

Currently, his group’s work focuses on single molecule junctions and 2D crystals. With regard to single molecule junctions, his work has focused on the study of electrical conductance, thermoelectricity and, more recently, thermal conductance. He has successfully implemented novel techniques to measure thermovoltage and thermal conductance during junction formation using an STM. For 2D crystals, his investigations of screening and mechanical properties using scanning probe microscopy (SPM) are noteworthy.

Throughout his career, Nicolás has been the principal investigator on many national and international research projects, working with some of the world’s leading scientists. His ability to bring together different teams and create a collaborative environment has been crucial to the success of these projects, contributing to the advancement of knowledge. He has been involved in over 30 research projects and has been the PI on 14 of them. These projects include 2 Marie Curie Initial Training Networks where he was PI of one of the nodes, an FP7-ICT collaborative project where he was PI of one of the groups, and an H2020 FETOPEN project where he was the project coordinator.

Professor Agraït has been invited to give more than 70 talks at international conferences and workshops. His more than 130 papers have been published in high-impact journals such as Nature, Nature Materials, Nature Communications, Physics Reports, Chemical Society Reviews, Nano Letters, Physical Review Letters, Advanced Materials and the Journal of the American Chemical Society and have received more than 12,000 citations, reflecting his influence and recognition in the global scientific community. With an H-index of 49 and six recognised research periods, his scientific contributions are widely recognized.

Nicolás Agraït is retiring, leaving behind an impressive legacy at the UAM, IFIMAC and in the international scientific community. His dedication to research and teaching has transformed the field of condensed matter physics and inspired countless students and colleagues. IFIMAC and the scientific community wish him a fulfilling and rewarding retirement, confident that his impact will be felt by future generations of scientists.

Rubén López Nebreda, PhD student supervised by Nicolás Agraït.
Akash was hired in 2021 as an IFIMAC Junior Group Leader, funded by the Maria de Maeztu Programme. In 2022, he was awarded the Ramón y Cajal Fellowship. During his time at IFIMAC, he has not only contributed to science, but has also been an active member of the Communications Committee.

This short interview is intended as a farewell and a big thank you for all his dedication over the past years. We wish you all the best in your new position as Professor at the University of Kaiserslautern, Germany.

Akash, can you tell us about your trajectory? Why you came to IFIMAC?

It has been a long road with ups, downs, twists and turns. I left my home country India in 2011 with the goal of living an interesting life and learning as much as I can. The beginning as a PhD student at the Delft University of Technology was especially hard with a major cultural shock and my lagging behind in understanding the normal social conventions. However, I was lucky to find amazing people there who taught me all I needed to know. I eventually started to enjoy being in an international environment and navigating different cultures. After the PhD, I was a Humboldt postdoc fellow at the University of Konstanz and then, a senior researcher at the Norwegian University of Science and Technology.

IFIMAC’s impressive track record of producing excellent research and researchers was the key factor in my coming to Madrid. IFIMAC hosts research groups contributing at the forefront of various fields which provides unique opportunities for interdisciplinary research and learning. Finally, IFIMAC’s strong support for young researchers combined with the Spanish Ramón y Cajal program offers good prospects for becoming a permanent professor in the long run.

What research did you develop here, and what challenges and opportunities did you find here?

Here, my group worked on a range of topics from superconductivity to magnetism. Exciting contributions emerged from the synergy my group found with various colleagues specializing in quantum optics and nanophotonics. I am especially proud of two theoretical predictions - (i) a protocol to detect an equilibrium quantum superposition published in Physical Review Letters (2023), and (ii) unconventional ferromagnetism due to spin-phonon-photon coupling published in Nature Communications (2024). I am optimistic that both these predictions will eventually be confirmed by experiments.

Listing all challenges and opportunities will get too long. I can only say that IFIMAC provided me exactly the challenges and opportunities, together with adequate support to manage them, that I was looking for and needed in order to grow, personally and professionally. To mention one concrete example, after living in Netherlands, Germany, and Norway which have quite similar cultures, I found Spain to be the next big cultural shock. Just like last time, I was lucky to find amazing people who made me feel at home and helped me navigate everything.
So, what lies ahead in the future?
Starting as a full professor of theoretical solid state physics in Kaiserslautern, I am feeling the same trepidation that I felt when starting my PhD in 2011. I have been warned by well-wishers and mentors that becoming a full professor this early does not mean that life is easy now with a permanent position, but it rather means that a committee has decided that I am ready to face still bigger challenges and responsibilities. I am optimistic that I will manage what awaits me with the help of new colleagues, friends, and mentors, like I have on previous occasions. In the face of this nervousness, I do what I always do – focus on the goals instead. I am really excited to have this professor position now when I have the extra high energy (after a much-needed break) and motivation to establish a group (entitled “Theory of Spin Systems”) that will produce world-class research and future leaders, carrying forward IFIMAC’s legacy. I am excited to give my best efforts to research, teaching, educating young minds, and contributing to my new employer – RPTU – in various other manners. And of course, I expect to keep a strong connection and continued collaborations with IFIMAC.

Thank you very much for all the hard work and dedication you have put into IFIMAC. Your scientific contributions have been invaluable and your presence has been greatly appreciated. We wish you the best of luck in your endeavours in Germany. We have no doubt that you will excel there as well.
In 1987, Santiago Márquez began his career at the Universidad Autónoma de Madrid. During most of this time, he worked in what is now the Department of Condensed Matter Physics until his retirement last April. His departure leaves a void that is difficult to fill.

‘I’m quite curious,’ says Santiago, and this quality has allowed him to understand the needs of researchers and to offer solutions for specific studies. His artisanal approach has been fundamental to the production of high-precision parts, indispensable for IFIMAC and the research carried out here.

Santiago worked closely with many IFIMAC researchers, especially in ‘module 3’, where he deployed his skills, from management tasks such as material purchases, installation of wiring in laboratories, to the creation of unique high-tech components for our scanning tunneling and atomic force microscopes - STM and AFM (such as the manufacture of piezoelectric scanners or tip holders). Always humble, his work has focused on constantly improving our facilities and equipment.

As an anecdote that illustrates his character, we mention here Julio Gómez Herrero’s experience with Santiago in the summer of 1987, when Julio was beginning his thesis under the supervision of Professor Arturo Baró. Arturo was on a research stay at the University of Stockholm with Professor Rao. It was the beginning of scanning probe microscopy and Professor Rao wanted to set up an STM in his department as soon as possible. Arturo called Julio and asked him to bring a high-voltage amplifier weighing more than 10 kg to Stockholm. As he was about to leave the faculty with the device in a bag, he encountered an unexpected obstacle. Santiago, who at the time was stationed at the reception desk of the science building, refused to let him leave without explicit authorisation. Julio’s pleas were to no avail, Santiago scrupulously carried out his duty and there was no way out of there. Finally, Arturo contacted Santiago, explained the situation and the electronics were able to reach their destination, not without the astonishment of the airport staff.

We wish the best of luck to Miriam Jaafar Ruiz-Castellanos, Alberto Cortijo Fernández, and Carlos Sánchez Muñoz, esteemed members of IFIMAC, as they transition to CSIC centers to further their scientific careers. Their contributions have been invaluable, and we are confident that their expertise and dedication will continue to thrive in their new endeavors.
IFIMAC Mentoring Programme is wrapping up its second year, supporting women students in their studies to enhance their academic careers and retention in science. We provide a safe and supportive environment for women in physics to interact with experienced researchers and offer guidance for both mentees and mentors. Indeed, Skills4Science gave training on the benefits of mentoring to both mentees and mentors, whereas Ivana Krpan led a workshop on communication skills using acting techniques.

The closing ceremony for the 2023-2024 IFIMAC Mentoring Programme was held at the Rectorate on June 3. Sara Gómez Martín gave an inspiring talk on the opportunities offered by mentoring programmes, followed by a musical interlude by Elena del Valle and her mentee Arianna Barreto, and we closed with a coffee to share experiences.

This academic year, we are delighted to have many mentees who are enthusiastic about participating in outreach activities. Our mentees have supported IFIMAC’s outreach initiatives on several occasions, including the International Day of Women and Girls in Science.

Isabel Guillamón and Francesca Marchetti, together with their mentees Lara Suárez and Clara Almudena Molina, conducted various workshops for high school students and presented the workshop titled "Exploring quantum physics in our classical world." In addition, Elena del Valle, along with her mentee Arianna Barreto, conducted multiple workshops for primary school students. Through these workshops, Elena and Arianna fostered a scientific curiosity in the students, guiding them to explore the world around them by observing phenomena such as sound and light.

These activities encouraged the students to engage scientifically with their environment, asking questions and seeking answers.
Outreach activities

IFIMAC’s Physics Fair on International Day of Women and Girls in Science 2024

This year, on February 10th, we celebrated the International Day of Women and Girls in Science with a science fair held at the UAM Science Faculty. Over 220 attendees immersed themselves in the realms of soft and hard matter, and optics. Participants of all ages joined our researchers in engaging activities such as extracting DNA from a banana, constructing batteries, manipulating light, delving into nanomaterials, exploring low-temperature physics, and uncovering the mysteries of quantum physics in the classical world.

In addition to this fair, Arin Escobar Ortíz, PhD student at IFIMAC, gave a talk on "Simulations, physics in your laptop" at the IES Iturralde secondary school (Madrid) on 14 and 15 February.

IFIMAC participates in the Madrid Es Ciencia Fair 2024

At our participation in the Madrid Es Ciencia Fair on 8 March 2024, attendees explored the fundamental concepts of light trapping in a workshop, immersing themselves in a journey through the physics of materials and the development of devices that harness light to revolutionize contemporary technologies. By placing two opposing mirrors, we created an infinite mirror that served as an analogy for the functioning of an optical cavity. We also presented a prototype developed in our laboratories, where we investigate new materials that interact significantly with photons trapped in microcavities.

Vermú de Nanociencia 2024 with 10alamenos9

Diego Fernández de la Pradilla, a PhD student at IFIMAC, took part in the 2024 Vermú de Nanociencia event hosted by 10alamenos9. His research explores how light interacts with matter at the atomic and nanoscale. Specifically, he examines how the electromagnetic properties of nanoparticles influence the electromagnetic field around an atom, affecting its behavior.

In his video "The Quantum Vacuum Tickles," Diego explains that the vacuum isn’t truly empty according to quantum mechanics. This concept is crucial for understanding how light and matter interact.
The main objective of the Consolidación Investigadora, funded by the National Plan for Scientific and Technical Research and Innovation 2021-2023, is to support the career development of researchers.

It aims to create permanent positions in their institutions, launch or consolidate research projects and improve premises, laboratories and equipment.

In the last edition, 6 IFIMAC members received funding for the following projects:

Juan Luis Aragonés: "Autonomous Sensing-Enabled micro-Robots (iRoll)".

Controlled transport of microscopic particles is crucial for fields like targeted drug delivery, micro-robotics and biosensing but faces unique challenges due to the lack of inertia and dynamic environments. Our project aims to optimize the transport of micro-robots able to move in these environments by applying machine learning models to provide them with the ability to autonomously navigate, sense and respond to changes in their environment.

Pablo Ares: “Defects and nanoscale thermal transport in 2D materials (2DefThermoNano)”.

In this project, we aim to elucidate the role of bubbles and wrinkles in the thermal transport properties of two-dimensional (2D) materials and to exploit their enormous potential for thermal management. To this end, we will prepare samples that favor the appearance of these defects on both supported and suspended atomically thin crystals, and we will study how heat propagation in bubbles and wrinkles varies at the nanoscale using scanning probe tools.

Pablo Burset: “Superconducting Quantum Coherent Electronics (SUQCES)”. 

SUQCES aims to leverage recent advancements in single-electron sources to develop flying electron qubits for quantum computation. These qubits, as propagating particles, offer scalable architectures and reduced hardware requirements. By combining the coherent manipulation of single-electron states with the long coherence lengths provided by superconductors, the project seeks to create on-demand entanglement sources, high-fidelity flying qubits, and scalable superconducting quantum-coherent electronics. This innovative approach holds promise for advanced quantum information processing applications.
Johannes Feist: "Harnessing Extreme Light Sources (HELIOS)".

The HELIOS project aims to leverage advanced light sources, such as intense and attosecond-scale ultraviolet and X-ray pulses, to explore new probing strategies and address fundamental questions about ultrafast electron dynamics. By focusing on one- and two-electron atoms, HELIOS seeks to achieve accurate results in nonperturbative and quantum light-matter interactions, enabling fully converged ab initio treatments with the latest extreme light sources.

Ferry Prins: "Visualising energy transport in disordered semiconductors (VISTA)".

The consolidacion project builds upon our recent work on imaging of carrier transport in semiconductors, now focussing on doing so in the most realistic, device-like settings. The big challenge is to be able to create the environment in which we can really look inside those devices using our microscopy techniques. The consolidacion program is a great opportunity for intermediate stage researchers to strengthen their independence, giving the financial impulse that lacks a bit in other national programs such as the Ramon y Cajal.

Laura Rodríguez: "Tissue-like vesicular materials: Emergent collective responses to electric fields (SPARKLE TISSUE)".

The SPARKLE TISSUE project aims to develop tools to understand tissue mechanics by engineering tissue-like materials using a bottom-up approach. Through advanced microfluidic technologies, lipid and polymer vesicles will be created with precise control over their properties. A novel oscillatory micro-rheology tool will be develop to measure these vesicles' mechanical properties using an alternating electric field on an inverted microscope. These vesicles will then form the building blocks for more complex tissue-like materials. The project's goal is to identify collective behaviors in tissues with potential applications in biomedicine and tissue engineering.
Interviews with the speakers and their colloquium talk can be found in our YouTube channel.

Maia Vergniory, February 16th: “Topology is everywhere”.

Susana Huelga, March 13th: "Coherent Effects in Biological Processes".

Florian Marquardt, April 19th: “Better Quantum Technologies via Machine Learning”.

Vahid Sandoghdar, May 10th: “On single photons and single molecules”.

Ludovic Berthier, May 31st: “Is glass a state of matter?”. 
Celia Polop, together with Carmen Morant (UAM), is a partner in the recently funded ION MEET project, a research and training project on energy storage and conversion devices. More detailed information about this project on page #13.

Salvatore Assenza received the "Enrique Pérez Payá-Prospera Biotech & BCN peptides" award from the Spanish Biophysics Society at the "European South Atlantic Biophysics Congress" (ESAB2024) in San Sebastián, 5-7 June. This prize recognizes the trajectory of a biophysicist with age under 40 with a special contribution to the progress of Biophysics in Spain.

Laura Rojo, undergraduate physics student and IFIMAC mentee, has won the ASTI TALENT & TECH FOUNDATION and STEM TALENT GIRL Best Research Project Award for her project "Atomic Force Microscopy for the Study of Single Breast Cancer Cells", which she developed in the BioNanoMechanicsLab group at the Institute of Micro and Nanotechnology of the CSIC under the academic tutorship of IFIMAC member Pablo Ares.

IFIMAC is a partner in SustainableNano - Spanish Network on Safe and Sustainable Nanotechnologies (SNSSN) that brings together Spain’s leading research institutions dedicated to nanoscale research and development.

The network aims to collaboratively promote safe, sustainable and socially beneficial nanosciences and nanotechnologies by integrating sustainability criteria throughout the process. Emphasising research that takes into account production, consumption, waste generation and management, and recycling, the network aims to achieve high-impact results both in the short term and to ensure a lasting impact through its activities.

The pathfinder project FASTCOMET is a consortium with Katholieke Universiteit Leuven (PI: Johan Hofkens (group coordinator), Universidad de Vigo, (PI: Marzan), Universidad Autónoma de Madrid, IFIMAC (PI: Rafael Delgado Buscalioni), IMEC Leuven (PI: Maarten Rosmeulen); Université de Strasbourg (PI: Andery Klymchenko); Universidad Ramon Llull (PI: Roger Bresoli).

This project aims to address the increasing demand for affordable, high-density data storage driven by digital transformation. It proposes a novel colloidal memory system that uses colloidal nanoparticles as data carriers. These nanoparticles, with antagonistic electrophoresis properties, are selectively inserted into nanocapillaries and controlled by a CMOS circuit. The project seeks to establish a proof-of-concept by identifying suitable nanoparticles, developing test structures, and using advanced imaging techniques for manipulation. The ultimate goal is to create a device capable of storing data with ultra-high densities exceeding 100 Gbit per square millimeter, potentially reaching up to 1 Tbit per square millimeter, at lower costs than current technologies.
PARTICIPATION IN SCIENTIFIC EVENTS


QUANTUMatter 2024. 7 - 10 May, Donostia. 4th edition Quantum Matter International Conference seeks to bring together scientific communities involved in quantum information and technology.

The 12th International Conference on Spontaneous Coherence in Excitonic systems (ICSCE-12). 10 – 14 June, Dublin. This event gathers researchers who study quantum collective phenomena in different types of electronic excitations in solids and similar phenomena in other physical systems. Francesca Marchetti has been a member of the Scientific Committee.

The 9th European Nanomanipulation Workshop. 17 - 19 June at Miraflores de la Sierra (Madrid). The workshop brings together scientists engaged in the controlled manipulation of atoms, clusters, molecules and other nanoscale entities through scanning probe and related techniques. Oscar Javier Gutiérrez, IFIMAC postdoc, is part of the local committee.

3rd Annual Nanoseries Conference. 17 - 19 June, Lisbon. This meeting covers a wide range of topics, including new and established techniques, fundamental principles, materials and their applications. Pablo Ares has been a member of the Scientific Committee.

Novel 2D materials explored via scanning probe microscopy & spectroscopy. 24 - 28 June. Organizers: Iván Brihuega from IFIMAC, together with Miguel Moreno Ugeda from DIPC, CFM-MPC, Spain. This conference aims to gather together researchers and students to discuss the latest advancements in 2D materials using SPM techniques.

SuperQumap: COST Action SuperQumap has participated in the European School on Superconductivity and Magnetism in Quantum Materials (21 - 25 April, Valencia), and the international conference "Quantum Sensing" (4 - 6 June, Paris).

Celia Polop (IFIMAC) and Carmen Morant (UAM) are partners in the ION-MEET project. The KOM of the The ION-MEET project was held in Marseille on 25 -26 March. The consortium includes AMU laboratories (MADIREL, ICR, CINAM, LIS) and international partners from universities in Rome (URoma1, URoma2), Madrid (UAM), Tarragona (ICIQ), and Lebanon (ULiban). In addition, the consortium will strengthen training activities through summer schools and invited fellows, with links to existing programmes such as the Erasmus Mundus Master in Chemical Nanoengineering.

The project brings together a wide range of expertise, from the development of new ion-conducting materials with a low carbon footprint to multiscale modeling of degradation and recycling. ION-MEET will also innovate catalytic electrodes for FC and WE.
PhD students

Eduardo Almanza. Advisor: Celia Polop.
Maria Jesús Martínez Morillo. Advisors: Luisa E. Bausá and Mariola Ramírez Herrero.
Pablo Diez Silva. Advisors: Rafael Delgado Buscalioni and Manuel Marqués.
Upasana Das. Advisor: Ferry Prins.

Postdoctoral researchers

Frieder Lindel. Supervisor: Johannes Feist.
Joaquín Guimbao Gaspar. Supervisors: Elena del Valle Reboul and Francesca Marchetti.
Mauricio Quintela. Supervisors: Antonio Picón y Juan José Palacios.
Subrata Chakraborty. Supervisors: Johannes Feist and F. J. García-Vidal (former supervision by Akashdeep Kamra).
Yuriko Baba. Supervisor: Pablo Burset.

IFIMAC administration

Susana Gil, Project Manager and Scientometrics Analyst.
To promote team spirit and take a break from work, IFIMAC members continue to meet every last Thursday of the month in the cafeteria of the Facultad de Psicología. After-work drinks are a great way to relax from work and create a community!

IFIMAC have also recently started a sport community to support the organization of friendly football and basketball games on the UAM campus. These games provide an opportunity to researchers to socialise outside the office and get some outdoor exercise. Some members have also started a chess club where they meet to play and enjoy this fascinating game.

If you want to simply know more about these activities or enjoy them, join the IFIMAC Sports WhatsApp community and be part of our sports teams.

Photorefractive Photonics and Beyond (PR24) - Interaction of Light. 2 - 5 July, Palacio de los Infantes (Euroforum) in San Lorenzo of El Escorial.

Multiphotonics meeting. 4 - 5 July, Munich. Organized with the support of Elena del Valle Hans Fisher Fellowship of the IAS (TUM) and the HF focused group Novel quantum-light sources: Kai Müller and Sang Kyu Kim.

The XXXIX RSEF Physics Biennial. 15 - 19 July in San Sebastian. The Biennial will provide a platform for discussing and sharing advancements in research, technology transfer, dissemination. It will support young researchers and will offer awards for doctoral and postdoctoral scholars. Linda A. Zotti and Salvatore Assenza are the organizers of the symposium "Molecular Biophysics" within the RSEF biennial.

Complex Nanophotonics Science Camp. 30 July - 2 August, Windsor Great Park (UK). This event gathers together photonic scientists along with writers and editors in an unconventional format featuring talks, seminars and debates.

XXXI International Summer School Nicolás Cabrera "Energy Storage Systems to face the Climate Challenge: Sustainable development of Li ion batteries". 2 - 6 September. Organizers: Carmen Morant (UAM) and Celia Polop (IFIMAC).

2nd Spanish Soft Matter 1 1/2 days. 3 - 6 November, Benasque. Organizers: J. L. Aragonés (IFIMAC-UAM), L. R. Arriaga (IFIMAC-UAM), A. Fernández Nieves (UB-ICREA), M. Ruiz-García (UCM).

Workshop "Universal themes on Bose-Einstein condensation". 4 - 8 November, Trento. The 2024 edition is a continuation of a series that started in 1993 in Levico and continued in 2013 in Leiden and in 2019 in Pittsburgh. The spirit of the series is to bring together specialists from different areas of theoretical and experimental condensed matter and atomic physics, as well as gravitational and nuclear physics, to explore together the different realisations of the general concept of Bose-Einstein condensation in the different fields of physics. Francesca Marchetti is organizing.
Antiaromatic non-alternant heterocyclic compounds as molecular wires

Antiaromatic compounds are of interest in molecular electronics for their low HOMO-LUMO gaps, promising high electrical conductance. A team led by Linda Zotti studied dithienopentalene molecular wires, finding that conductance is influenced by HOMO-LUMO gap reduction and destructive quantum interference, affected by heteroatom positions. Traditional “curly-arrow” rules failed for some isomers.

doi.org/10.1039/D3TC04266

Unconventional magnetism mediated by spin-phonon-photon coupling

IFIMAC team theoretically demonstrated a biquadratic long-range interaction between spins mediated by phonon-polariton coupling, reminiscent of superconductivity. This interaction causes a first-order phase transition, leading to abrupt magnetization on cooling, enabling low-power magnetic memories with high data stability. Photon involvement allows in-situ control, presenting new scientific and technological opportunities.

doi.org/10.1038/s41467-024-48404-z

Heat Dissipation Mechanisms in Hybrid Superconductor-Semiconductor Devices

Understanding heating and cooling in mesoscopic hybrid superconductor—semiconductor devices is crucial for quantum technologies, as self-heating affects performance. Eduardo Lee and coworkers show using Joule Spectroscopy that cooling in these devices is limited by inefficient electron-phonon coupling in superconducting islands, unlike grounded superconductors, which cool primarily through quasiparticle diffusion.

doi.org/10.1021/acs.nanolett.4c00574

Quantum Circuits with Multiterminal Josephson-Andreev Junctions

To mitigate environmental noise on qubits, a novel platform using multiterminal Josephson junctions has been proposed by Alfredo Levy-Yeyati and co-workers. Unlike conventional two-terminal junctions, multiterminal devices offer intrinsic noise immunity and additional tunability. Fabricated with current techniques, these junctions feature fermionic-bosonic coupling, akin to strong light-matter interactions, and resemble multidimensional lattices in circuit models.

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doi.org/10.1021/acs.nanolett.4c00574
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