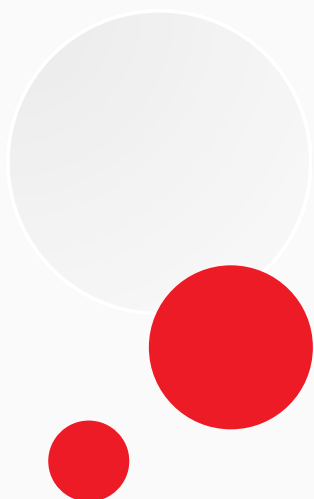
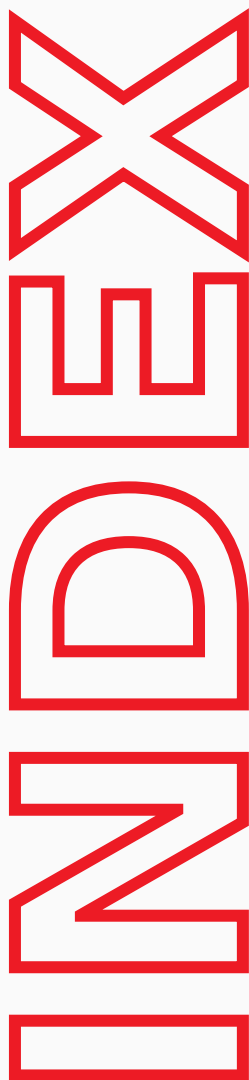




Activity Report.

2025





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1



OUR CENTER

LETTER FROM OUR DIRECTOR



Rubén Pérez

IFIMAC Director

Welcome to the annual report of the Condensed Matter Physics Center (IFIMAC). Established in 2012, IFIMAC's mission is to pursue cutting-edge research and scientific excellence in this broad field, at the crossroads of Physics, Chemistry, Materials Science and Biology, fostering a truly multidisciplinary approach. During 2025, IFIMAC developed the scientific project linked with its third consecutive award as a "Maria de Maeztu (Mdm) research unit of excellence".

The ambitious goal of this project is to strengthen our scientific capacities and to foster our activity in areas of social impact like gender equality, outreach and knowledge transfer to prepare the center for an application to a recognition as a Severo Ochoa research center of excellence at the end of our current Mdm project.

On March 14th 2025, IFIMAC reached one of its strategic objectives: the Social Council of the Universidad Autónoma de Madrid (UAM), our hosting institution, approved the creation of the IFIMAC Foundation. Almost one year later, on April 13th 2026, with a significant delay due to the elections for Rector at UAM, we are finally ready to complete the legal steps and start our adventure as IFIMAC Foundation. This is a key step in the path to reach the status of a Severo Ochoa Center in the 2028 call.

IFIMAC membership is awarded to individual researchers, based on the scientific excellence achieved at the different levels of academic career. IFIMAC had 86 members in 2025, including 58 permanent research and teaching staff from UAM, 7 emeritus professors, 3 assistant professors and 18 young researchers associated with different programs of international talent attraction. These young researchers are supported by national (12 Ramón y Cajal contracts), regional (3 Atracción de Talento Comunidad de Madrid (AT-CM) modalidad 1), Fundación La Caixa (1) and IFIMAC (2). One of our young researchers has been granted an ERC Starting grant in the 2025 call. Work at IFIMAC is supported by a technical staff that included 2 IT and High-Performance Computing Infrastructure officers, 1 Laboratory Technician, 2 Project Managers and an Outreach technician. Apart from its members, IFIMAC hosted in 2025 the research activity and training of 31 post-doctoral researchers (70% of them, non-Spaniards), and 87 PhD students. They contribute significantly to the achievement of the IFIMAC's mission.

Our research outcome in 2025 increases the total number of articles (199) and the publication in top-cited journals with respect to the previous year (32.5% in D1 according to WoS). A selection of papers highlighting the research activity of IFIMAC in key areas –spanning from Quantum Materials and Technologies, Nano and Quantum optics, and Nanotechnology, to Soft and Active Matter and Biophysics– can be found in section 4 of the report. Considering the end of the national calls for projects and infrastructure associated with the Next Generation Funds, IFIMAC researchers have continued to be very successful in the attraction of funding in 2025, with 139 active projects representing a total budget of 8.8 million €, and EU support through Horizon, ERA and ERC calls representing 20.66% of the total 2025 funding. Together with vibrant basic research (more than 16% of IFIMAC researchers are among the top 2% most cited authors), It is worth noting the increasing knowledge transfer activity of IFIMAC. Between 2022 and 2025, nine IFIMAC researchers have participated in the UAM Emprende programme across the General, Industry, and Health tracks. 2025 ends with three new patents, a Knowledge-Based Company (KBC) and three collaboration agreements with private companies. These activities demonstrate our sustained commitment to promote a culture of knowledge transfer, research valorization, market validation, and entrepreneurship-oriented innovation.

These research activities are complemented by the IFIMAC's involvement in training and outreach. We directly promote the Master in Physics of Condensed Matter and Biological Systems (<https://www.masternanobio.es>) and the PhD Program in Physics of Condensed Matter, Nanoscience and Biophysics (<http://doctorate-nanobio-uam.es>), and are involved in another three master and three doctoral programs at UAM. Our outreach activities cover from lectures for primary and high schools to promote STEM studies and scientific careers in the areas covered by IFIMAC, 29 technical seminars, to the monthly IFIMAC Colloquia. Among the outreach activities, I would like to highlight the third edition of the mentoring program for women physics students (with 43 women mentees and 41 mentors –with no gender restriction–) organized by the IFIMAC Gender Committee, and the consolidation of the IFIMAC Newsletter. This platform for sharing our activities within IFIMAC and with the broader Condensed Matter Physics Community is released twice a year and aims to strengthen the identity of our organization, and to provide regular updates on our achievements.

I invite you to explore this annual report and, through its pages, to discover IFIMAC's reality and promising future.

Rubén Pérez
IFIMAC Director

OVERVIEW

The Condensed Matter Physics Center is a Research Center within UAM, located in the campus of the Universidad Autónoma de Madrid pursuing cutting-edge research and scientific excellence. It comprises researchers from several university departments aiming to advance the limits of knowledge in both theoretical and experimental Condensed Matter Physics. 62 researchers constitute its permanent staff with nineteen young researchers (RyC, talent grant, Junior leader IFIMAC positions) and up to one hundred fourteen postdoctoral researchers and PhD students.

The IFIMAC – Condensed Matter Physics Center is a María de Maeztu Excellence Research Unit. The Center got the first Maria de Maeztu Excellence accreditation (MDM-20140377) in the 2014 call and it was renewed in 2018 (CEX2018-000805-M). The third María de Maeztu accreditation was evaluated during 2023 and awarded in April 2024 (CEX2023-001316-M).

Research performed in the institute has gained world reputation in the following areas:

- Advanced Materials
- First Principles Simulations and Modeling
- Nanophysics
- Nano and Quantum Optics
- Soft Condensed Matter and Biophysics

RESEARCH LINES

Research developed in the IFIMAC since it was set up in 2012 is organized in the following areas. Here we describe relevant general aspects of each line in the past years:



Advanced materials

Today's devices and appliances require materials with ever increasing capabilities. Superconductors deliver considerable improvements in energy storage and transport and are fundamental in medicine for magnetic resonance imaging. Graphene and graphene-based materials promise to improve functionalities of many devices. New molecular systems are excellent sieves and are used in gas storage or photovoltaics.

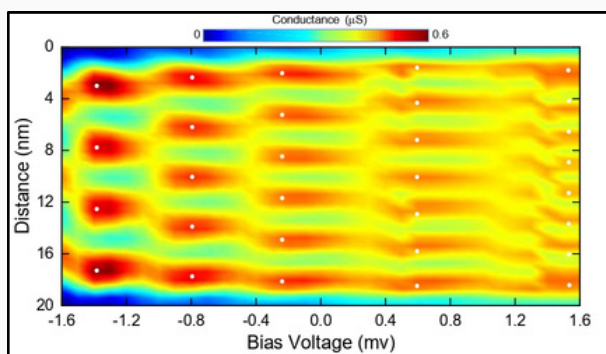


Figure 1: Conductance (color scale on the top) vs bias voltage (x-axis) and distance (y-axis) demonstrating lateral quantization of collective electronic states at the surface of the heavy fermion superconductor URu_2Si_2 . Image taken at 100 mK. From *Nature* 616, 465 (2023).

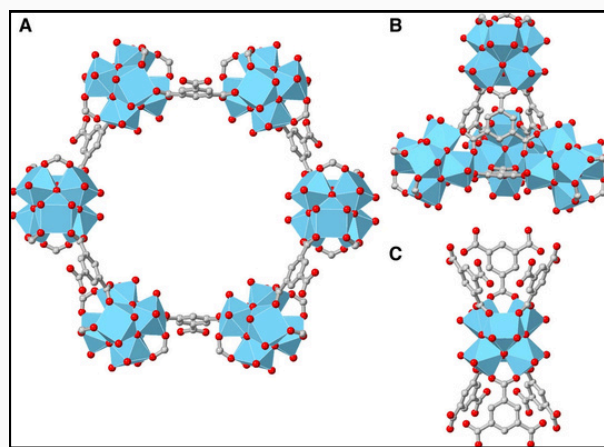


Figure 2: Hexagonal pore (A) and tetrahedral cavity (B) in the luminescent metal organic framework MOF-808, an emergent class of optical sensors. We show an unsaturated Zr_6O_8 cluster in C. Blue is Zr, grey is C and red is O, hydrogen is removed for clarity. From *Nature Communications* 14, 2506 (2023).

IFIMAC works on the fundamental properties of materials with the aim to set the pace for future transformational changes in technology. For this, we carry an extensive research program in the synthesis, characterization, and modeling of new materials (Figure 1). We develop state-of-the-art instrumentation and techniques which we offer to other research groups through spin-offs or scientific collaborations. Among them are computational techniques as well as atomic manipulation and surface characterization techniques (Figure 2).

IFIMAC takes full advantages of the possibilities offered by UAM, leveraging the use of fabrication, nanofabrication (Figure 3) and characterization facilities of the Campus. The Helium liquefaction unit of the UAM is unique nation-wide and recovers and liquefies Helium for science, often also delivering industry. The fabrication facilities include state-of-the-art machines, with a new metal 3D printer and a development center for new instrumentation. IFIMAC allows researchers to measure and characterize materials from atomic scale to large sizes, from low to high frequencies, at temperatures down to 7 mK and magnetic fields up to 22 T.

IFIMAC includes the only laboratory contributing to the access system of a large-scale European infrastructure (the European high magnetic field laboratory), and collaborates very actively in synchrotron, neutron scattering and free electron laser facilities. Advanced calculations, from ab-initio to modeling, leverage experimental efforts in instrumentation to creating top level science. Practically any new idea in materials synthesis can be addressed at IFIMAC.

IFIMAC studies all sorts of topical quantum materials, obtaining advances in magnetism, superconductivity, topological properties of materials, interfaces, optical properties, electronics and spintronics, surface physics, molecular systems, graphene and other two-dimensional materials (Figure 4). Regarding the material properties under study at IFIMAC, several groups are very active in the research on magnetism, superconductivity, spintronics and vortex physics.

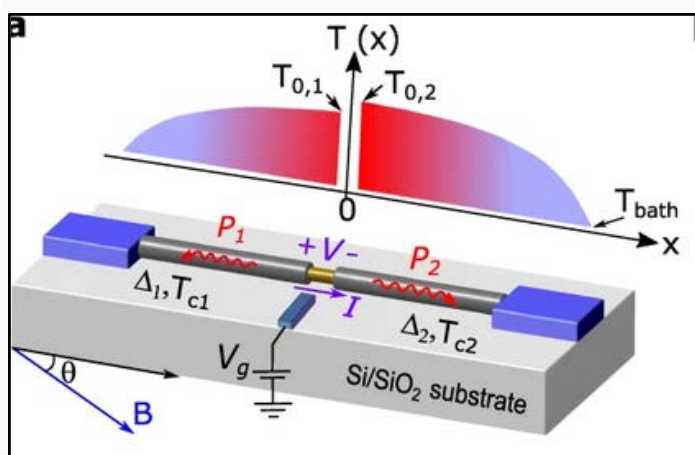


Figure 3: Device made of superconducting leads and a semiconducting nanowire. An etched part in the middle of the nanowire allows applying a gate. Heat flow (red lines) leads to a new characterization tool, Joule spectroscopy. From **Nature Communications** 14, 2873 (2023).

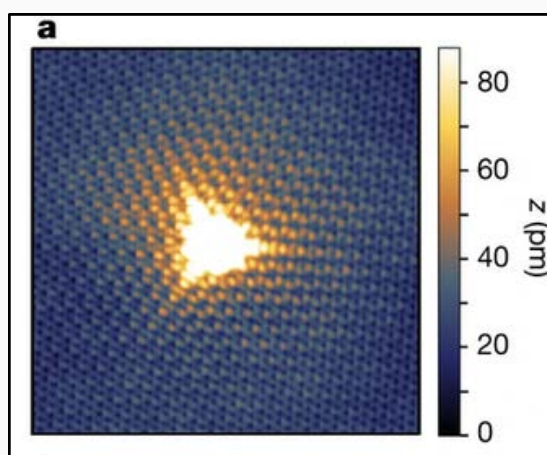


Figure 4: Friedel oscillations from H atoms in graphene. Additional wavefronts appearing due to dislocations are shown in red. From **Nature**, 574, 219 (2019).



First Principles Simulations and Modelling

Computer modeling has grown over the years into a scientific discipline on its own. Models are used to evaluate real-world phenomena that may be too complex to analyze directly in the laboratory or through experimentation, allowing hypotheses to be tested at a fraction of the cost. Models in industry, government, and educational institutions shorten design cycles, reduce costs, and enhance knowledge. In Physics, the modeling of materials, through what is known as “first principles”, has become a major research field. By “first principles” one understands the use of the fundamental quantum mechanical laws of nature without any assumptions. The properties of the materials should emerge from the numerical solution of these laws. The models here are in fact a faithful representation of reality, but in a controlled environment.

Researchers at IFIMAC have a long-standing and well-deserved international reputation on computer modeling and, in particular, on the development of efficient first principles codes for the simulation of the optoelectronic and structural properties of molecules, materials, and systems in general described down to the atomic level (SIESTA, ANT. Gaussian, FIREBALL, MOLCAS, EDUS, etc.). All the other research lines at IFIMAC benefit one way or another from this expertise. This knowledge not only benefits fundamental research, but can also be transferred directly into the society through spin-offs. IFIMAC researchers exploit these simulation codes to explore a wide variety of problems, including electronic transport, catalysis on reducible oxides and out-of-equilibrium electron dynamics.

Spin-dependent electronic transport is an essential feature not only in engineered devices for spintronics, but also in chemical and biological processes involving the propagation of a current through molecules. In recent years, it has been experimentally verified that an initially unpolarized beam of electrons will emerge polarized (in some cases, significantly) upon traversing a chiral molecule such as a DNA-like helicene; a realization of the so-called chirality-induced spin selectivity (CISS) effect. In a recent article published in *ACS Nano* IFIMAC researchers based on the use of representation theory within the scattering formalism for transport, that the

appearance of such spin polarization is fundamentally allowed in a much wider family of systems, namely those that lack symmetry planes or axes containing the propagation direction (Figure 5). The role of the contacts is hence as qualitatively important as that of the molecules, to the point that the presence of the latter is not generally needed to observe spin polarization.

Spin-dependent electronic transport is an essential feature not only in engineered devices for spintronics, but also in chemical and biological processes involving the propagation of a current through molecules. In recent years, it has been experimentally verified that an initially unpolarized beam of electrons will emerge polarized (in some cases, significantly) upon traversing a chiral molecule such as a DNA-like helicene; a realization of the so-called chirality-induced spin selectivity (CISS) effect.

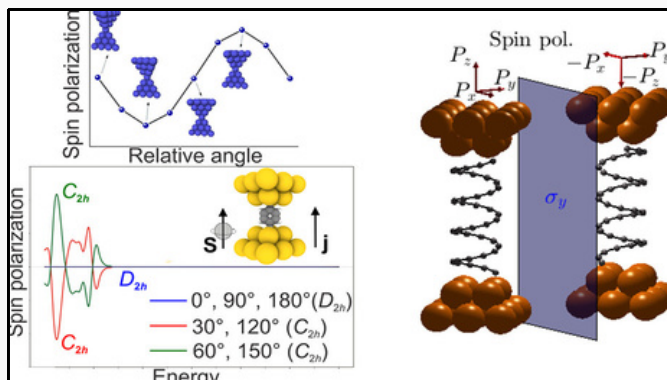


Figure 5: Different types of chiral systems such as those in the figure may exhibit the CISS effect. From *ACS Nano*, 17, 6452 (2023).

These predictions are illustrated by DFT calculations where they also show that the polarization vector is accompanied by a net spin accumulation in the system for finite bias, which may be detected in magneto-conductance setups.

Proteins are key biological molecules that are responsible for numerous energy conversion processes such as photosynthesis or respiration. In recent years, proteins have been investigated in a new setting, namely in solid-state electronic junctions, with the goal of understanding the charge transfer mechanisms in these biomolecules, but also with the hope of developing a new generation of bio-inspired nanoscale electronic devices.



Figure 6: An electrically driven switch can be formed by a cytochrome C monolayer, sandwiched between a gold layer and a gold nanowire. From *Angewandte Chemie*, 58, 11923 (2019).

A new step towards this goal was reported in *Angewandte Chemie* by a collaboration between Weizmann Institute of Science (Israel) and IFIMAC researchers. In this work, the authors show that a redox protein, cytochrome C, can behave as an electrically driven switch when incorporated in a solid-state junction with gold electrodes (Figure 6).

By changing the external bias voltage in the junction, it was shown that the relevant molecular orbitals of the protein can be brought in and out of resonance with the chemical potential of the electrodes, which leads to the current switch behavior. Showing transition from off- to on-resonance can be very challenging and this is the first time it has been achieved for proteins within the same working junction. Extensive ab initio DFT calculations revealed that the charge transport proceeds through the heme unit in these proteins and that the coupling between the protein's frontier orbitals and the electrodes is sufficiently weak to prevent Fermi level pinning. The on-off change in the electrical current was shown to persist up to room temperature, demonstrating reversible, bias-controlled switching of a protein ensemble, which provides a realistic path to protein-based bioelectronics.



Figure 7: Front cover artistic view of the catalytic process for acetylene hydrogenation. From *J. Phys. Chem. C*, 118, 5352 (2014).

These findings rationalize for the first time the applicability of CeO_2 as a catalyst for olefin production and potentially broaden its use for the hydrogenation of polyunsaturated and polyfunctionalized substrates containing triple bonds. In a recent manuscript published in the *Journal of Chemical Theory and Computation* a collaboration of IFIMAC researchers have presented a theoretical framework and its numerical implementation to simulate the out-of-equilibrium electron dynamics induced by the interaction of ultrashort laser pulses in

condensed-matter systems (Figure 8). Their approach is based on evolving in real time the density matrix of the system in reciprocal space. It considers excitonic and nonperturbative light-matter interactions. They show some relevant examples that illustrate the efficiency and flexibility of the approach to describe realistic ultrafast spectroscopy experiments. The approach is suitable for modeling the promising and emerging ultrafast studies at the attosecond time scale that aim at capturing the electron dynamics and the dynamical electron-electron correlations via X-ray absorption spectroscopy.

The unique catalytic properties of ceria for the partial hydrogenation of alkynes have been examined for acetylene hydrogenation (Figure 7). Catalytic tests over polycrystalline CeO_2 at different temperatures and $\text{H}_2/\text{C}_2\text{H}_2$ ratios reveal ethylene selectivities in the range of 75–85% at high degrees of acetylene conversion and hint at the crucial role of hydrogen dissociation on the overall process. DFT is applied to $\text{CeO}_2(111)$ in order to investigate reaction intermediates and to calculate the enthalpy and energy barrier for each elementary step.

At a high hydrogen coverage, b- C_2H_2 radicals adsorbed on-top of surface oxygen atoms are the initial reactive species forming C_2H_3 species effectively barrierless. The high alkene selectivity is owed to the lower activation barrier for subsequent hydrogenation leading to gas-phase C_2H_4 compared to that for the formation of b- C_2H_4 radical species.

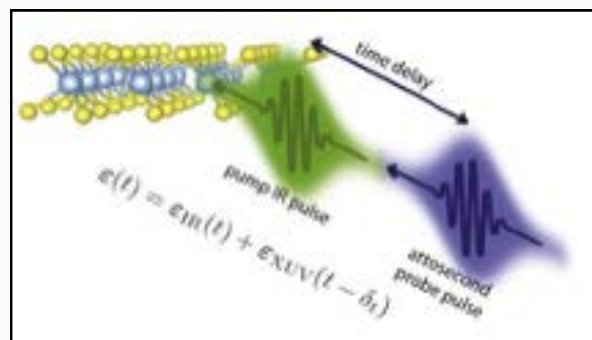


Figure 8: Schematics of a pump-probe experiment where a first laser pulse excites the material while a second one explores the time evolution of the excitation. From *Journal of Chemical Theory and Computation*, 19, 333 (2023).



When the characteristic dimensions of a system or a device are shrunk to the nanoscale, their properties change dramatically. The reason for that is that at this scale quantum mechanical effects set in, which leads to novel physical phenomena that, in turn, are often the basis of unforeseen technological applications. One of the main goals of researchers at IFIMAC is the study of the electronic, mechanical, thermal, and optical properties of structures and devices with nanometric dimensions, for which classical laws do not longer apply. For this purpose, we make use of a wide range of nanofabrication techniques, experimental probes, and theoretical tools.

Some of our main activities in the field of Nanophysics are related to the theoretical and experimental study of novel low-dimensional systems such as graphene and graphene-based nanostructures. Antimonene, a single layer of antimony atoms, was firstly obtained at IFIMAC. This 2D material is attracting much attention due to its strong spin-orbit coupling and its potential in optoelectronics, thermoelectric applications, and biomedicine. This work was the result of an internal theoretical-experimental collaboration at IFIMAC, whose researchers are world leaders in this topic. Making use of experimental techniques such as Angle Resolved Photoemission Spectroscopy (ARPES) or Low Energy Electron Diffraction (LEED), IFIMAC researchers also investigate topics like 2D structural phase transitions, surface charge density waves, or the electronic structure of laterally nanostructured systems. Furthermore, we study the growth and properties of nanometer-scale objects on solid surfaces with applications in spintronics, optoelectronics, magnetic recording, nanoscale catalysis, nanomechanical biosensing, medical nanoimaging, etc.

IFIMAC researchers work actively in 2D materials and heterostructures, and its associated topological properties. Recently, they have predicted, on the basis of DFT, a quantum phase transition in franckeite (Figure 9), originating from stoichiometric changes in one of its composing layers (the quasi-hexagonal one). Franckeite is a natural superlattice composed of two alternating layers of different composition, easy to exfoliate into very thin heterostructures, which has shown potential for optoelectronic applications.

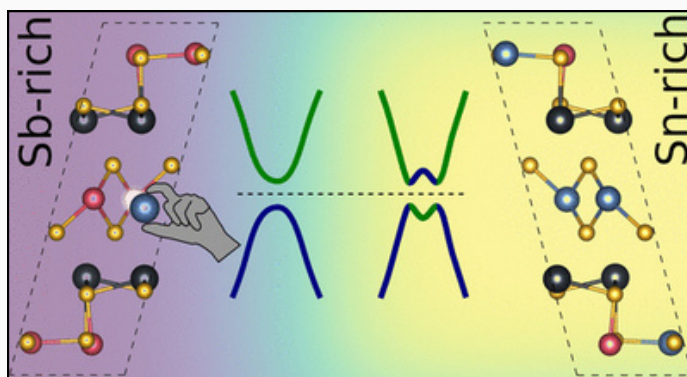


Figure 9: A quantum phase transition, predicted from DFT calculations and originating from stoichiometric changes in one of its composing layers (a large concentration of Sn in the quasi-hexagonal one) turns franckeite into a strong topological insulator. From **Nano Lett.** 21, 7781 (2021).

Not surprisingly, its chemical composition and lattice structure are so complex that franckeite has escaped screening protocols and high-throughput searches of materials with nontrivial topological properties. Now, it has been predicted that, while for a large concentration of Sb, franckeite is a sequence of type-II semiconductor heterojunctions, for a large concentration of Sn, these turn into type-III, much alike InAs/GaSb artificial heterojunctions, and franckeite becomes a strong topological insulator. Transmission electron microscopy observations confirm that such a phase transition may actually occur in nature.

Other important areas of expertise in our center are the fields of Nanoelectronics and Quantum Transport. In particular, in recent years researchers at IFIMAC have played a leading role in the understanding of the electronic transport in a great variety of nanoscale systems such as metallic atomic-size contacts, single-molecule junctions, superconducting hybrid structures, or strongly correlated low-dimensional systems.

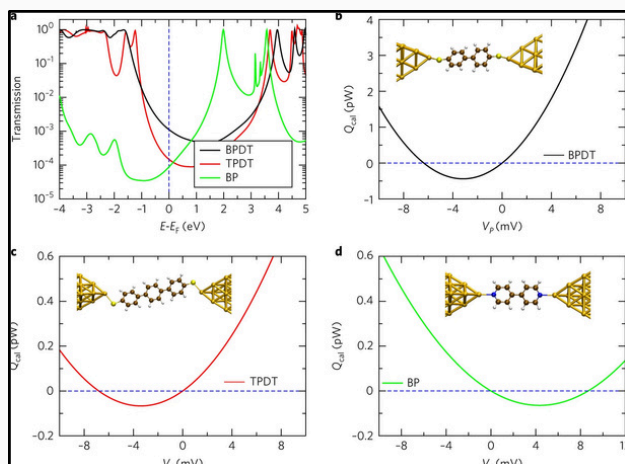


Figure 10: (b-d) Computed heating/cooling effect in the molecular junctions formed by gold electrodes and prototypical molecules (Au-biphenyl-4,4'-dithiol-Au, Au-terphenyl-4,4'-dithiol-Au and Au-4,4'-bipyridine-Au). The transmission (a) and its derivative at E_F determine the electrical conductance and the Seebeck coefficient of the molecular junctions. From **Nat. Nanotechnol.** 13, 122 (2018).

The study of thermoelectricity in molecular junctions is of fundamental interest for the development of various technologies including cooling (refrigeration) and heat-to-electricity conversion. IFIMAC researchers have developed theoretical methods, based on self-energy-corrected density functional theory calculations, to characterize the electrical and thermoelectric properties of molecular junctions (Figure 10).

Within the area of nanoelectronics, our groups are currently developing a strong theoretical/experimental activity on hybrid superconducting devices. This work ranges from the understanding of their basic transport properties to their potential application for quantum information processing using microwave techniques of the so-called Andreev qubits. The qubit is based on a circuit that consists of a submicron indium arsenide (InAs) nanowire enclosed by a superconducting aluminum loop (Figure 11). Discrete localized states, known as “Andreev bound states,” form in the nanowire as a result of coupling to the superconductor. When the absorption of a photon induces a transition between two of these states, the loop inductance changes. The absorption spectrum of the circuit can be measured by monitoring the resulting frequency shift of a microwave resonator inductively coupled to the loop. The spectrum shows a fine structure of spin-split Andreev states, well accounted for by a simple model with spin-orbit coupling as the key ingredient.

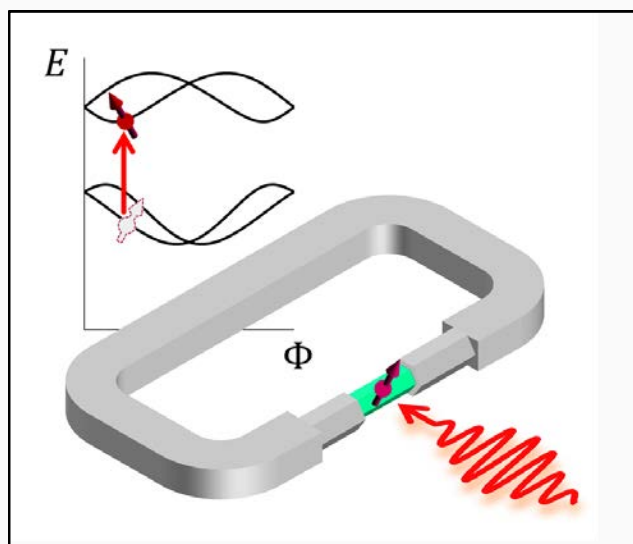
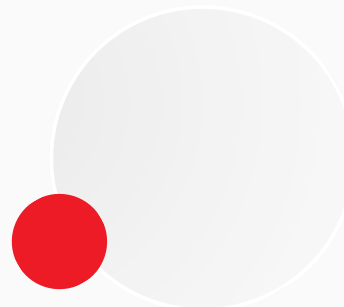


Figure 11: Spin-Orbit Splitting of Andreev States Revealed by Microwave Spectroscopy. The circuit includes an InAs nanowire enclosed by a superconducting aluminum loop. The spin state of a single electron in the nanowire has a measurable impact on the electrical properties of the circuit. From **Phys. Rev. X** 9, 011010 (2019).



A very important topic in our center is also the use and modeling of Scanning Probe Microscopes (SPMs). Atomic Force Microscopy (AFM) is being currently used for the study of the mechanical, electrical and frictional properties of low-dimensional materials. Another key subject is the use of cryogenic Scanning Tunneling Microscopy (STM) and Spectroscopy (STS) for the surface characterization of semiconductor and superconductor nanostructures. One recent example involves the first observation of Yu–Shiba–Rusinov (YSR) states in graphene (Figure 12). Superconductivity in graphene is induced by proximity effect brought by adsorbing nanometer-scale superconducting Pb islands. Using STM and STS the superconducting proximity gap is measured and YSR states are visualized, extending more than 20 nm away from the graphene grain boundaries. These observations provide the long-sought experimental confirmation that graphene grain boundaries host local magnetic moments and constitute the first observation of YSR states in a chemically pure system. From a theoretical point of view, IFIMAC researchers are among the worldwide leaders in the area of ab initio modeling of nanowires and SPMs.

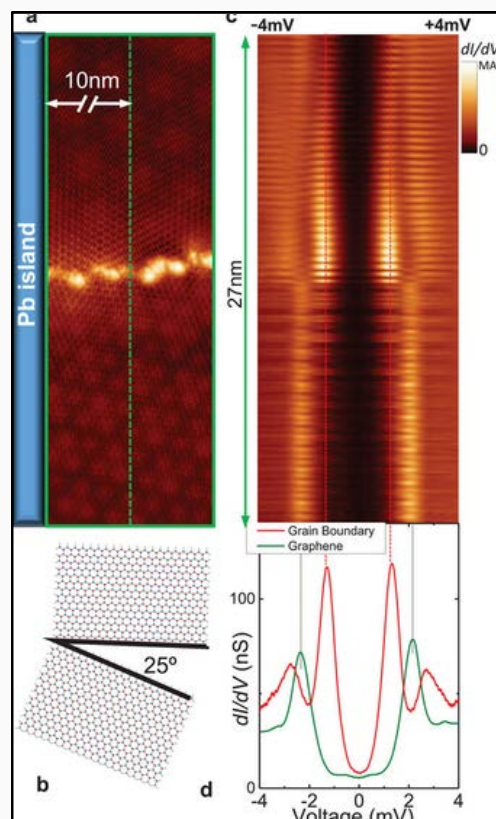


Figure 12: Grain Boundary (GB) magnetism induces Yu–Shiba–Rusinov states in superconducting graphene. From **Advanced Materials** 33, 2008113 (2021).



Nano and Quantum Optics

The related areas of Nano and Quantum Optics are dedicated to the study of light-matter interactions at the nanoscale and at a quantum level and are two promising lines for the development of efficient, energy-saving, and compact platforms for future information technology. Nanophotonic systems offer a key advantage over other platforms: Their unique ability to concentrate light in the nanoscale (Figure 13) enables scalability and integration in

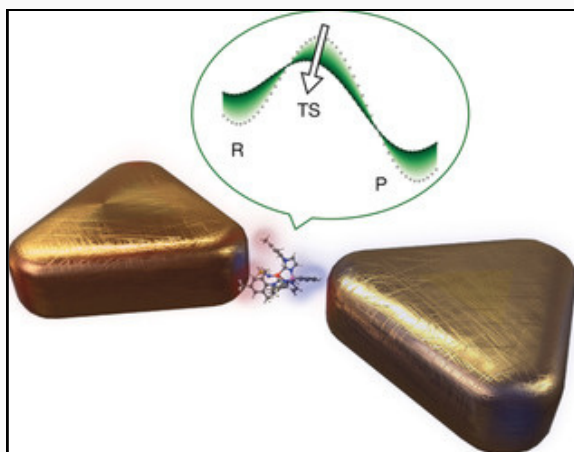


Figure 13: Light focused on the nanoscale can interact with quantum emitters, including complex molecules. From, **Angew. Chem. Int. Ed.** 58, 8698 (2019)

the solid-state, and at the same time gives access to the quantum properties of photons. IFIMAC hosts a group of internationally recognised researchers working in this field and counts with extensive laser lab facilities for spatial, spectral, and angular characterization of nano and quantum optical effects.

Nano Optics is devoted to the study of electromagnetic field propagation, confinement, and interaction with matter at a sub-wavelength scale. Advances in fabrication and characterization techniques nowadays permit the study of optical phenomena at the nanoscale. Researchers at IFIMAC have made seminal contributions to the field through the study of nano-plasmonic systems, including the phenomenon of extraordinary optical transmission through subwavelength apertures or the proposal of spoof surface plasmon polaritons that mimic the

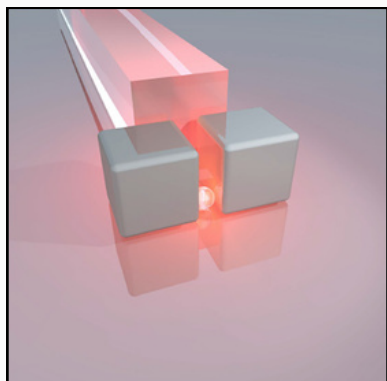


Figure 14: Nanophotonic structures allow confining light on the nanoscale. From **ACS Photonics**, 5(9), 3447-3451 (2018).

light confinement properties of metals but at lower frequencies. Other important contributions were in the field of plasmon-assisted transport in atomic-scale junctions and the propagation of electromagnetic waves in magneto-plasmonic nanostructures (Figure 14). Light-matter interaction in two-dimensional systems, such as graphene and graphene-based heterostructures, graphene relatives, transition metal dichalcogenides and their combination in vertical stacks are also investigated at IFIMAC.

Quantum optics is a related field of research, merging the areas of quantum field theory and optics, and dealing with phenomena involving light and its interaction with matter at the quantum level.

The field has evolved considerably from its early studies of coherence properties of radiation and parametric processes of light to recent topics of investigation such as quantum information, manipulation of single atoms, Bose-Einstein condensation, etc. Theorists at IFIMAC have produced seminal contributions to the understanding of light emission and absorption spectra in low-dimensional semiconductor structures.

We have worked on the quantum optics produced by interacting bosonic complexes describing cavity polaritons and contributed with pioneering works on the superfluidity and coherence properties of polariton gases both under resonant and non-resonant pumping (Figure 15).

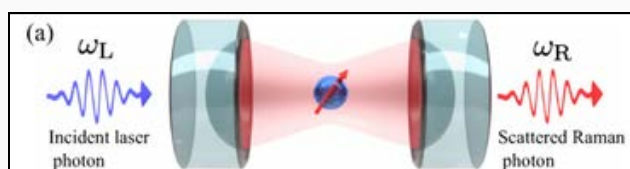


Figure 15: Ultrastrong coupling enables the spontaneous Raman scattering of incident radiation. From **Phys. Rev. Lett.** 129, 273602 (2022).

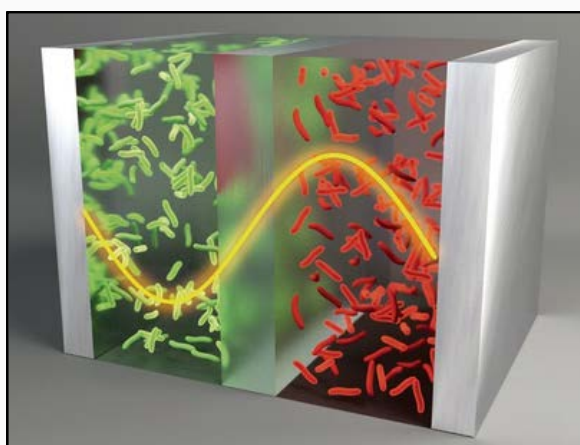


Figure 16: Energy transfer between molecules is modified by the presence of vacuum fields in a photonic cavity. From **Science** 373, eabd0336 (2021).

IFIMAC gathers leading theorists worldwide on quantum nanophotonics, the area of overlap between nano and quantum optics. The group has extensive experience on designing nanophotonic systems to achieve and control interactions between quantum emitters and photon modes and to generate quantum states of light, with a particular focus on hybrid plasmonic-photonic structures that combine the advantages of strong field confinement and long lifetimes.

The group has also been at the forefront of a new interdisciplinary area of research aimed at taking advantage of QED phenomena such as strong light-matter coupling to manipulate atomic, molecular, and condensed-matter systems, and has participated actively in the birth and development of this new area of research through several seminal contributions (Figures 16 and 17).

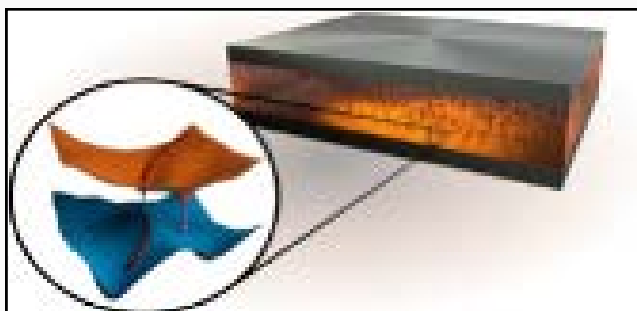


Figure 17: With polaritonic chemistry, chemical structure can be manipulated through strong coupling between light and matter. From *ACS Photonics* 9, 1096 (2022).

Experimental groups at IFIMAC have a long experience on optical spectroscopy of semiconductor low-dimensional systems, such as quantum optics based on semiconductor quantum dots. IFIMAC researchers have expertise in photon correlation techniques, properties of single photon emitters (Figure 18), time-resolved spectroscopy, quantum microcavities based on semiconductor nanostructures, exciton polaritons, and on the preparation of Bose-Einstein condensates in solid-state systems.

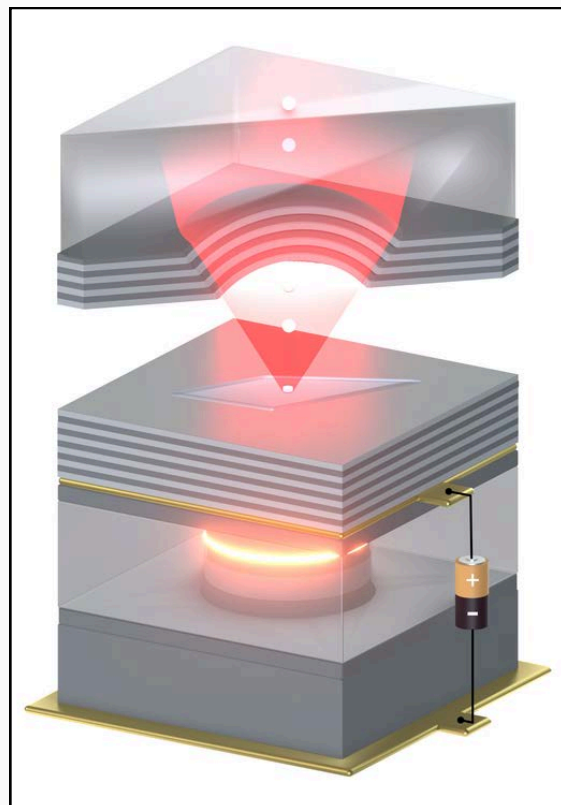


Figure 18: Sketch of a room temperature single photon source for quantum communication protocols. A quantum emitter (such as a defect in hBN) couples to the open cavity, enhancing the single photon emission.

Furthermore, we have also developed compact laser sources based on plasmonic nanoparticles. Another very active area of experimental research at IFIMAC is the study of exciton diffusion in complex semiconductors or perovskites to optimise their ability to harvest solar energy, in combination with artificial intelligence approaches (Figure 19).

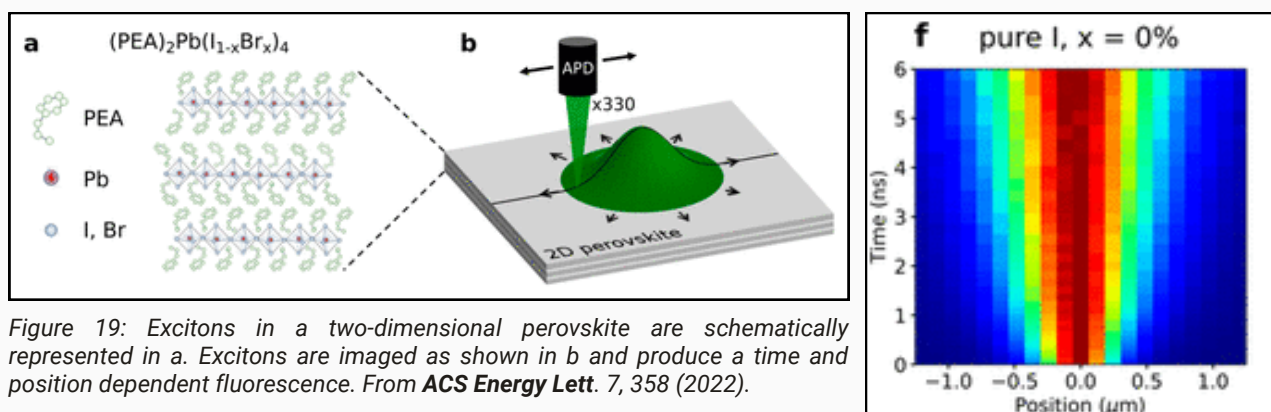


Figure 19: Excitons in a two-dimensional perovskite are schematically represented in a. Excitons are imaged as shown in b and produce a time and position dependent fluorescence. From *ACS Energy Lett.* 7, 358 (2022).



Soft condensed matter comprises a variety of mesoscopic physical systems that are easily deformed by small thermal or mechanical stresses, including liquids, colloids, polymers, liquid crystals, gels, membranes, foams, etc. The relevant length and time scales of these systems are thus naturally larger than those of atoms or molecules, which facilitates experimentally accessing the microscopic states of these

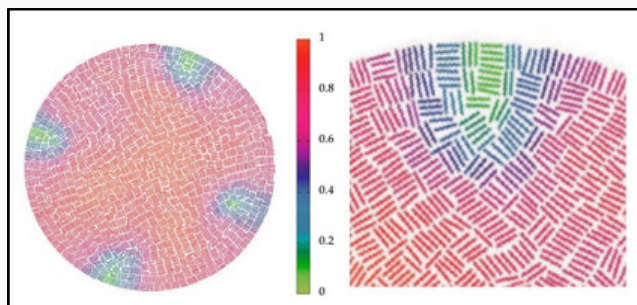


Figure 20: Exotic liquid crystalline phases in monolayers of vertically vibrated granular particles. From **Liquid Crystals** 50, 1261–1278 (2023)

systems to understand and predict their emergent macroscopic properties, using the framework of statistical mechanics. Using vibrated granular particles, a variety of fluid patterns with orientational order that resemble equilibrium liquid-crystal phases were found, exhibiting topological defects due to confinement, much as molecular liquid crystals (Figure 20). This system represents a novel approach to study order in 2D fluids of hard particles.

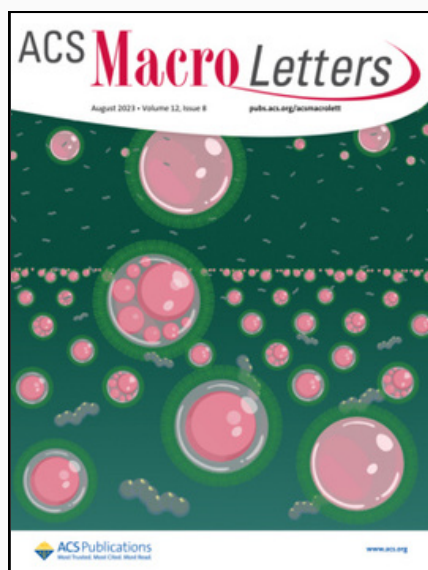


Figure 21: Aqueous two-phase systems within selectively permeable membranes. From **ACS Macro Lett.**, 12, 132 (2023).

Biological systems are also soft and built on the rich diversity of mesoscale structures mentioned. A tissue is a soft hydrogel, a hierarchical dynamic structure composed by many cells, which in turn are made up of many molecular assemblies orchestrating processes at different length and time scales. These systems set the most outstanding challenge in our goal to understand the spontaneous self-assembly of matter. Bottom-up approaches to recreate biological systems may enable to isolate fundamental physical principles from the complex set of signaling and metabolic pathways of natural systems. With this in mind, we have recently transferred microfluidic technologies from Harvard to IFIMAC, to fabricate vesicles as cell mimetics with exquisite control, enabling to study physical phenomena such as adhesion, fusion, and motility in model systems. These vesicles can also mimic the complex organization of the cell cytoplasm.

IFIMAC researchers have used this technology to fabricate vesicles enclosing aqueous compartments to study the effect of permeable membranes in phase separations (Figure 21). Importantly, these vesicles may also find applications in biomedicine, pharmacy, and cosmetics.



Figure 22: Trapping flocking particles with asymmetric obstacles. From **Soft Matter**, 16, 4739, 2020.

Moreover, biological systems are active, they constantly produce and consume energy, which results in the emergence of sometimes unintuitive collective properties. The emergent subdiscipline of Active Matter focuses on understanding such collective properties, which frequently requires out-of-equilibrium physics descriptions. Using bacteria, modeled as run-and-tumble particles, IFIMAC researchers are studying the emergence of collective motion in confined environments (Figure 22).

Molecular Dynamics (MD) simulations are a powerful tool to understand biological processes at the atomic scale. IFIMAC researchers are applying them to the study of proteins, nucleic acids and viruses in their native liquid environment. The elasticity of double-stranded DNA (dsDNA) is a key molecular determinant in the many cellular contexts in which this molecule is found, as it affects the binding affinity of dsDNA with proteins as well as the dsDNA response to the mechanical action exerted by proteins.

Using all-atom MD simulations, IFIMAC researchers have proposed that parts of the DNA sequence act as a physical code that controls the structure and mechanical properties of dsDNA at short scales, paving the way for protein-DNA interaction and organization of the genomic material (Figure 23). This work has been extended to dsRNA, where they identified a sequence motif consisting of alternating adenines and uracils, or AU-tracts, that strongly bend the RNA double-helix. This result may be exploited in the emerging field of RNA nanotechnology and might also constitute a natural mechanism for proteins to achieve recognition of specific dsRNA sequences.

IFIMAC has a strong tradition in the construction and use of scanning probe microscopes, in particular in Atomic Force Microscopy (AFM). One of the most exciting applications of AFM is the characterization of biological material at the single-particle level. Physical Virology, the study of viruses usually involve bulk experiments, which gather average data from large ensembles of structures, thus considering all the particles as indistinguishable. However, biochemical processes are highly asynchronous and intermediate states are poorly populated. Therefore, average measurements might conceal details of the processes taking place in viruses. AFM allows the imaging and manipulation of individual virus particles adsorbed on a surface in liquid milieu by using a sharp tip (~ 10 nm) located at the end of a microcantilever.

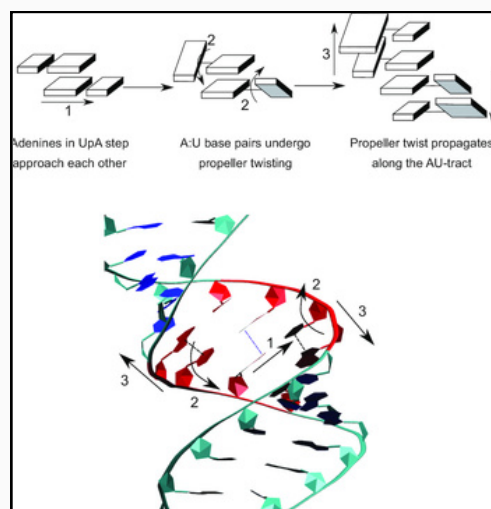


Figure 23: Proposed mechanism for AU-tract induced bending. AU-tract bending is illustrated using rigid blocks representation (top) and a snapshot of the molecular dynamics trajectory (bottom, AU-tract is marked in red). From **Nucleic Acid Res.** 22, 12917 (2020).

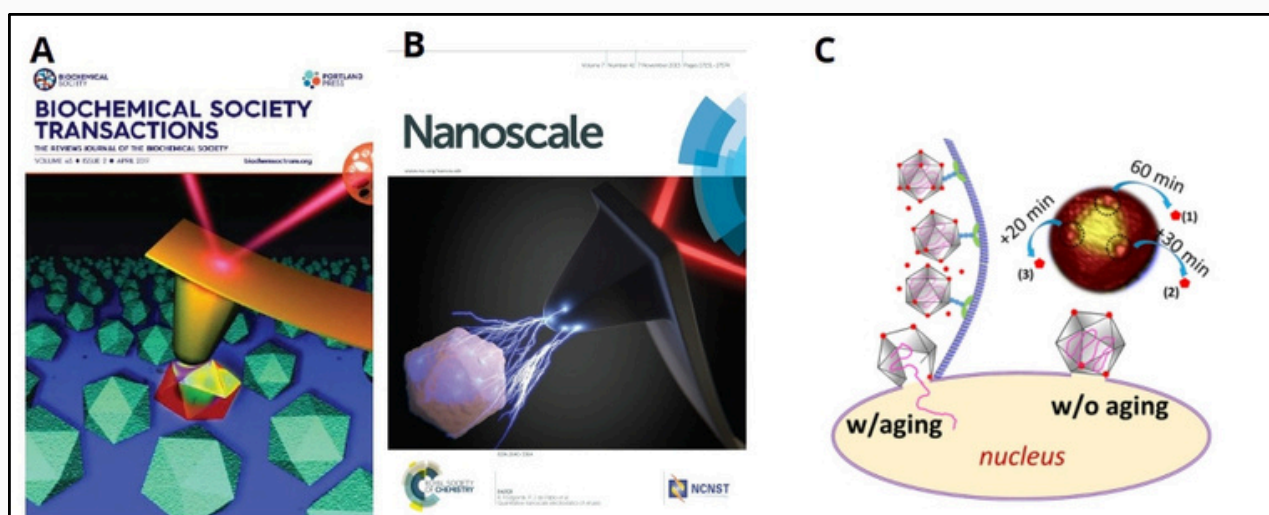
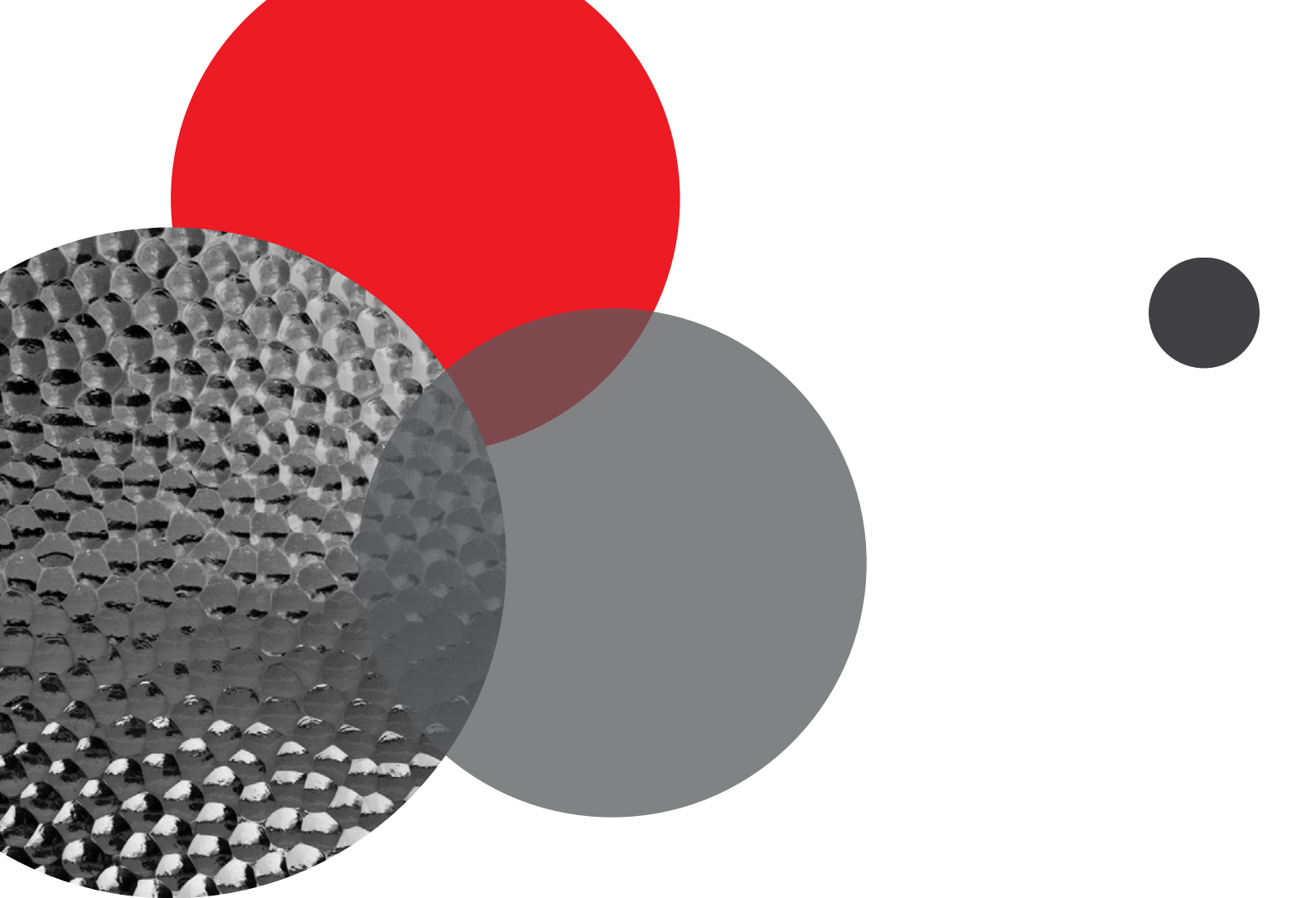


Figure 24: AFM is the perfect tool for seeing and touching individual viruses (A), allowing the study of the electrostatic charge of virus structures (B), and resemble the disruption process of viruses taking place during infection (C). From: *Biochem. Soc. Trans.* 45, 499 (2017); *Nanoscale* 7, 1728 (2015), and *Phys. Rev. X* 11, 021025 (2021).

In this way, IFIMAC researchers study the electrostatic charge of virus structures, monitor differences between wild type and mutant viruses during disassembly, and resemble the disruption process of viruses taking place during infection (Figure 24). Some of these studies are supported by MD simulations using coarse-grained models and simulation codes developed at IFIMAC.



2

ORGANIZATION

STEERING COMMITTEE



Rubén Pérez Pérez

IFIMAC Director

Full Permanent Professor at the
Department of Theoretical Condensed
Matter Physics, Universidad Autónoma
de Madrid.



Luisa E. Bausá López

IFIMAC Deputy Director

Full Permanent Professor at the
Department of Physics of Materials,
Universidad Autónoma de Madrid.



**Antonio I. Fernández-
Domínguez**

Member

Professor at the
Department of
Theoretical Condensed
Matter Physics,
Universidad Autónoma
de Madrid.



**Cristina Gómez-
Navarro González**

Member

Professor at the
Department of
Condensed Matter
Physics, Universidad
Autónoma de Madrid.



**Félix Zamora
Abanades**

Member

Full Permanent
Professor at the
Department of Inorganic
Chemistry, Universidad
Autónoma de Madrid.

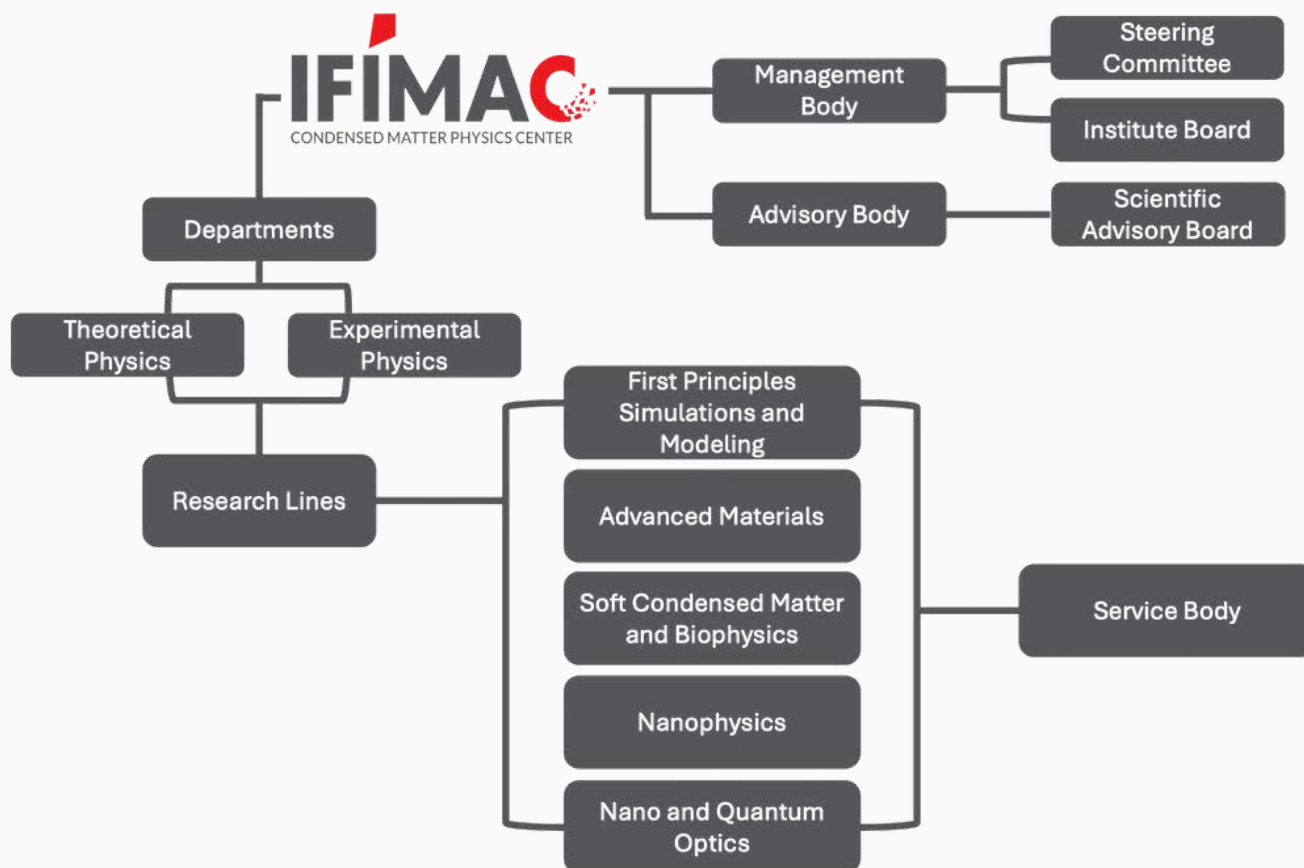


Hermann Suderow

Member

Full Permanent
Professor at the
Department of
Condensed Matter
Physics, Universidad
Autónoma de Madrid.

ORGANIZATION CHART



COMMUNICATION COMMITTEE

As members of the Communication Committee, their mission is to enhance the visibility of the activities, achievements, and news from the Center. Their research communication aims to promote a greater understanding of science, its relevance to everyday life, and its role in addressing global challenges.



Pablo Ares García
Head of the Committee

Ramón y Cajal Fellow at the Department of Condensed Matter Physics, Universidad Autónoma de Madrid.



Carlos Antón Solanas
Member

CM-Talento Fellow at the Department of Physics of Materials, Universidad Autónoma de Madrid.



Paloma Arroyo Huidobro
Member

Ramón y Cajal Fellow at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.



Salvatore Assenza
Member

Ramón y Cajal Fellow at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.



Antonio I. Fernández-Domínguez
Member

Professor at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.



Héctor González Herrero
Member

Ramón y Cajal Fellow at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.



Diego Martín Cano
Member

Ramón y Cajal Fellow at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.

GENDER EQUALITY COMMITTEE

In April 2021, the Gender Equality Committee was created at IFIMAC. Its main goal is to promote good practices and organize activities that support women's role in science, especially within IFIMAC, while also raising awareness about gender equality among its members.



Cristina Gómez-Navarro
Mentoring Program Coordinator

Professor at the Department of Condensed Matter Physics, Universidad Autónoma de Madrid.



Isabel Guillamón
Member

Associate Professor at the Department of Condensed Matter Physics, Universidad Autónoma de Madrid.



Francesca Maria Marchetti
Member

Associate Professor at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.



Elena del Valle Reboul
Member

Associate Professor at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.



Johannes Feist
Member

Associate Professor at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.



Carlos Antón Solanas
Member

CM-Talento Fellow at the Department of Physics of Materials, Universidad Autónoma de Madrid.



Diego Martín Cano
Member

Ramón y Cajal Fellow at the Department of Theoretical Condensed Matter Physics, Universidad Autónoma de Madrid.



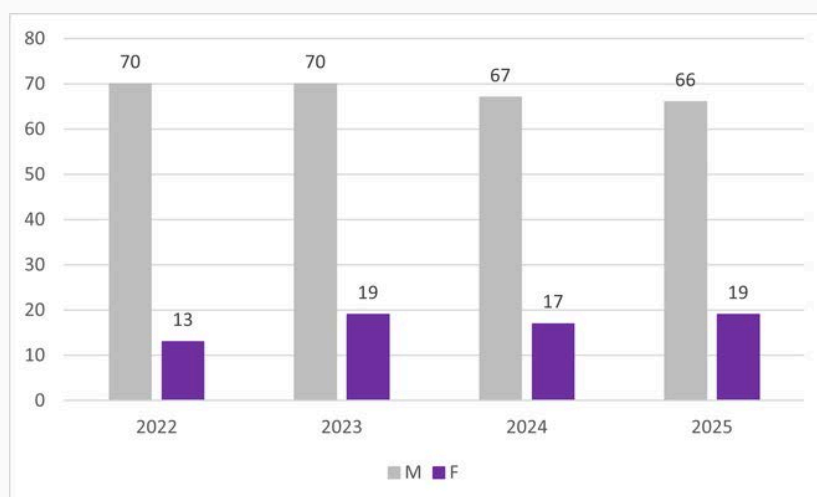
Celia Polop
Member

Professor at the Department of Condensed Matter Physics, Universidad Autónoma de Madrid

The committee's activities focus on different areas: monitoring and evaluation, participation, visibility and awareness, and student support.

1. **Monitoring gender balance at IFIMAC:** The graph below illustrates the evolution of the of women at IFIMAC over recent years. Our monitoring shows a steady increase in the representation of women within the institute, a positive trend that the committee is committed to sustaining in the coming years. (See IFIMAC at a glance for further details.)

Evolution by Gender (2022–2025)



2. **Mentoring Program:** The establishment of the fourth edition of the mentoring program for women physics students has been one of the committee's main priorities this year. This initiative, launched as one of the committee's earliest actions, aims to foster a close and supportive connection between undergraduate students and research activities.

The program provides:

- Support for women students pursuing undergraduate, master's, and doctoral degrees in physics.
- Female role models to inspire and guide students.
- Training and empowerment opportunities for mentors.
- A strong academic network for women in physics.

This year, 43 mentees are enrolled in the program, representing approximately 40% of all women physics students at UAM. In addition, more than 55% of senior researchers at IFIMAC are actively involved as mentors. Since the program's launch in 2022, when it began with 32 students, participation has evolved very positively, showing steady growth over successive editions. Furthermore, feedback collected through evaluations from both mentees and mentors has been consistently excellent, highlighting the program's strong impact and high level of satisfaction among participants.

A central component of the program is mandatory training in mentoring and gender in science for both mentors and mentees, delivered by an external expert from Skills4Science. A mid-year evaluation and additional training session are also held to ensure continuous improvement.

The impact of the mentoring program has extended beyond IFIMAC itself. It has generated significant discussion within the gender equality meetings of SOMMA, where the initiative has been presented as a best-practice example. As a result of this broader interest, a scientific article has recently been published outlining the objectives and cornerstones of the program, its unexpected outcomes, and a set of practical recommendations for institutions planning to implement similar mentoring systems.

Mentoring to cultivate female talent in science, C Gómez-Navarro, J Hansen, FEBS letters 599 (19), 2689-2692.

INAUGURACION PROGRAMA MENTORIA - IFIMAC
CURSO 25/26

12 septiembre 2025
Sala conferencias
Modulo 0
Facultad de Ciencias
UAM

programa MENTORÍA
Alumnas de física

12 septiembre 2025
Modulo 0
Facultad de Ciencias

11:45 Bienvenida e Indicaciones prácticas
Cristina Gómez-Navarro: investigadora IFIMAC

12:00 De los últimos Informes a la Acción:
Género y Educación
Sofia Facal, Skills4Science

12:20 "La importancia de acompañarnos:
mi experiencia en las mentorías"
Miriam Moreno, mente

12:40-13:15 Aperitivo

Mas información en : ifimac.uam.es/mentoría
Para consultas: mentoría.ifimac@uam.es

IFIMAC
Condensed Matter Physics Center

3. **Promoting Outreach Activities on Women in Science:** To celebrate the International Day of Women and Girls in Science on February 11th, we organized a science fair featuring a series of interactive workshops. (See outreach section for details)

4. We also **participated in educational centers** by giving talks and organizing workshops. Some of these initiatives include:

- 2025 Cristina Gómez-Navarro: "**Mamá, quiero ser científica, ¿y ahora qué?**" at IES Luis Gongora.

The committee remains devoted to expanding these initiatives and continuing to foster an inclusive and supportive environment for women in science.

SEMINARS COMMITTEE

As members of the IFIMAC seminar committee, their main objective is to organize the center's seminars and colloquia. This includes planning the schedule, selecting speakers, coordinating logistics, and promoting the events.



Iván Brihuega
Member

Professor at the Department of
Condensed Matter Physics,
Universidad Autónoma de
Madrid.



Antonio I. Fernández-Domínguez
Member

Professor at the Department of
Theoretical Condensed Matter
Physics, Universidad
Autónoma de Madrid.



Isabel Guillamón
Member

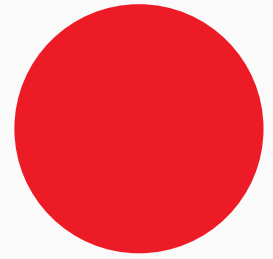
Associate Professor at the
Department of Condensed
Matter Physics, Universidad
Autónoma de Madrid.



Laura Rodríguez Arriaga
Member

Ramón y Cajal Fellow at the
Department of Theoretical
Condensed Matter Physics,
Universidad Autónoma de Madrid.

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Lawyer Taylor Professor at the
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Northwestern University (USA).



Prof. Päivi Törmä

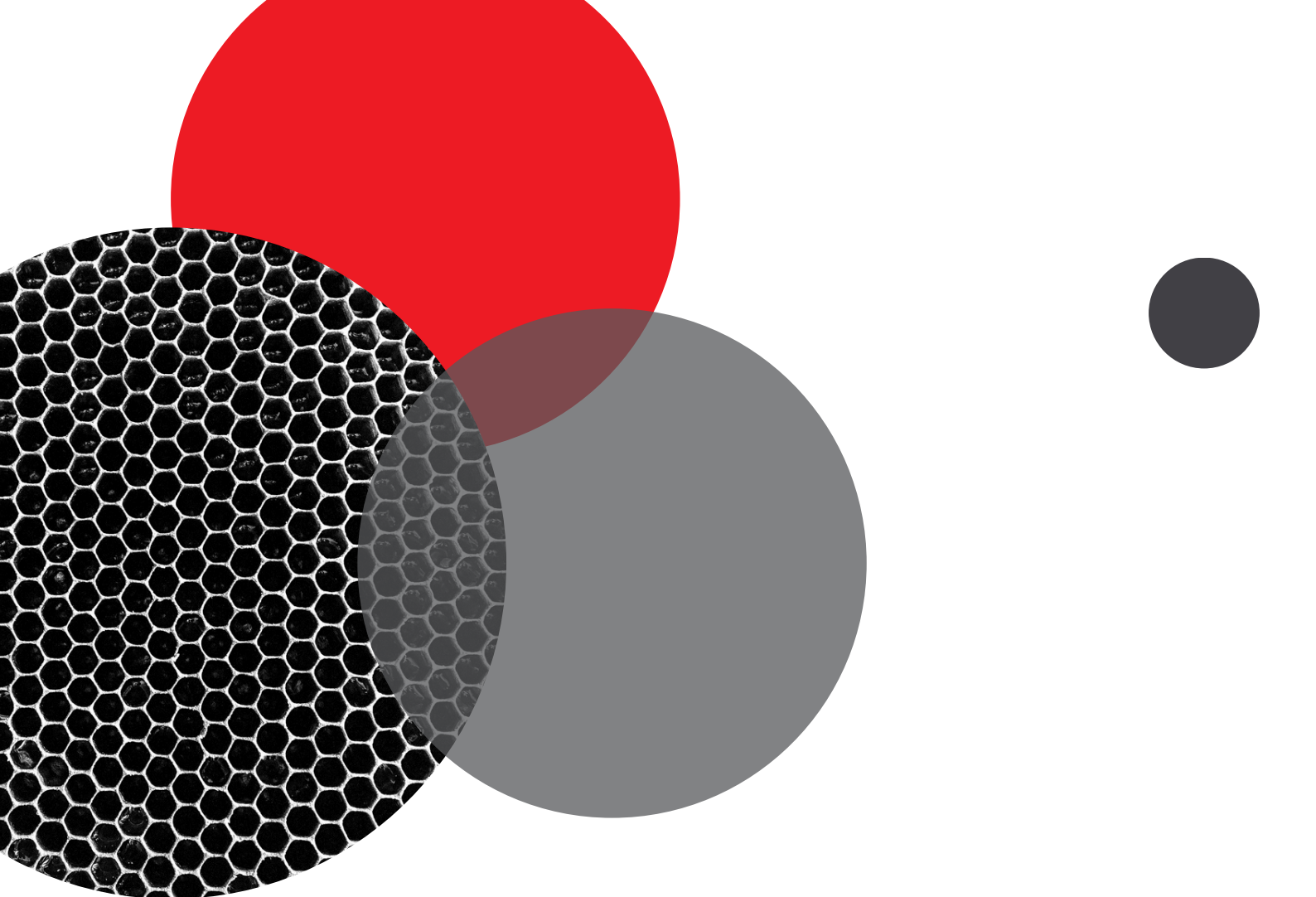
Professor at the Department of
Applied Physics, Head of the
Quantum Dynamics (QD) research
group. Aalto University (Finland).



Prof. Roser Valentí

Professor at the Institut für
Theoretische Physik, Goethe
Universität Frankfurt am Main,
Frankfurt (Germany).





3

**IFIMAC AT
A GLANCE**

HUMAN RESOURCES

IFIMAC Researchers: 86

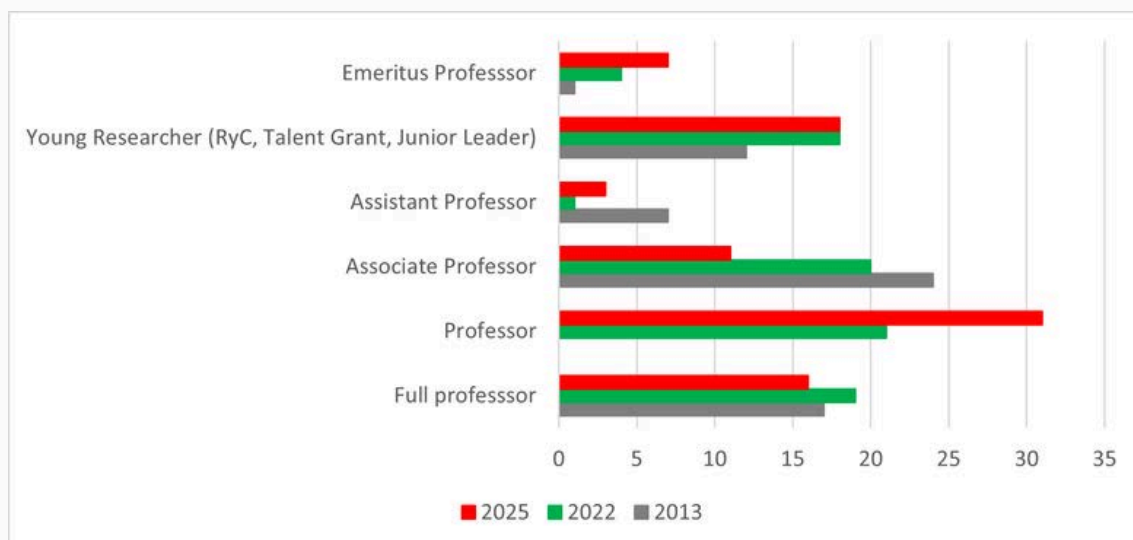
NEW

5 new researchers affiliated during 2025.

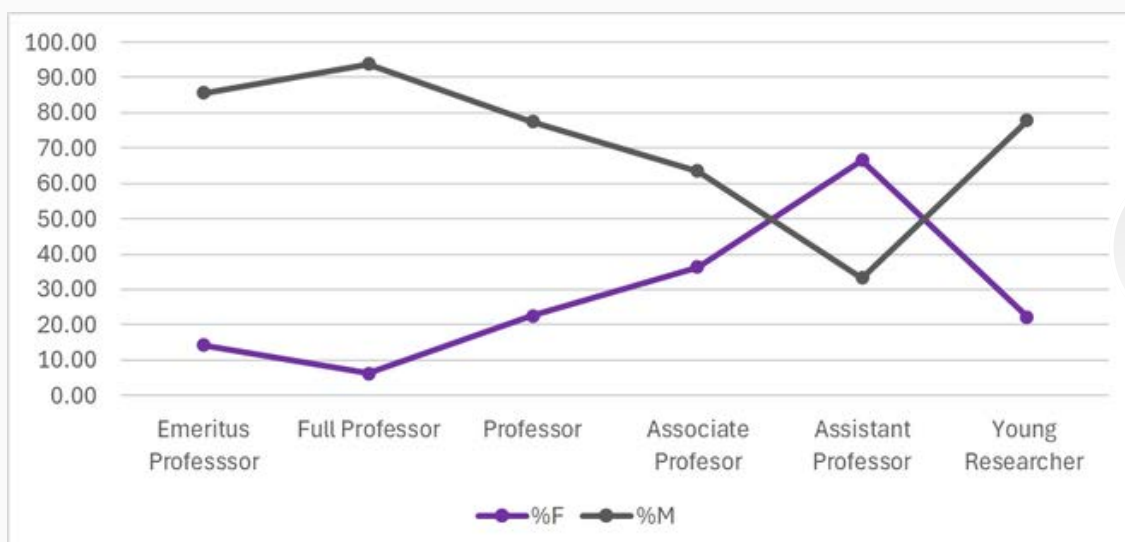
16 Full Professor
31 Professor
11 Associate Professor
3 Assistant Professor
7 Emeritus Professor

18 Young researcher (RyC, Talent Grant, IFIMAC Young Leader, LaCaixa Junior Leader)

Evolution by Professional Category (2013-2025)



By gender 2025:



IFIMAC Staff: 6

2 IT and High-Performance Computing Infrastructure
2 Project Manager
1 Laboratory Technician
1 Outreach

By gender: Male: 50% Female: 50%

IFIMAC Predoctoral

N° PREDOCTORAL RESEARCHERS	MALE	FEMALE	SPANISH	NON SPANISH
87	63	24	72	15

By gender: 72.41% Male 27.59% Female

IFIMAC Postdoctoral

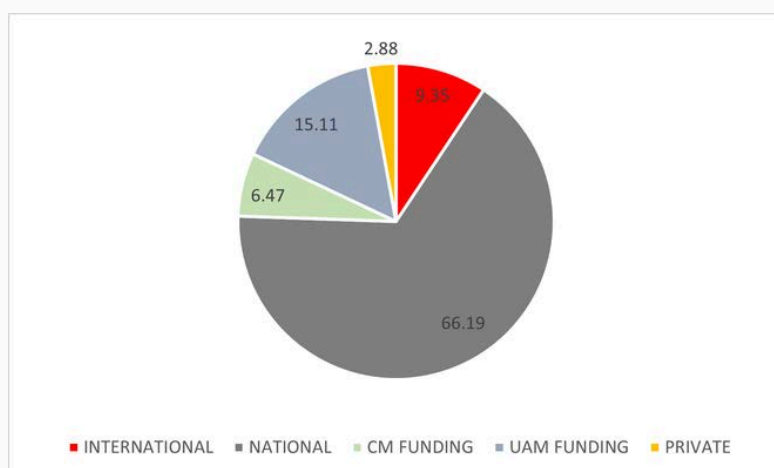
N° POSTDOCTORAL RESEARCHERS	MALE	FEMALE	SPANISH	NON SPANISH
31	25	6	9	22

By gender: 81% Male 19% Female

COMPETITIVE PROJECTS

N° ACTIVE PROJECTS	INTERNATIONAL	NATIONAL	CM FUNDING	UAM FUNDING	PRIVATE
139	13	92	9	21	4
NEW 25 new projects	1	13	4	5	2

97.12% are **public** projects and 2.88% are **private** projects.





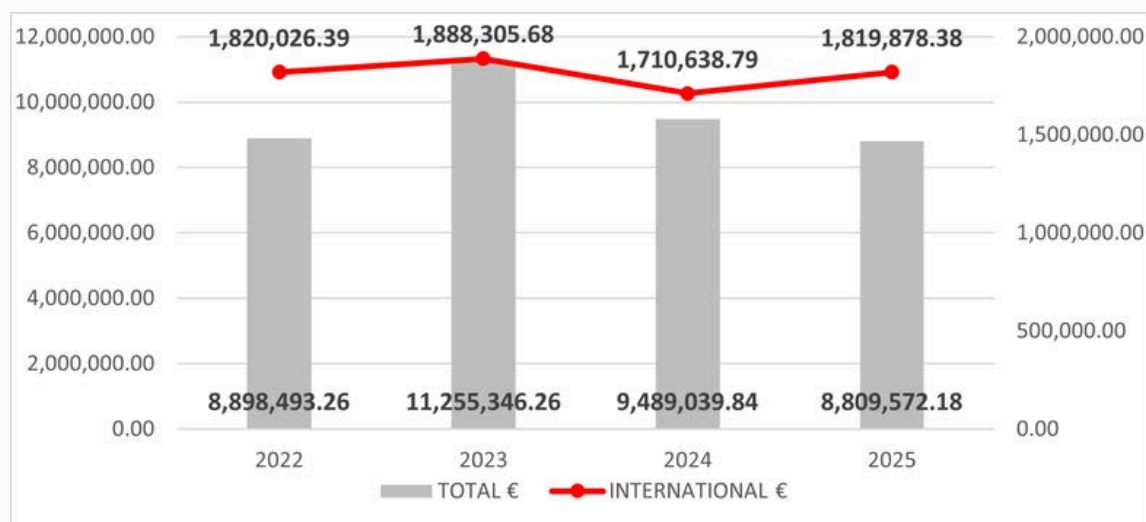
TOTAL ERC	3
FUNDING	999,680.38 EUR
ERC MALE (2)	699,513.62 EUR
ERC FEMALE (1)	300,166.76 EUR
NEW ERC (Male)	1

Funding

102,436.88 € by IFIMAC researcher

N° ACTIVE PROJECTS	INTER-NATIONAL	NATIONAL	CM FUNDING	UAM FUNDING	PRIVATE	TOTAL ANNUAL FUNDING
139	1,819,878.38 EUR	5,266,154.50 EUR	1,322,798.49 EUR	209,002.65 EUR	191,738.16 EUR	8,809,572.18 EUR

Evolution by Professional Category (2013-2025)

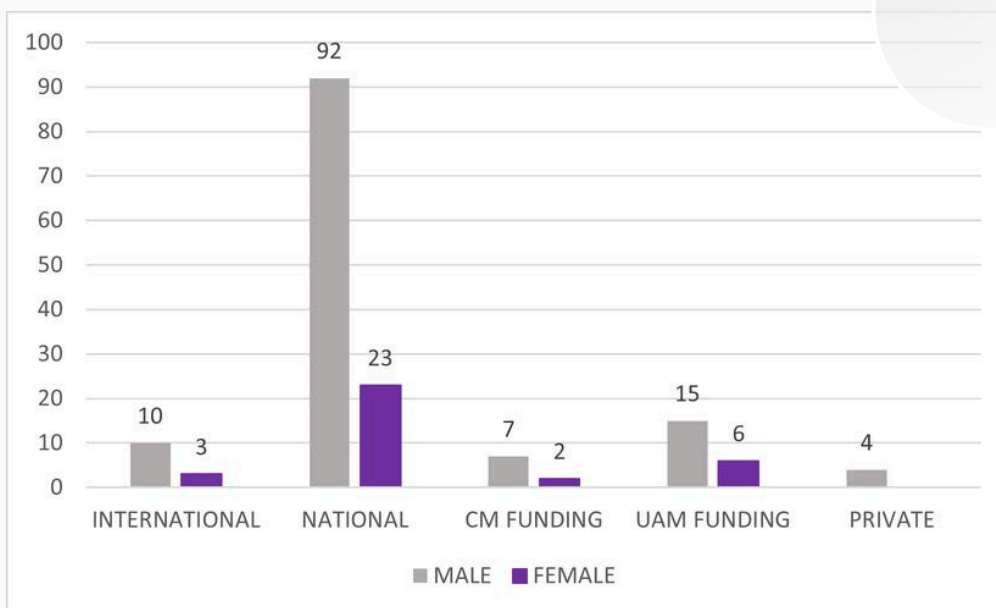


Competitive projects by gender and funding

78% competitive projects lead by male.

22% competitive project lead by female.

23 competitive projects with two PI (male and female) and 3 lead by two female.



These are people who participate in the projects and therefore contribute to more than 139 active projects.

GENDER	INTER-NATIONAL	NATIONAL	CM FUNDING	UAM FUNDING	PRIVATE	TOTAL ANNUAL FUNDING
MALE	1,167,188.79 EUR	4,553,762.11 EUR	1,266,341.15 EUR	158,505.30 EUR	191,738.16 EUR	7,337,535.52 EUR
FEMALE	652,689.59 EUR	712,392.39 EUR	56,457.33 EUR	50,497.35 EUR	0.00 EUR	1,472,036.65 EUR

77,475.61€ by IFIMAC woman researcher.
109,515.46€ by IFIMAC man researcher.

SCIENTIFIC PRODUCTION

199 Docs (WoS & Scopus)
96.48% citable items
76.38% OA

2.31 papers by IFIMAC researcher.

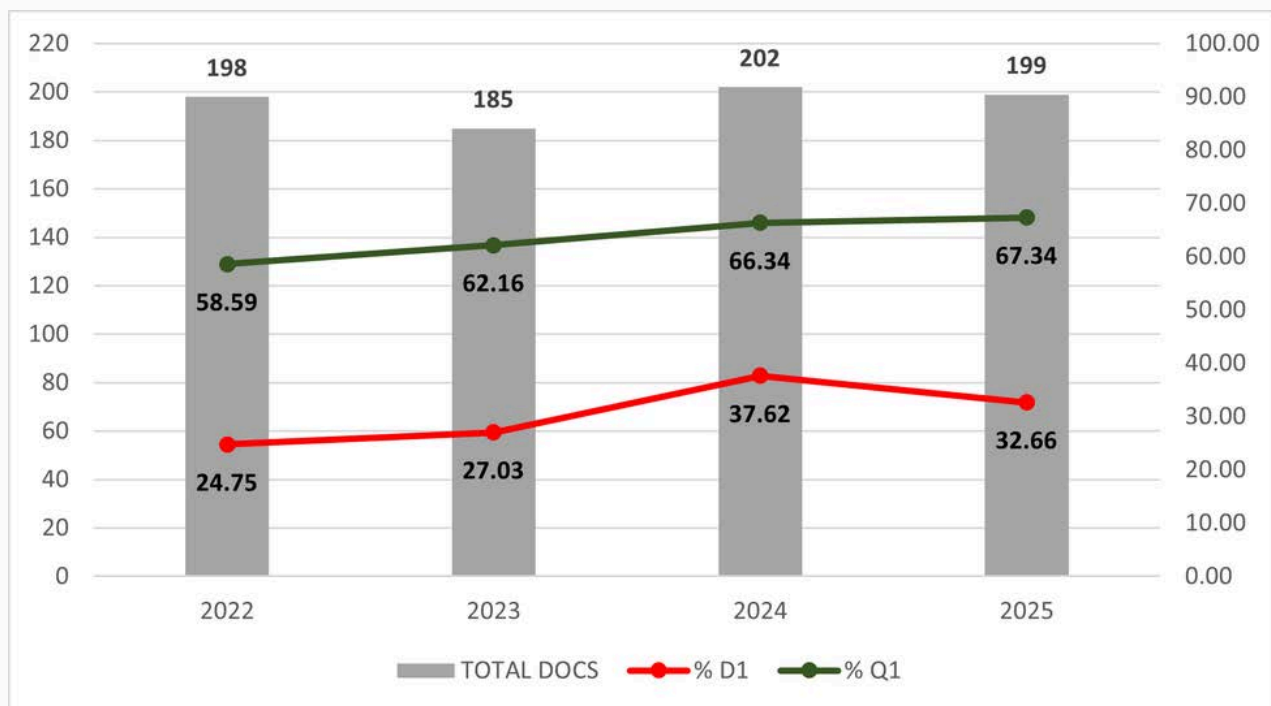


Q1 (JCR)	D1 (JCR)
133	64

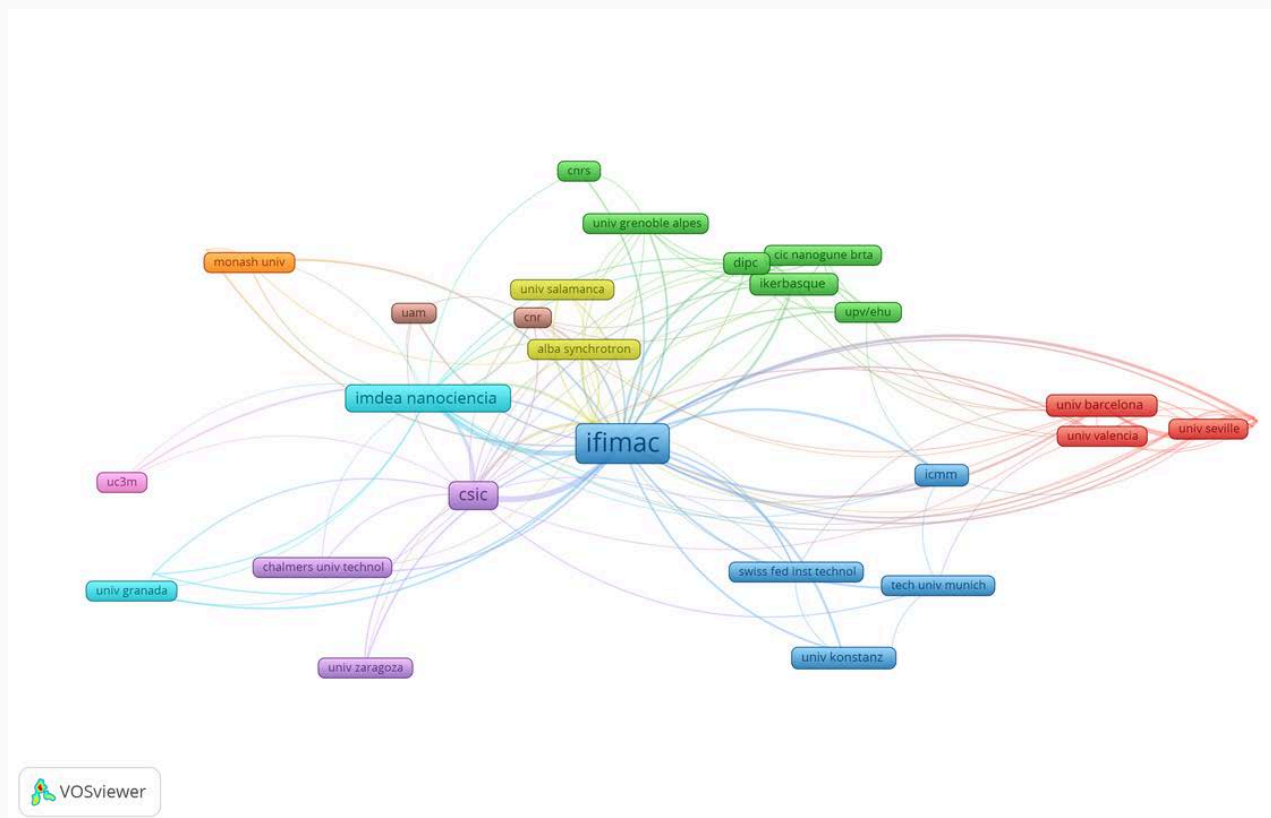


Q1 (SJR)	D1 (SJR)
176	112

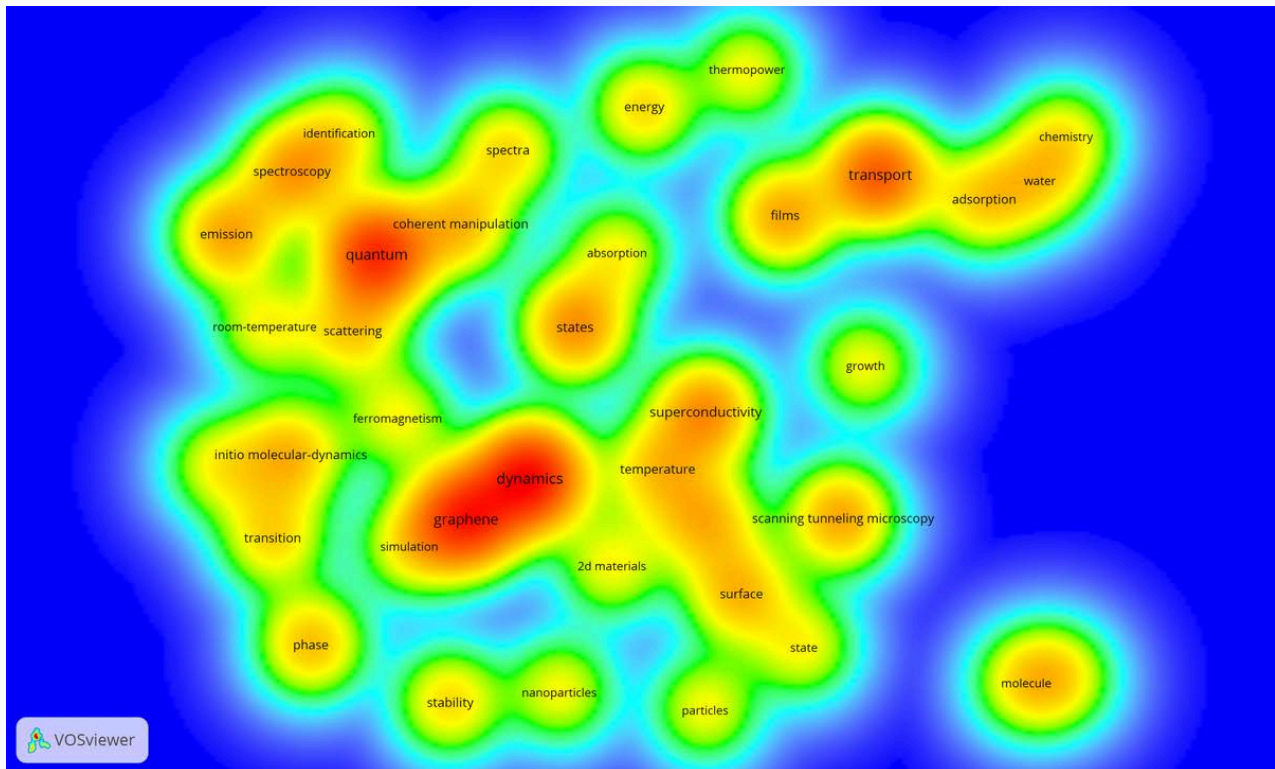
Evolution IFIMAC's Scientific production 2022-2025 (Source: WoS)



IFIMAC's scientific collaboration. (Source: WoS)



IFIMAC's scientific production by keywords. (Source: WoS)

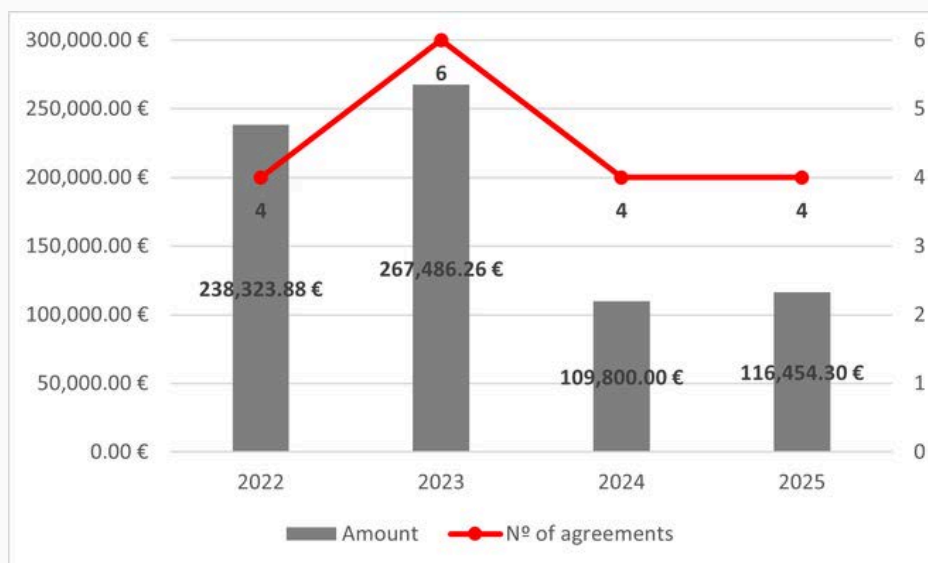


TRANSFER ACTIVITIES

Patent applications: 3

UAM Emprrende activities 2022-2025: 9

Art 60 2022-2025: Total of agreements: 18 Total amount: 732,064.44€



Knowledge-Based Companies: 1

TRAINING ACTIVITIES

Doctoral thesis defended: 38

By gender: 94.74% Male 5.26% Female

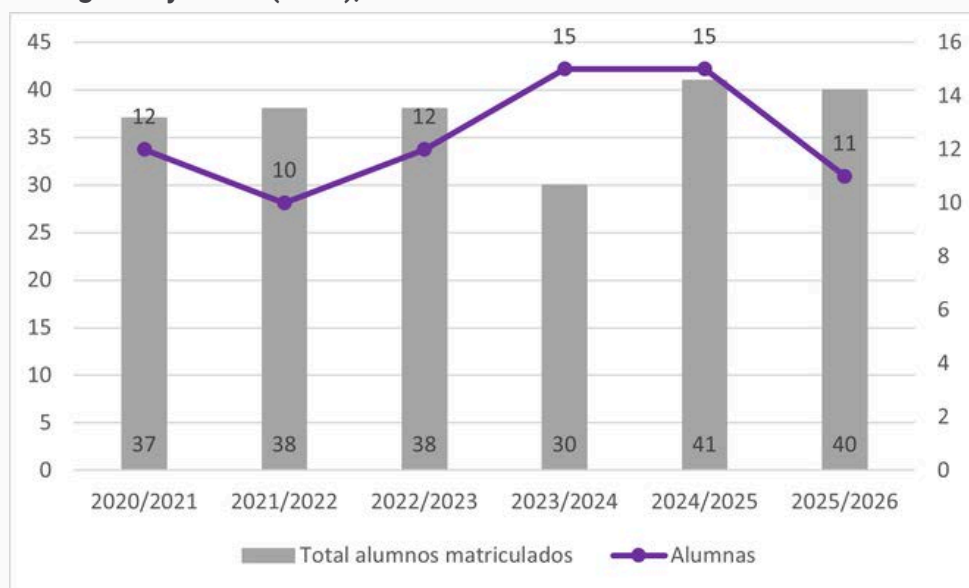
Predoctoral Fellowships Program of the Spanish AEI: 4 [1]

IFIMAC's Master Fellowships: 10

Research Awards for Physics Students: 2

IFIMAC Mentoring Program: 43 mentees and 41 mentors

Students in the master's degree in Condensed Matter Physics and Biological Systems (UAM), 2020/21–2025/26



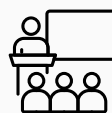
OTHER RESEARCH AND OUTREACH ACTIVITIES



Awards
3



Organization of congresses
20



Invited lectures
67



Sponsorships
7



IFIMAC Colloquium
7

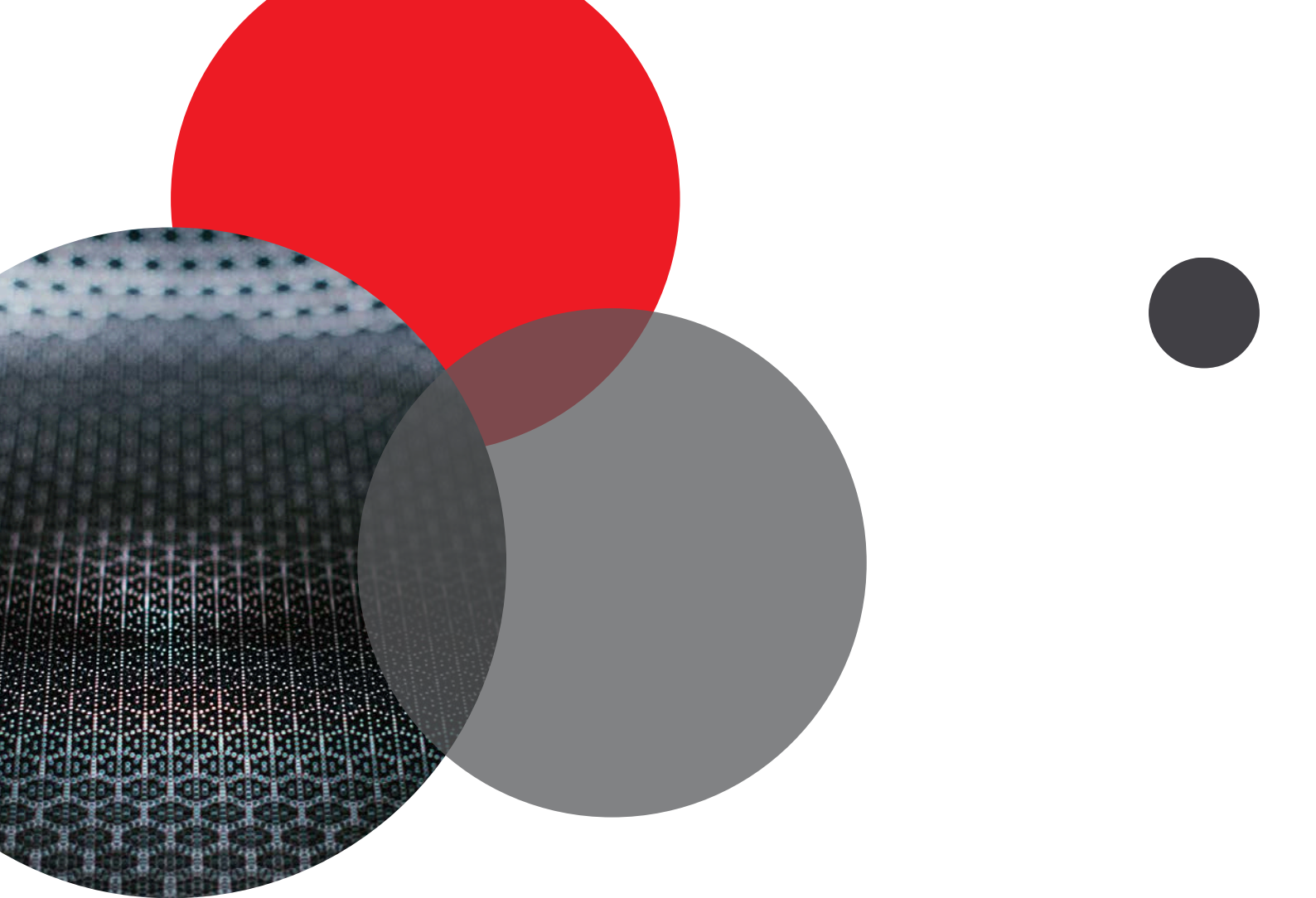


IFIMAC Seminars
29



Outreach activities
12

[1] All IFIMAC predoctoral students benefit from financial support for their doctoral thesis. In this item, we only highlight the FPI grants linked to the María de Maeztu Unit of Excellence.



4

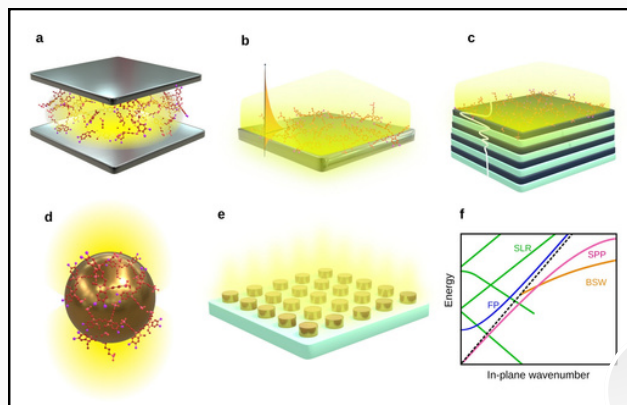
RESEARCH

RESEARCH HIGHLIGHTS

Cavity-enhanced energy transport in molecular systems. *Nature Materials* 24, 344 (2025). DOI: 10.1038/s41563-024-01962-5

Gal Sandik, **Johannes Feist**, **Francisco J. García-Vidal** & Tal Schwartz

Molecules are the building blocks of all of nature's functional components, serving as the machinery that captures, stores and releases energy or converts it into useful work. However, molecules interact with each other over extremely short distances, which hinders the spread of energy across molecular systems. Conversely, photons are inert, but they are fast and can traverse large distances very efficiently. Molecules are the building



blocks of all of nature's functional components, serving as the machinery that captures, stores and releases energy or converts it into useful work. However, molecules interact with each other over extremely short distances, which hinders the spread of energy across molecular systems. Conversely, photons are inert, but they are fast and can traverse large distances very efficiently. Using optical resonators, these distinct entities can be mixed with each other, opening a path to new architectures that benefit from both the active nature of molecules and the long-range transport obtained by the coupling with light. In this Review, we present the physics underlying the enhancement of energy transfer and energy transport in molecular systems, and highlight the experimental and theoretical advances in this field over the past decade. Finally, we identify several key questions and theoretical challenges that remain to be resolved via future research.

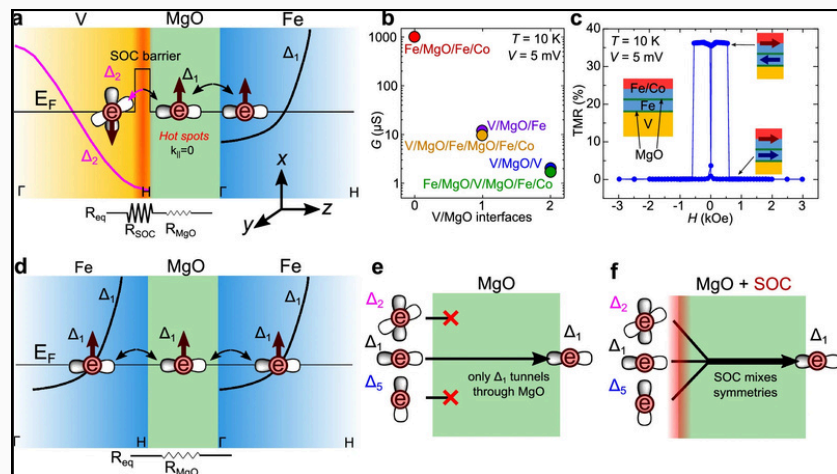
Giant shot noise in superconductor/ferromagnet junctions with orbital-symmetry-controlled spin-orbit coupling. *Nat Commun* 16, 9524 (2025). DOI: 10.1038/s41467-025-64493-w

César González-Ruano, Chenghao Shen, **Pablo Tuero**, Coriolan Tiusan, Yuan Lu, Jong E. Han, Igor Žutić & **Farkhad G. Aliev**

Researchers from the MAGNETRANS-UAM group, working with collaborators at the University at Buffalo (SUNY, USA) and in University of Lorraine, France, have discovered an unusually large shot noise in epitaxial superconducting V/MgO/Fe junctions. The origin of this giant noise is a peculiar realization of a superconducting proximity effect, where a simple superconductor influences its neighbors.

The measurements reveal largely unexplored implications of orbital-symmetry-controlled proximity effects. The importance of orbital symmetries and the accompanying spin-orbit coupling is manifested by an unexpected emergence of another superconducting region strikingly different from the parent superconductor.

Unlike vanadium's common spin-singlet superconductivity, the broken inversion symmetry in V/MgO/Fe junctions and the resulting interfacial spin-orbit coupling leads to the formation of spin-triplet superconductivity across the ferromagnetic iron. The authors show that the enhanced shot noise, known from Josephson junctions with two superconductors, could be measured even in a single superconductor.



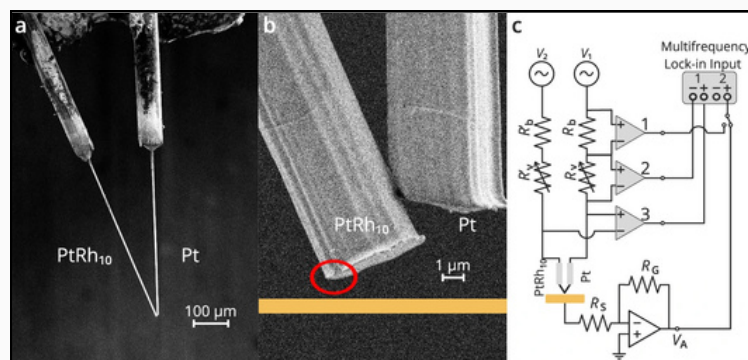
This discovery, recently published in Nature Communications, motivates revisiting how the spin-orbit coupling and superconducting proximity effects can transform many materials.

Heat transfer in metallic nanometre-sized gaps. Nat Commun 16, 7342 (2025). DOI: 10.1038/s41467-025-62672-3

Rubén López-Nebreda, Oscar Mateos-Lopez, Pablo Martinez Martinez, Juan José García-Esteban, Ángel Ibabe, Nuria Roca-Giménez, Pilar Segovia, Enrique García Michel, Eduardo J. H. Lee, Jose Guilherme Vilhena, Juan Carlos Cuevas & Nicolás Agraït

Heat transfer in nanoscale gaps is of key relevance for a variety of technologies. Recent experiments have reported contradictory results shedding doubts about the fundamental mechanisms for heat exchange when bodies are separated by nanometre-sized gaps. Here, we aim at resolving this controversy by measuring the thermal conductance of gold atomic-sized contacts with a custom-designed scanning tunnelling microscope that incorporates a novel thermal probe.

This technique enables the measurement of thermal and electrical conductance in different transport regimes. When the electrodes are separated by a nanometre-sized gap, we observe thermal signals whose magnitude and gap size dependence cannot be explained with standard heat transfer mechanisms.



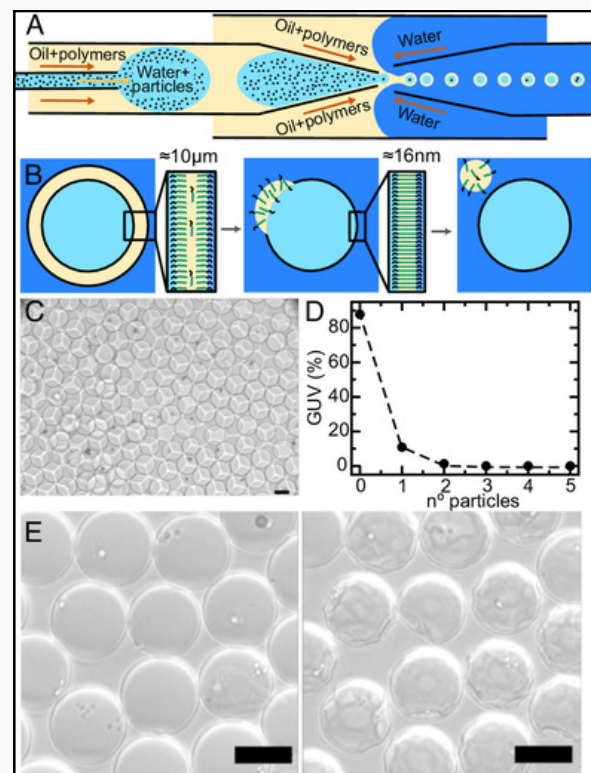
With the help of non-equilibrium molecular dynamic simulations, we elucidate that these anomalous signals are due to the thermal conduction through water menisci that form between tip and sample under customary operation conditions. Our work resolves this fundamental puzzle and suggests avenues for the investigation of heat conduction in atomic and molecular junctions.

From confined rotational flows to surface-enabled motion, Proc. Natl. Acad. Sci. U.S.A. 122 (13) e2424236122 (2025) DOI: 10.1073/pnas.2424236122

Paula Magrinya, Pablo Palacios-Alonso, Pablo Llombart, Rafael Delgado-Buscalioni, Alfredo Alexander-Katz, Laura R. Arriaga and Juan L. Aragonés.

Friction forces are essential for cell movement, yet they also trigger numerous active cellular responses, complicating their measurement *in vivo*. Here, we introduce a synthetic model designed to measure friction forces between biomimetic membranes and substrates.

The model consists of a vesicle with precisely controlled properties, fabricated via microfluidics, encapsulating a single ferromagnetic particle that is magnetically driven to rotate. The rotation of the particle generates a confined rotational flow, setting the vesicle membrane into motion. By adjusting the magnetic field frequency and vesicle size, the rotation frequency of the vesicle can be finely controlled, resulting in a rolling vesicle that functions as an effective tribological tool across a wide frequency range. At low frequencies, molecular contact between the membrane and substrate dominates frictional interactions, which enables determination of the contact friction coefficient. At higher frequencies, lubrication becomes predominant, causing the vesicles to slip rather than roll. Adjusting membrane fluidity and incorporating specific ligand–receptor interactions within this model will enable detailed studies of frictional forces in more complex biomimetic systems, providing key insights into the mechanisms of cell movement and mechanotransduction.

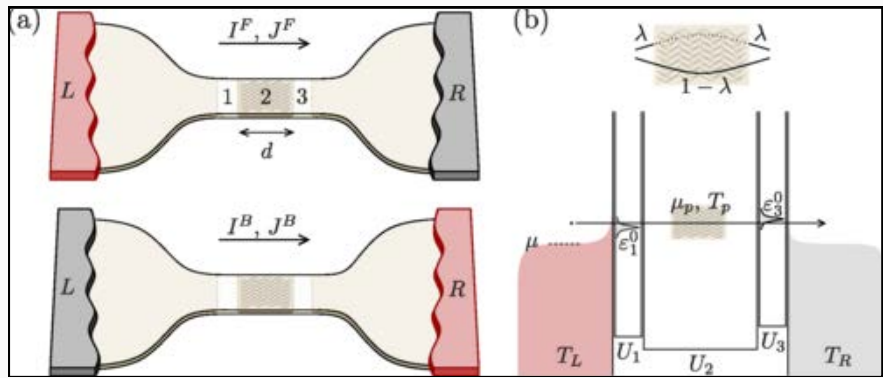


Scattering Theory of Thermal and Bipolar Thermoelectric Diodes Phys. Rev. Lett. 134, 186301 (2025). DOI: 10.1103/PhysRevLett.134.186301

José Balduque and Rafael Sánchez

Linear conductors are reciprocal: reversing the nonequilibrium forces they are coupled to (e.g., temperature differences) also reverses the response currents. Devices working as thermal diodes need to break this constriction by using nonlinearities, so the reversed

currents are asymmetric (nonreciprocal) when the reservoir temperatures are exchanged. In this work, we describe the onset of interaction-induced nonlinearities in a quantum conductor, identifying thermalization and charging effects as



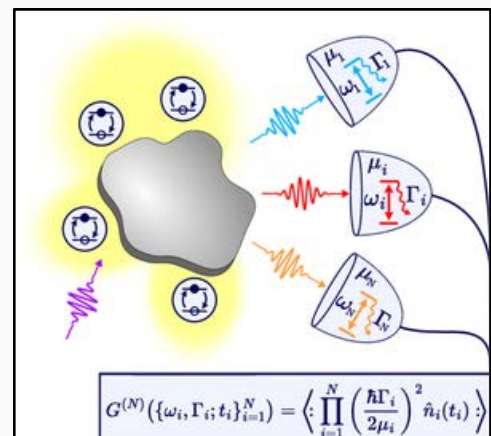
responsible for measurable thermal and thermoelectric diodes. Furthermore, we show that realistic quantum-coherent conductors manifest what we name antireciprocal responses, with charge currents being unaffected by the reversal of temperatures.

Spatially Resolved Photon Statistics of General Nanophotonic Systems. PRX Quantum 6, 020361. DOI:10.1103/z3cr-l7pw

Maksim Lednev, Diego Fernández de la Pradilla, Frieder Lindel, Esteban Moreno, Francisco J. García-Vidal and Johannes Feist.

Many quantum technologies require light sources with intrinsically quantum properties, in which the photons that are emitted are correlated and entangled with each other. Such quantum light sources often are inefficient and/or too large for integration in compact devices. A promising route to solve these issues are nanophotonic setups which offer subwavelength confinement of light, which dramatically enhances light-matter interactions and reduces system sizes, opening the door to the efficient production of highly nonclassical photon states. However, the complex structure of the electromagnetic field in such systems makes it challenging to theoretically access and predict the quantum state of the photons, which is a prerequisite for the efficient design of nanophotonic quantum light sources. In research published in PRX Quantum, we introduce a new theoretical framework that overcomes this challenge. To probe the photons at the positions of interest, we include auxiliary two-level systems that act as field detectors, sensing the electric field at their respective locations. To make the problem computationally tractable, we map the complex electromagnetic field to an equivalent network of a few lossy, interacting modes. This approach enables the use of standard quantum optical tools to fully characterize the quantum correlations of the emitted photons in space, frequency, time and polarization.

We apply our framework to a hybrid system consisting of quantum emitters and metallic nanoparticles and show that even in these simplified scenarios, the emitted light displays quantum features that depend nontrivially on the position at which it is detected. The presented techniques and obtained results pave the way to a deeper understanding of light-matter interactions at the nanoscale and open up possibilities for designing novel sources of nonclassical light.



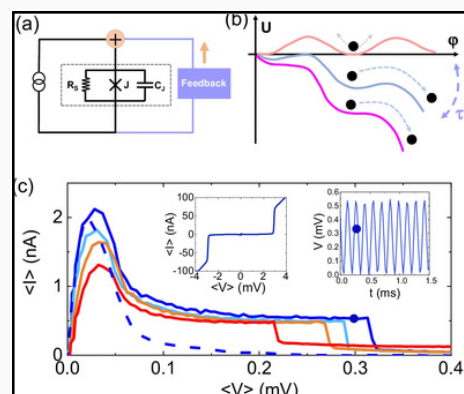
$$G^{(N)}(\{\omega_i, \Gamma_i; t_i\}_{i=1}^N) = \left\langle \prod_{i=1}^N \left(\frac{\hbar \Gamma_i}{2\mu_i} \right)^2 \hat{n}_i(t_i) \right\rangle$$

The feedback driven atomic scale Josephson microscope. Nat Commun 16, 5843 (2025). DOI :10.1038/s41467-025-60569-9

Samuel D. Escribano, Víctor Barrena, David Perconte, Jose Antonio Moreno, Marta Fernández Lomana, Miguel Águeda, Edwin Herrera, Beilun Wu, Jose Gabriel Rodrigo, Elsa Prada, Isabel Guillamón, Alfredo Levy Yeyati & Hermann Suderow.

The ultimate spatial limit to establish a Josephson coupling between two superconducting electrodes is an atomic-scale junction. The Josephson effect in such ultrasmall junctions has been used to unveil new switching dynamics, study coupling close to superconducting bound states or reveal non-reciprocal effects. However, the Josephson coupling is weak and the sensitivity to temperature reduces the Cooper pair current magnitude. Here we show that a feedback element induces a time-dependent bistable regime which consists of spontaneous periodic oscillations between two different Cooper pair tunneling states (corresponding to the DC and AC Josephson regimes respectively). The amplitude of the time-averaged current within the bistable regime is almost independent of temperature.

By tracing the periodic oscillations in the new bistable regime as a function of the position in a Scanning Tunneling Microscope, we obtain atomic scale maps of the critical current in 2H-NbSe₂ and find spatial modulations due to a pair density wave. Our results fundamentally improve our understanding of atomic size Josephson junctions including a feedback element in the circuit and provide a promising new route to study superconducting materials through atomic scale maps of the Josephson coupling.

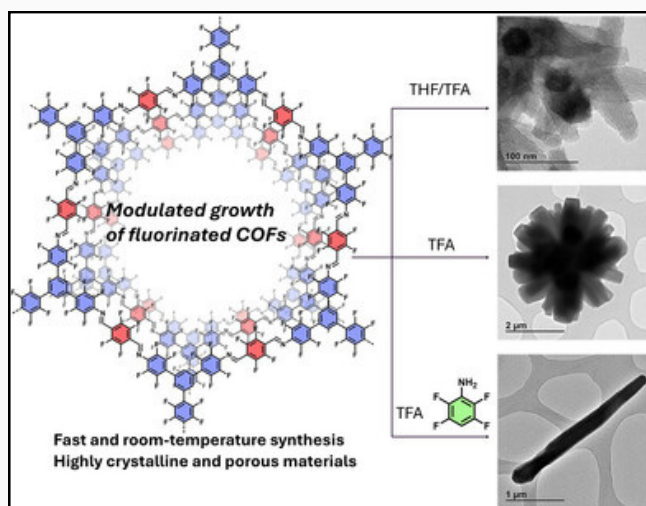


Unconventional Fast Room Temperature Synthesis of Covalent Organic Framework Single Crystals Unveiling Precise Structural Insights. Angew. Chem.-Int. Edit., 64, 37 (2025) DOI: 10.1002/anie.202510312.

Miguel Jiménez-Duro, Dr. Marcos Martínez-Fernández, Dr. Jorge J. Cabrera-Trujillo, Eva Osuna, Miguel Fernández-Ramos Humanes, Cristina Gómez-Navarro, Julio Gómez-Herrero, Félix Zamora & José L. Segura.

Two-dimensional covalent organic frameworks (COFs) are a special kind of crystalline polymers produced by the polycondensation reaction of organic linkers. However, the polymerization is often uncontrolled and conventionally yields polycrystalline powders. For that reason, the development of new methods to obtain single-crystalline COFs is an urgent need. Herein, we report a modulated, room-temperature, and fast synthesis of a highly fluorinated COF where the reaction conditions were systematically analyzed to yield single-crystalline rods of around three microns. The increase in crystal size enabled the analysis of precise structural features such as the mechanical properties or the different aggregation states of the bidimensional framework.

In addition, the reaction mechanism was computationally elucidated, and the roles of the modulator agent and the catalyst were analyzed, confirming the critical importance of trifluoroacetic acid and 2,3,5,6-tetrafluoroaniline in modulating Schiff base bond formation and, consequently, the crystallinity of the resulting COF. This study reveals new insights into the crystallization of high-quality 2D COFs.



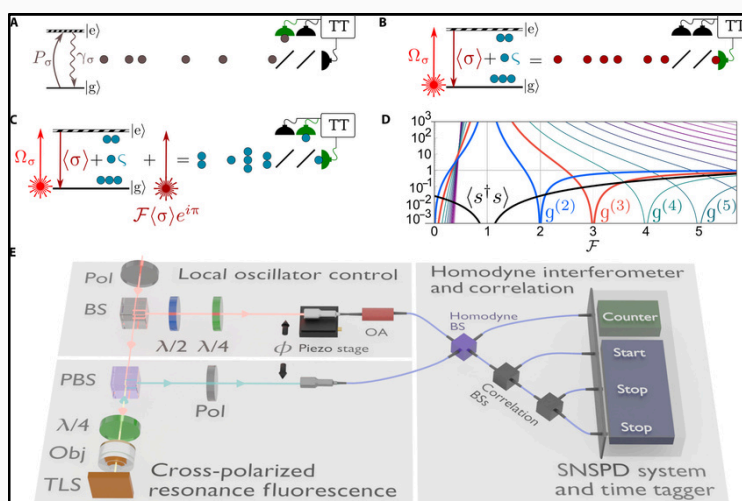
Unlocking multiphoton emission from a single-photon source through mean-field engineering.

Science Advances 11, 3395 (2025). DOI: 10.1126/sciadv.adw3395

Sang Kyu Kim, Eduardo Zubizarreta Casalengua, Katarina Boos, Friedrich Sbresny, Carolin Calcagno, Hubert Riedl, Jonathan J. Finley, **Carlos Antón-Solanas**, Fabrice P. Laussy, Kai Müller, Lukas Hanschke & **Elena del Valle**

A collaboration between researchers at the Technical University of Munich, Universidad Autónoma de Madrid, and ICMM-CSIC has demonstrated a groundbreaking way to turn a single-photon emitter into a controlled multiphoton source. The work, published in Science Advances (Kim et al., 2025), reveals how subtle control over a quantum emitter's mean electromagnetic field can unlock new regimes of light emission once thought inaccessible.

Traditionally, single-photon sources are engineered to avoid simultaneous emission of multiple photons — a cornerstone for quantum communication and computing. However, the study shows that in coherently driven systems, multiphoton processes are not accidental but intrinsic to the underlying quantum dynamics. By using a finely tuned homodyne setup, the team introduced an external coherent field to interfere with the emitter's own mean field.



This “mean-field engineering” allowed them to switch between single-, two-, and even three-photon emission with remarkable precision. “Our results show that even in the simplest quantum system — a two-level emitter — multiphoton correlations can be revealed and controlled,” explains the leading author Elena del Valle (UAM). “It’s a striking reminder that quantum fluctuations play a key role, even when they seem negligible.” This discovery opens new avenues for photonic quantum technologies, including deterministic generation of multiphoton states, photon sorting, and precision control in quantum networks

YOUNG RESEARCHERS

One of the objectives of the recently approved María de Maeztu Unit of Excellence is to recruit up to three outstanding young international researchers for a period of three years, together with additional funding to support the development of their research groups. In June 2024, the selection process was launched with the aim of hiring these researchers in the first quarter of 2025. The call was resolved in November 2024 with the selection of two candidates; one declined the offer, and the other, Miguel Bello, joined IFIMAC in 2025. In 2025, a new call was launched and was resolved with the selection of two candidates; one declined the offer, and the other, Edouardos Loukopoulos, joined IFIMAC in November 2025.

The vacancies were published on the IFIMAC website, Nature Careers, and EurAxess.



RESEARCH POSITIONS FOR YOUNG SCIENTISTS

The Condensed Matter Physics Center (IFIMAC) invites applications for three 3-years research positions for young scientists aiming to start and lead an independent research group.

IFIMAC is a "María de Maeztu" Excellence Research Unit since 2014, located in the campus of the Universidad Autónoma de Madrid (UAM) pursuing cutting-edge research and scientific excellence at the crossroads of Physics, Chemistry, Materials Science and Biology, fostering a truly multidisciplinary approach. Research performed in IFIMAC has gained world reputation in the following areas: Advanced Materials, First Principles Simulations and Modelling, Nanophysics, Nano and Quantum Optics and Soft Condensed Matter and Biophysics.

More information on IFIMAC research can be found in its webpage: www.ifimac.uam.es.

We are looking for ambitious young scientists with an innovative research program at the forefront of any branch within Condensed Matter Physics. The scope of this opening is similar to that of the Ramón y Cajal grant scheme of the Spanish Government. We will also provide the position with research funds of up to 200k Euros for the whole period. Applications with programs addressing topics that complement IFIMAC existing core strengths are particularly welcome. Applicants are expected to hold an outstanding record of research achievements and publications in top-quality journals. The key criteria for appointment are potential for original contributions and major commitment to frontier research at the highest-international level.

Applicants are requested to send a statement of interest, a research plan, a complete curriculum vitae (including a list of publications), and the contact information for at least three references. All this information should be sent via e-mail to ifimac@uam.es.

Deadline for applications: September 15th 2024.

Contact information: Rubén Pérez
IFIMAC Director
E-mail: director.ifimac@uam.es



More information 2024 call:

<https://www.ifimac.uam.es/job-s-opportunities/ifimac-research-positions-for-experimental-young-scientists/>



More information 2025 call:

<https://www.ifimac.uam.es/job-s-opportunities/ifimac-research-positions-for-experimental-young-scientists/>



RESEARCH POSITION FOR EXPERIMENTAL YOUNG SCIENTISTS

The Condensed Matter Physics Center (IFIMAC) invites applications for one 3-year research position for young scientists with an experimental profile aiming to start and lead an independent research group.

IFIMAC is a "María de Maeztu" Excellence Research Unit since 2014, located in the campus of the Universidad Autónoma de Madrid (UAM) pursuing cutting-edge research and scientific excellence at the crossroads of Physics, Chemistry, Materials Science and Biology, fostering a truly multidisciplinary approach. Research performed in IFIMAC has gained world reputation in the following areas: Advanced Materials, First Principles Simulations and Modelling, Nanophysics, Nano and Quantum Optics and Soft Condensed Matter and Biophysics.

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Applicants are requested to send a statement of interest, a research plan, a complete curriculum vitae (including a list of publications), and the contact information for at least three references. All this information should be sent via e-mail to ifimac@uam.es.

Deadline for applications: March 15th 2025.

Contact information: Rubén Pérez
IFIMAC Director
E-mail: director.ifimac@uam.es



IFIMAC COLLOQUIA SERIES AND SEMINARS

IFIMAC continued in 2025 with the IFIMAC Colloquia Series, complementing our existing programs, including the ongoing IFIMAC Seminars. In 2025, 7 IFIMAC Colloquia Series and 29 IFIMAC Seminars were held.

IFIMAC Colloquia Series



IfiMAC Colloquium

William D. Oliver

“

Friday
Jan 24, 2025
15h, Module 0
Conference Room
Coffee served
at 14:30h

Emulating the Bose-Hubbard Model with Arrays of Superconducting Qubits

UAM | IFIMAC | INSTITUTO DE INVESTIGACIONES CIENTÍFICAS DE BARCELONA | IIB | IIB | IIB



William D. Oliver, Massachusetts Institute of Technology, USA.

Emulating the Bose-Hubbard Model with Arrays of Superconducting Qubits

https://www.youtube.com/watch?v=XQtaE_KuSy4



IfiMAC Colloquium

Jordi Gracia-Ojalvo

“

Friday
Feb 7, 2025
12h, Building C
at EPS "Sala de grados"
Coffee served
at 11:30h

Bacterial biofilms as minimal models of living matter

UAM | IFIMAC | INSTITUTO DE INVESTIGACIONES CIENTÍFICAS DE BARCELONA | IIB | IIB | IIB



Jordi Garcia-Ojalvo, Universitat Pompeu Fabra, Barcelona, Spain.

Bacterial Biofilms as Minimal Models of Living Matter

<https://youtu.be/qWsLkesU7NU>



IfiMAC Colloquium

Raffaele Mezzenga

“

Friday
March 14, 2025
12h, Building C
at EPS, Sala de grados
Coffee served
at 11:30h

LLPS vs LLCPS: lesson learned from amyloid and nanocellulose fibrils

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Raffaele Mezzenga, ETH Zurich, Switzerland.

LLPS vs LLCPS: lesson learned from amyloid and nanocellulose fibrils

<https://www.youtube.com/watch?v=x0zPfMG7kts>



Jérôme Faist, ETH Zurich, Switzerland. Max Planck Institute for the Science of Light (Germany)

Controlling Solid State Phases Through Vacuum Field

<https://youtu.be/HhykpYJpytQ>



Päivi Törmä, Aalto University, Finland

Quantum Geometry in flat-band superconductivity, Bose-Einstein condensation, and nanophotonics

<https://youtu.be/PWhbvp4xc-I>



Jaroslav Fabian, Department of Physics, University of Regensburg, Germany

Spirotronics with 2D Materials

<https://youtu.be/umom6czBYN0>



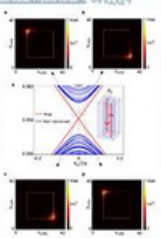
Vidya Madhava, University of Illinois, Urbana Champaign (USA)

Ultrafast measurements of massive phase oscillations of a condensate with a laser coupled STM

<https://www.youtube.com/watch?v=r7aZxHgWwxM>

IFIMAC Seminars



3D topological photonics: 3D Chern photonic insulators and electromagnetic axions

Aitzol García-Etxarri

Donostia International Physics Center and IKERBASQUE, Basque Foundation for Science, Spain

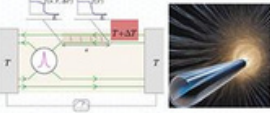
Monday, January 13, (2025), 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Aitzol García-Etxarri: 3D topological photonics: 3D Chern photonic insulators and electromagnetic axions
<https://www.ifimac.uam.es/ifimac-seminars/3d-topological-photonics-3d-chern-photonic-insulators-and-electromagnetic-axions/>



Nonlocal and local thermoelectricity in topological nanosystems

Alessandro Braggio

Scuola Normale Superiore (Pisa, IT)

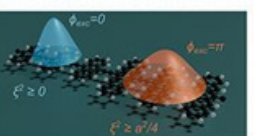
Thursday, Jan 16, (2025), 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Alessandro Braggio: Nonlocal and Local Thermoelectricity in Topological Nanosystems
<https://www.ifimac.uam.es/ifimac-seminars/nonlocal-and-local-thermoelectricity-in-topological-nanosystems/>



Modelling excitons: from vibrational coupling to topology

Bartomeu Monserrat

University of Cambridge

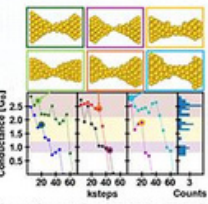
Thursday, 23 January (2025) 12:00h

Department of Condensed Matter Physics, Faculty of Sciences, Module 3, Seminar Room (5th Floor).



Bartomeu Monserrat: Modelling excitons: from vibrational coupling to topology
<https://www.ifimac.uam.es/ifimac-seminars/modelling-excitons-from-vibrational-coupling-to-topology/>



Exploration of Three-Atom-Thick Structures and Advances in Molecular Electronics Techniques at Room Temperature

Carlos Sabater

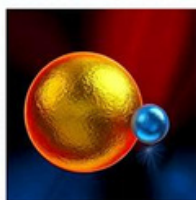
Universidad de Alicante

Thursday, Feb 6, (2025), 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Carlos Sabater: Exploration of Three-Atom-Thick Structures and Advances in Molecular Electronics Techniques at Room Temperature
<https://www.ifimac.uam.es/ifimac-seminars/exploration-of-three-atom-thick-structures-and-advances-in-molecular-electronics-techniques-at-room-temperature/>



Thursday, Feb 13, (2025), 12:00h

Department of Physics and
Materials Science, Faculty of
Sciences, Module 4, Seminar Room.

Controlling light-matter interactions with plasmonic and dielectric architectures

Christos Tserkezis

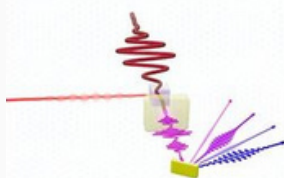
POLIMA—Center for Polariton-driven Light-
Matter Interactions, University of Southern
Denmark



Christos Tserkezis: Controlling light-matter interactions with plasmonic and dielectric architectures

POLIMA University of Southern
Denmark (Denmark)

<https://www.ifimac.uam.es/ifimac-seminars/controlling-light-matter-interactions-with-plasmonic-and-dielectric-architectures/>



Wednesday, Feb 19, (2025), 15:00h

Department of Theoretical Condensed
Matter Physics, Faculty of Sciences,
Module 5, Seminar Room (5th floor).

Strong-fields and photons in solids, from classical to quantum light

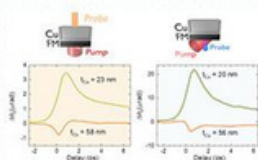
David N. Porschke

Joint Attosecond Science Laboratory,
University of Ottawa and National Research
Council of Canada



David N. Porschke: Strong-fields and photons in solids, from classical to quantum light

<https://www.ifimac.uam.es/ifimac-seminars/strong-fields-and-photons-in-solids-from-classical-to-quantum-light/>



Friday, March 21, (2025), 13:00h

Department of Theoretical Condensed
Matter Physics, Faculty of Sciences,
Module 5, Seminar Room (5th floor).

Disentangling the ultra-fast demagnetization and spin accumulation in magneto- optical detection

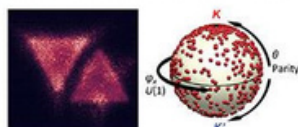
Alberto Anadón

Université de Lorraine, CNRS, Nancy, France



Alberto Anadón: Disentangling the ultra-fast demagnetization and spin accumulation in magneto-optical detection

<https://www.ifimac.uam.es/ifimac-seminars/disentangling-the-ultra-fast-demagnetization-and-spin-accumulation-in-magneto-optical-detection/>



Wednesday, April 9, (2025), 11:00h

Department of Theoretical Condensed
Matter Physics, Faculty of Sciences,
Module 5, Seminar Room (5th floor).

Spontaneous symmetry breaking and plasmon lattices with gain

Femius Koenderink

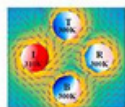
AMOLF, Amsterdam



Femius Koenderink: Spontaneous symmetry breaking and plasmon lattices with gain

<https://www.ifimac.uam.es/ifimac-seminars/spontaneous-symmetry-breaking-and-plasmon-lattices-with-gain/>

Near-field heat transfer close to the physical contact and in many-body systems



Philippe Ben-Abdallah

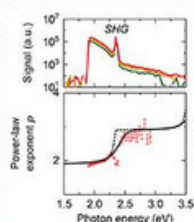
Laboratoire Charles Fabry, Institut d'Optique
(CNRS), Paris

Thursday, April 24, (2025), 12:00h

Department of Theoretical Condensed
Matter Physics, Faculty of Sciences, Module
5, Seminar Room (5th floor).



Philippe Ben-Abdallah: Near-field heat transfer close to the physical contact and in many-body systems
<https://www.ifimac.uam.es/ifimac-seminars/near-field-heat-transfer-close-to-the-physical-contact-and-in-many-body-systems/>



Photoluminescence from metals: Theory and experiments

Yonatan Sivan

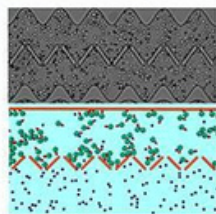
Ben Gurion, University of the Negev

Monday, May 19, (2025), 12:00h

Department of Theoretical Condensed
Matter Physics, Faculty of Sciences,
Module 5, Seminar Room (5th floor).



Yonatan Sivan: Photoluminescence from metals – theory and experiments
<https://www.ifimac.uam.es/ifimac-seminars/photoluminescence-from-metals-theory-and-experiments/>



Exploring active-passive mixtures at the microscale: simulations and experiments

Horacio Serna

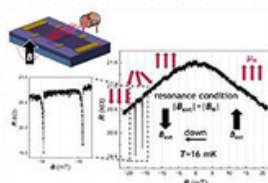
Marie Skłodowska-Curie Postdoctoral Fellow,
Universidad Complutense de Madrid,
Departamento de Estructura de la Materia, Física
Térmica y Electrónica.

Tuesday, May 20, (2025), 12:00h

Department of Theoretical
Condensed Matter Physics,
Faculty of Sciences, Module 5,
Seminar Room (5th floor).



Horacio Serna: Exploring active-passive mixtures at the microscale: simulations and experiments
<https://www.ifimac.uam.es/ifimac-seminars/exploring-active-passive-mixtures-at-the-microscale-simulations-and-experiments/>



Illuminating C13-based graphene: spin-orbit splitting, g-factor, and hyperfine coupling

Marta Prada

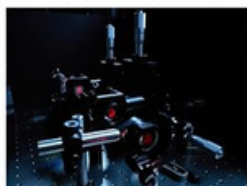
University of Hamburg

Thursday, May 22, (2025), 15:00h

Department of Theoretical
Condensed Matter Physics, Faculty of
Sciences, Module 5, Seminar Room
(5th floor).



Marta Prada: Illuminating C13-based graphene: spin-orbit splitting, g-factor, and hyperfine coupling
<https://www.ifimac.uam.es/ifimac-seminars/illuminating-c13-based-graphene-spin-orbit-splitting-g-factor-and-hyperfine-coupling/>



Monday, May 26, (2025), 14:30h

Department of Theoretical
Condensed Matter Physics,
Faculty of Sciences, Module 5,
Seminar Room (5th floor).

Coherent perfect absorption, transmission and emission of light

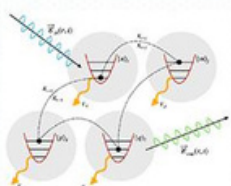
Stefan Rotter

Vienna University of Technology



**Stefan Rotter: Coherent perfect
absorption, transmission and
emission of light**

<https://www.ifimac.uam.es/ifimac-seminars/coherent-perfect-absorption-transmission-and-emission-of-light/>



Monday, June 2, (2025), 12:00h

Department of Theoretical Condensed
Matter Physics, Faculty of Sciences,
Module 5, Seminar Room (5th floor).

Quantum Dynamics of Polarizable Media: A Pseudo-Bosonic Approach to Dissipative Optics

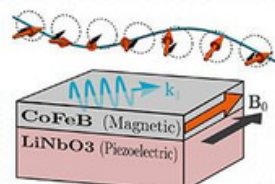
Frank E. Quintela Rodriguez

Scuola Normale Superiore, Pisa



**Frank E. Quintela Rodriguez:
Quantum Dynamics of Polarizable
Media: A Pseudo-Bosonic
Approach to Dissipative Optics**

<https://www.ifimac.uam.es/ifimac-seminars/quantum-dynamics-of-polarizable-media-a-pseudo-bosonic-approach-to-dissipative-optics/>



Tuesday, June 3, (2025), 12:00h

Department of Theoretical
Condensed Matter Physics,
Faculty of Sciences, Module 5,
Seminar Room (5th floor).

Shaking magnons: active and passive role of acoustic phonons in quantum magnonics

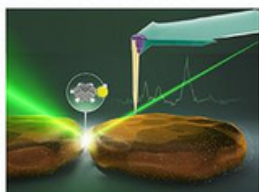
Carlos González Ballesteros

Institute for Theoretical Physics, Vienna
University of Technology (TU Wien)



**Carlos González Ballesteros:
Shaking magnons: active and
passive role of acoustic phonons in
quantum magnonics**

<https://www.ifimac.uam.es/ifimac-seminars/shaking-magnons-active-and-passive-role-of-acoustic-phonons-in-quantum-magnonics/>



Thursday, June 5, (2025), 12:00h

Department of Theoretical Condensed
Matter Physics, Faculty of Sciences,
Module 5, Seminar Room (5th floor).

Vibrational spectroscopy and optomechanical interactions with tip-enhanced nanocavities

Philippe Roelli

CIC nanoGUNE, San Sebastián, Spain

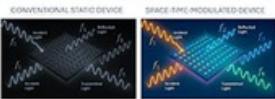


**Philippe Roelli: Vibrational
spectroscopy and optomechanical
interactions with tip-enhanced
nanocavities**

<https://www.ifimac.uam.es/ifimac-seminars/vibrational-spectroscopy-and-optomechanical-interactions-with-tip-enhanced-nanocavities/>

IfiMAC Seminar
Condensed Matter Physics Center

EXCELENCIA
MARIA
DE MAEZTU



Time Modulations to Enhance the Properties of Conventional RF and Photonic Devices

Antonio Alex Amor

RFCAS Group, Dpt. of Electronics and Communications Technology, Universidad Autónoma de Madrid.

Wednesday, June 25, (2025), 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Antonio Alex Amor: Time Modulations to Enhance the Properties of Conventional RF and Photonic Devices

<https://www.ifimac.uam.es/ifimac-seminars/time-modulations-to-enhance-the-properties-of-conventional-rf-and-photonic-devices/>

IfiMAC Seminar
Condensed Matter Physics Center

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DE MAEZTU



Spontaneous breaking of time-reversal symmetry and time-crystal states in chiral atomic systems

Mauro Antezza

Université de Montpellier

Tuesday, July 1, (2025), 12h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).

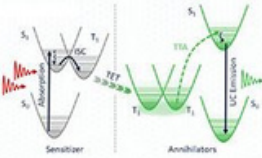


Mauro Antezza: Spontaneous breaking of time-reversal symmetry and time-crystal states in chiral atomic systems

<https://www.ifimac.uam.es/ifimac-seminars/spontaneous-breaking-of-time-reversal-symmetry-and-time-crystal-states-in-chiral-atomic-systems/>

IfiMAC Seminar
Condensed Matter Physics Center

EXCELENCIA
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DE MAEZTU



Design Rules for Triplet-Triplet Annihilation Upconversion Annihilators

Andrew Pun

University of California San Diego

Wednesday, July 2, (2025) 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).

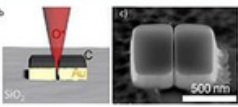


Andrew Pun: Design Rules for Triplet-Triplet Annihilation Upconversion Annihilators

<https://www.ifimac.uam.es/ifimac-seminars/design-rules-for-triplet-triplet-annihilation-upconversion-annihilators/>

IfiMAC Seminar
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DE MAEZTU



Plasmonic waveguides - a step closer to integrated nonlinear nanophotonics architectures

Stefano Palomba

University of Sydney, Australia

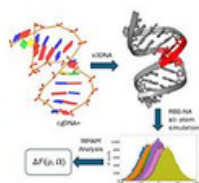
Monday, July 21, (2025), 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Stefano Palomba: Plasmonic waveguides - a step closer to integrated nonlinear nanophotonics architectures

<https://www.ifimac.uam.es/ifimac-seminars/plasmonic-waveguides-a-step-closer-to-integrated-nonlinear-nanophotonics-architectures/>



DNA mechanics beyond the twistable wormlike chain

Enrico Carlon

KU Leuven

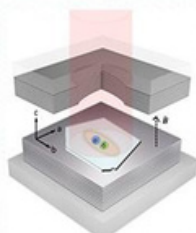
Thursday Sept 11 (2025), 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Enrico Carlon: DNA mechanics beyond the twistable wormlike chain

<https://www.ifimac.uam.es/ifimac-seminars/dna-mechanics-beyond-the-twistable-wormlike-chain/>



Magneto-optical properties of Van-der-Waals Exciton-Polaritons

Christian Schneider

Institut für Physik, Carl von Ossietzky University of Oldenburg, Germany

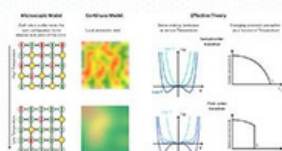
Monday, September 22 (2025), 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Christian Schneider: Magneto-optical properties of Van-der-Waals Exciton-Polaritons

<https://www.ifimac.uam.es/ifimac-seminars/magneto-optical-properties-of-van-der-waals-exciton-polaritons/>



Perception of a sensation as an emergent state of a cognitive network

Belen Valenzuela

ICMM-CSIC

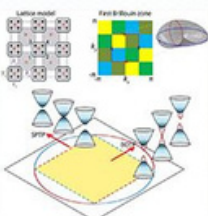
Thursday, October 23 (2025), 12:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Belen Valenzuela: Perception of a sensation as an emergent state of a cognitive network

<https://www.ifimac.uam.es/ifimac-seminars/perception-of-a-sensation-as-an-emergent-state-of-a-cognitive-network/>



Synthetic non-Abelian gauge fields for photons

Yi Yang

Department of Physics, University of Hong Kong

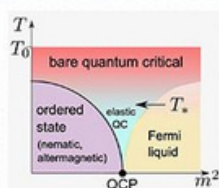
Monday October 27 (2025), 15:00h

Department of Theoretical Condensed Matter Physics, Faculty of Sciences, Module 5, Seminar Room (5th floor).



Yi Yang: Synthetic non-Abelian gauge fields for photons

<https://www.ifimac.uam.es/ifimac-seminars/synthetic-non-abelian-gauge-fields-for-photons/>



Elastocaloric effect in nematic and alter magnetic quantum criticality

Iksu Jang

Karlsruhe Institute of Technology
Germany

Thursday November 13 (2025), 12h

Department of Theoretical
Condensed Matter Physics, Faculty of
Sciences, Module 5, Seminar Room
(5th floor).



Iksu Jang: Elastocaloric effect in nematic and alter magnetic quantum criticality

<https://www.ifimac.uam.es/ifimac-seminars/elastocaloric-effect-in-nematic-and-alter-magnetic-quantum-criticality/>

SEMINAR by IEEE Distinguished lecturer

Tailoring Magnetic Spin Textures in La_{0.7}Sr_{0.3}MnO₃-Based Micromagnets

YAYOI TAKAMURA

Universidad de California Davis

November 18

12:00 h

Conference Room, Module 0

Faculty of Sciences

Autonomous University of Madrid



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EXCELENCIA MARIA DE MAEZTU

CSIC

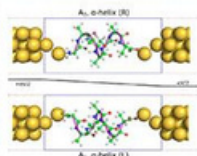
icmm

EXCELENCIA MARIA DE MAEZTU



Yayoi Takamura: Tailoring Magnetic Spin Textures in La_{0.7}Sr_{0.3}MnO₃-Based Micromagnets

<https://www.ifimac.uam.es/ifimac-seminars/tailoring-magnetic-spin-textures-in-la0-7sr0-3mno3-based-micromagnets/>



Biomolecules as spin dependent information pathways

Dr. Mario Galante

Assistant research scientist School of
Molecular Sciences, Tempe Campus,
Arizona State University

Monday November 24 (2025), 12h

Department of Theoretical
Condensed Matter Physics, Faculty of
Sciences, Module 5, Seminar
Room (5th floor).



Mario Galante: Biomolecules as spin dependent information pathways

<https://www.ifimac.uam.es/ifimac-seminars/biomolecules-as-spin-dependent-information-pathways/>



Boojums, Hedgehogs, Rings and Walls – Defects in Confined Nematics

Alberto Fernandez-Nieves

Department of Condensed Matter Physics, U Barcelona,
Barcelona, Spain ICREA – Catalan Institution for
Research and Advanced Studies (ICREA): Barcelona,
Spain Institute for Complex Systems, U Barcelona, Spain

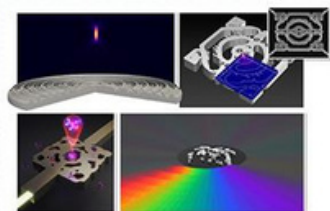
Tuesday, December 2 (2025),
12:00h

Department of Theoretical
Condensed Matter Physics,
Faculty of Sciences, Module 5,
Seminar Room (5th floor).



Alberto Fernandez-Nieves: Boojums, Hedgehogs, Rings and Walls – Defects in Confined Nematics

<https://www.ifimac.uam.es/ifimac-seminars/boojums-hedgehogs-rings-and-walls-defects-in-confined-nematics/>



Thursday, December 11 (2025), 12:00h

Department of Theoretical Condensed
Matter Physics, Faculty of Sciences,
Module 5, Seminar Room (5th floor).

Topology Optimization &
Wave Physics - Photonics,
Plasmonics, Optomechanics
and Acoustics

Rasmus E. Christiansen, PhD

Technical University of Denmark

**Rasmus E. Christiansen: Topology
Optimization & Wave Physics -
Photonics, Plasmonics,
Optomechanics and Acoustics**

<https://www.ifimac.uam.es/ifimac-seminars/topology-optimization-wave-physics-photonics-plasmonics-optomechanics-and-acoustics/>

IFIMAC DAY

On October 17, 2025, IFIMAC hosted its annual celebration, bringing together researchers, faculty, and students for a day of scientific exchange. Vice-Rector María Ángeles Martín Cabrejas and Vice-Dean José Luis Pau Vizcaíno opened the event with remarks that set the tone for a day centered on "Shaping the Future of IFIMAC." Director Rubén Pérez then delivered the State of IFIMAC address, highlighting the institute's accomplishments over the past year and unveiling its strategic vision for advancing condensed matter physics research.





SESSION 1 – 09:30–11:00H

The morning session, chaired by Cristina Gómez-Navarro, Head of the Experimental Section, highlighted the Institute's commitment to fostering emerging talent. Two recently appointed researchers, Miguel Bello and Iolanda di Bernardo, presented their research.



Video: <https://www.youtube.com/watch?v=RdyZSfU6clk&t=2s>

SESSION 2 – 11:30–13:00H

The afternoon session opened with a special recognition ceremony, chaired by Luis Viña, IFIMAC member and President of the Royal Spanish Physics Society (RSEF), and UAM Rector Amaya Mendikoetxea. The ceremony honored two IFIMAC researchers who had received the 2025 RSEF-Fundación BBVA Physics Award.

Francisco José García Vidal received the Gold Medal for his pioneering work in nanophotonics. His presentation, "The first thirty years of Nanophotonics: a personal journey," traced the field's evolution from theoretical foundations to current applications in controlling light at the nanoscale—a journey he himself helped chart.

Julio Gómez Herrero received the Physics, Innovation and Technology Award for his contributions to scanning probe microscopy. In his talk, "A Journey into the Nanoworld with Scanning Probe Microscopy," he demonstrated how advanced microscopy techniques have transformed our understanding of materials at the atomic level.



Video: <https://www.youtube.com/watch?v=ylnkN8XrhRQ>

Following a networking lunch at Plaza Mayor, a Knowledge Transfer and Entrepreneurship session led by Jorge Álvarez Cercadillo (UAM Emprende) and chaired by Félix Zamora, Vice-Rector for Innovation and Transfer, explored translating fundamental research into practical applications and building innovation ecosystems.

The day concluded with a poster session and reception where young researchers presented their research, fostering interdisciplinary discussions and collaborations between senior faculty and early-career researchers—embodying IFIMAC's collaborative spirit.