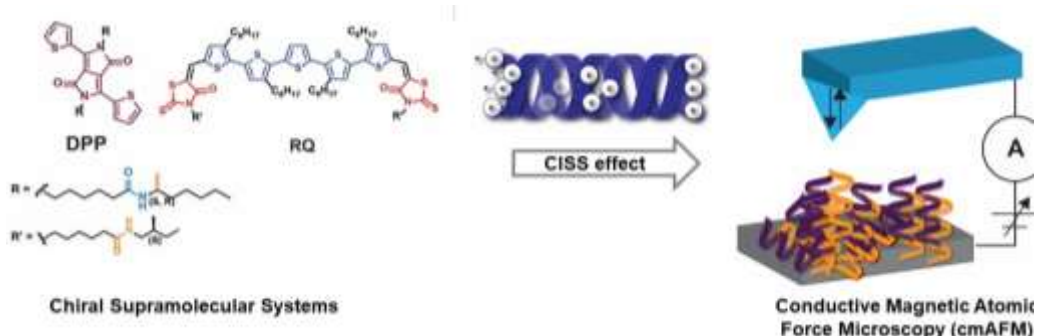


Selective Probing of Innovative Nanochiral Structures (SPINS)



The demand for faster, smaller, and more energy-efficient electronic and spintronic devices necessitates new materials. Organic materials are promising due to their flexibility, low-temperature processing, and chemical tunability, offering avenues for flexible electronics and quantum computing. A key emerging field is chiro-spintronics, which explores how electron spins interact with chiral (helical) structures, holding significant potential for data processing and storage. This PhD project will investigate chiral organic materials for spin and charge selective transport, aiming to create next-generation digital materials. This involves designing and synthesizing organic molecules that self-assemble into helical structures, exploiting the Chiral Induced Spin Selectivity (CISS) effect.

To characterize these materials, we'll use advanced scanning probe microscopy, specifically magnetic conductive probe-atomic force microscopy (mc-AFM) with a ferromagnetic electrode as a spin analyzer. We will develop the setup for operando measurements under various stimuli (temperature, magnetic fields, light). Complementary studies include electron transport, magneto-optical Kerr effect and experiments at large-scale facilities like synchrotron ALBA. Ultimately, the project aims to identify optimal chiral materials for spin logic devices and establish design rules and fabrication protocols for future digital technology applications.

This thesis project is based on a **collaboration** between Amparo Ruiz-Carretero (ARC), responsible for synthesis and spectroscopy of chiral materials, and Miriam Jaafar (MJ), leading the advanced Scanning Probe Microscopy (SPM) developments and magnetic measurements. Their expertise is **fully complementary and synergistic**. ARC brings ATRAE funds, organic synthesis lab chiral materials characterization tools, and a team with experience in chirality and organic electronics (<https://wp.icmm.csic.es/ms-mm/>). MJ provides state-of-the-art conductive Atomic Force Microscopy (AFM) capabilities and resources to build a setup with *in-situ* magnetic fields for *operando* magneto-transport characterization. Her lab is well-equipped through various European, national, and autonomous projects, and has additional instrumentation for magneto-optical, variable-temperature transport, and high-frequency measurements (<https://wp.icmm.csic.es/gnmp/>).

The project builds on both PIs' knowledge¹ and preliminary results,² ensuring the feasibility of the project, while establishing a new research line at the ICMM aligned with the excellent strategy of the Severo Ochoa Program.

By the end of the PhD, the student will be skilled in organic materials synthesis and characterization (solution/thin film) and advanced SPM techniques. Training will include UAM courses and seminars (e.g., www.iadchem.uam.es/lectures), biweekly CISS seminars (<https://www.weizmann.ac.il/sites/ciss/videos>), the Escuela Nacional de Materiales Moleculares (ENMM), ICMM-CSIC events (e.g., School in operando characterization, International PhD school in SPMs), and Summer Schools (CEMAG, ESM, IEEE) to enhance education and networking. Participation in group/project meetings and national/international conferences will provide critical training. At least one internship in a partner lab, such as Prof. Shu Seki's group (Kyoto Univ., Japan) for electrodeless measurements (funded through our collaboration), and visits to synchrotron facilities are planned.

Summary of CVs

Amparo Ruiz Carretero

I have been a researcher at the French National Center for Scientific Research (CNRS) since 2016, and will continue until August 2025. After completing my PhD at the University of Castilla La Mancha (Spain) and Eindhoven University of Technology (Netherlands), I held postdoctoral positions at Northwestern University (USA) and the Institute of Supramolecular Science and Engineering in Strasbourg (France).

In 2016, I secured my permanent position at the CNRS within the Charles Sadron Institute (Strasbourg), where I am the head of one of the seven research teams. I am the only female team leader and the first since the institute's founding in 1947. My research focuses on supramolecular chemistry and organic electronics.

As a principal investigator, I have successfully supervised 4 doctoral theses, 5 postdoctoral researchers, and over 12 master's students, all of whom were fully funded under my direction. I have published 15 articles as corresponding author (30 in total) and have secured 11 funded projects as an independent researcher, raising over 1 million euros in total. I have been an invited speaker at 27 international conferences, including one keynote invitation.

I collaborate with groups at Kyoto University (Japan), Max Planck Institute (Mainz, Germany), the University of Málaga (Spain), the National Institute of Technology Patna (India), and the University of Strasbourg. In 2017, I was elected a member of the laboratory council. I am also a member of the executive committee of a University of Strasbourg's cluster of excellence dedicated to functional materials and sustainability, and a member of its gender equality committee.

I have organized numerous outreach events, participating in the "Science Week" since 2018 and serving as my institute's coordinator for the campus's sixtieth anniversary. Since 2019, I have been the organizer of the IUPAC Global Women's Breakfast, being the first organizer from the University of Strasbourg. I have participated in 14 thesis defense committees and review an average of 12 articles per year.

My recognitions include the University End-of-Degree Award and FPU and Marie Curie fellowships. In 2023, I was awarded the CNRS Bronze Medal, an honor bestowed upon less than 3% of all researchers in France. After 17 years abroad, I am eager to demonstrate my research and leadership capabilities in Spain. Specifically, I will be joining the Institute of Materials Science of Madrid (ICMM, CSIC), thanks to an ATRAE project.

Miriam Jaafar Ruiz- Castellanos:

Bachelor of Science in Physics (UCM, 2003) and Ph.D. in Physics (UAM, 2009). My research focuses on expanding the capabilities of Scanning Force Microscopy (SFM), particularly Magnetic Force Microscopy (MFM), by developing novel techniques, instruments, and applications. These include the creation of custom SFM systems, the adaptation of SFM to diverse environments, and the development of specialized probes and operating modes.

My research interests span a broad range of topics, including nanomagnetism, biological systems, and 2D materials. This interdisciplinary approach combines fundamental research with technology transfer and impactful teaching. My research has resulted in over 67 peer-reviewed publications in high impact journals (e.g., Chem Science, Phys. Rev. Lett., Nanoscale, ACS Nano, ACS AMI, Small, Adv Electr Mater, Carbon). I have successfully translated research into applications through collaborations with industry and through three licensed patents, including one recently awarded by the Spanish Patent and Trademark Office (2022).

As part of my PhD research at the ICMM, conducted under the supervision of Dr. Asenjo, I collaborated with Nanotec Electrónica S.L. to develop the first variable field MFM in Spain. During my subsequent Juan de la Cierva postdoctoral fellowship at UAM, working within Prof. J. Gómez-Herrero's group, I continued to collaborate with industry. I was a co-founder of Nanoate S.L., a UAM spin-off company dedicated to developing nanostructured platforms for highly selective materials detection (two awards).

I have been Principal Investigator (PI) of several competitive research projects, including national projects (MAT2015-73775-JIN, PID2024-155385NB-C33), an Ecological Transition project (TED2021-130957B-C55), that has spawned a new European collaboration and two regional projects (500k+).

Over the past 5 years, I have been actively involved in three highly competitive international projects. These include an European project with a budget of 7.5M euros involving 14 partners to develop rare earth free permanent magnets, an ERANET initiative focused on advancing Li-based battery materials, and a collaborative i link project with the University of Sydney.

I am an active member of the scientific community, serving as a project evaluator for the Spanish Research Agency and presenting my work at over 100 national and international conferences (including 25 contributed talks and 6 invited talks presented by myself). I have been responsible for organizing several international and national academic conferences. Furthermore, I have actively contributed to the academic community by supervising 1 PhD student (now a Ramon y Cajal researcher), 1 Master's student, 2 Postdocs, 5 undergraduate theses and 2 two students during their external internships. I am passionate about mentorship and currently participate in programs for high-ability undergraduate students. I have served as Associate Professor at UAM for almost six years in the frame of a University Teaching Excellence Program (funded by the Community of Madrid, 150k). Beyond research, I am committed to science outreach, participating in initiatives like

the 10alamenos9 Festival, "Science Week", "European Researchers night" and the "Day of Women and Girls in Science". My dedication to research excellence is further evidenced by the I3 certificate (since 2018) and the recent Early Career Scientist Award from the Spanish Magnetism Association (2021).

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