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From Starlight to Knowledge: The Power of Modern Telescopes

Alberto Rebassa

> Within a given research field, scientists generally belong to two categories: theorists and experimentalists. The outcome of experiments must be predicted by the models that theorists build. Likewise, experiments must confirm the hypotheses proposed by those models. If either of these approaches fails, then there is a problem that needs to be solved. In this way, science advances. For example, in the 1860s, James Clerk Maxwell predicted that electromagnetic waves travel at the speed of light. A few years later, Heinrich Hertz carried out experiments that generated and detected radio waves in the laboratory. These waves behaved exactly as Maxwell had predicted.

According to NASA's definition, astronomy is the scientific study of matter in outer space, especially the positions, dimensions, distribution, motion, composition, energy, and evolution of celestial bodies and phenomena. It becomes obvious that astronomers cannot experiment with celestial bodies such as a star and its planets, galaxies, or the Universe itself. We are simply observers of what surrounds us. As a consequence, "experimental" astronomers are referred to as observational astronomers. Thus, it is through the light that we receive from the objects of study that we can improve our understanding of the cosmos. In such a way, the direct comparison



UNIVERSITAT POLITÈCNICA DE CATALUNYA
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Department of Physics

The Group of Astronomy and Astrophysics at the UPC will target over 100,000 binary stars in our Galaxy during the next 5 years using the 4MOST facility in Chile. The goal: to study the evolution and formation of the Milky Way.

between observations and theoretical expectations must be in agreement. >>>
In order to collect light from celestial objects, observational astronomers use either ground-based telescopes or satellites. Satellites allow observations at all wavelengths and avoid atmospheric turbulence, although they are limited in size. Ground-based telescopes are easier to maintain and can be as large as 30–40 meters in diameter. However, the atmosphere not only blocks a large part of the electromagnetic spectrum, but also distorts the incoming wavefront because of intrinsic turbulence, which produces variations in the refractive index. To minimize the effects of atmospheric turbulence as much as possible, astronomers search for sites that are elevated (thereby reducing the atmospheric column compared to sea level), flat (to avoid non laminar winds), and located near large bodies of water (which help homogenize the temperature). Moreover, observatories should be located in dry regions to minimize rain and as far as possible from cities in order to reduce light pollution. The three most important observational sites in the world that fulfill these requirements are the Canary Islands, Hawaii, and Chile.



The 4MOST facility at Cerro Paranal Observatory.
Image credit: G. Hüpdepohl; atacamaphoto.com).

Located in the southern hemisphere, Chile is the observational site of excellence chosen by the European Southern Observatory (ESO), one of the most prestigious astronomical organizations. Since the 1960s, ESO has built numerous telescopes of a wide variety of diameters and instrumentation at different locations within Chile: La Silla Observatory, Cerro Paranal Observatory, and Chajnantor Plateau or Atacama site. Whereas La Silla and Paranal are bases for optical and near-infrared observations, Chajnantor is exclusively dedicated to radio astronomy. Currently, ESO is building at Paranal one of the forthcoming next-generation wide-aperture telescopes, with a 39 m diameter.

The two most common techniques used in observational astronomy are photometry and spectroscopy. Photometry uses filters that select specific wavelength ranges to measure the fluxes of a given object, which are then converted into magnitudes following a logarithmic scale similar to that of our eyes. A color, that is, the difference between two magnitudes, provides valuable information

on surface temperatures and locates different bodies in specific locations in color-color diagrams, thus allowing us to differentiate among them. Plotting magnitudes as a function of time is also widely used to identify, for example, transiting planets. Spectroscopy uses grisms or gratings to disperse the light of the objects we observe, thus producing spectral lines within the continuum emission. These lines not only provide information on the chemical composition of the bodies, but also allow us to measure their radial velocities (which was used to demonstrate, for instance, the expansion of the Universe), temperatures and surface gravities, and identify binary stars, accretion disks, etc. □

Arguments for maintaining winter time all year round for health and climate adaptation

To read the arguments in detail, please read the article published in The Conversation: *Mantindre l'horari d'hivern, ajudaria a adaptar-nos al canvi climàtic?*

<https://theconversation.com/mantindre-lhorari-dhivern-ajudaria-a-adaptar-nos-al-canvi-climatic-277545>

Professors Jordi Mazón and David Pino from the Physics department in UPC propose the abolition of seasonal time changes in the European Union, arguing that the permanent adoption of winter time (UTC+1) would provide critical benefits for public health and safety in the face of global warming.

> Diverse scientific studies consistently link the transition to daylight saving time with an increased risk of heart attacks, traffic accidents, and sleep disorders due to the desynchronization between our biological and social clocks. Maintaining winter time permanently would allow human activity to be better aligned with the natural solar cycle, especially in the Iberian Peninsula. This change would reduce the “social jet lag”, making it easier for the population to wake up with natural sunlight and improving general well-being by avoiding the chronic lag that our metabolism suffers under the current day-light saving time.



The proposal is also supported by geographical considerations. Due to its longitude, most of the Spanish mainland is naturally aligned with the Greenwich meridian and would therefore be closer to UTC+0 in terms of solar time. Maintaining UTC+1 throughout the year is thus presented as a balanced compromise that reduces the mismatch between official time and the natural day-night cycle. This issue is particularly relevant in the Iberian Peninsula, where sunrise and sunset times can differ by nearly one hour between its eastern and

western regions, making the choice of time zone especially significant for daily life and social schedules.

On the other hand, the adoption of UTC+1 throughout the year is offered as a key strategic measure to mitigate the effects of climate change in the Mediterranean region. According to the authors, the western Mediterranean is one of the European regions most vulnerable to global warming and is already experiencing increasingly frequent heat waves and hotter summers leading to greater nighttime thermal discomfort. Advancing sunset by one hour during the summer months would allow buildings to cool down earlier in the evening, improving nighttime rest and reducing dependence on air conditioning. In addition, shifting the daily temperature peak towards periods of lower human activity could help reduce heat exposure among outdoor workers and lower the risk of forest fires during the most critical hours of the day.

The authors note that most forest fires in Spain are linked to human activity and frequently occur during the hottest and driest hours of the day. Under a permanent UTC+1 schedule, the daily temperature maximum would be shifted towards a period that more closely coincides with the traditional midday break, when human activity in rural and forested areas is generally lower. Although such a measure would not eliminate the risk of wildfires entirely, it could contribute to reducing the likelihood of ignition during the most critical meteorological conditions.

The proposal would also have significant implications for occupational safety in a warming climate given that by moving the hottest part of the day to an earlier time, periods of extreme heat would overlap more closely with lunch breaks and times of reduced outdoor activity. Earlier summer sunrises would also allow agricultural, construction and other outdoor work to begin under milder thermal conditions, thereby helping to reduce exposure to heat stress and other heat-related health risks.

The authors argue that the choice of a time zone should not be regarded merely as a cultural or administrative issue. In the context of accelerating climate change, this type of decision becomes highly strategic. It has implications for public health, energy consumption, occupational safety and climate adaptation. The proposal suggests that maintaining winter time throughout the year could represent a simple and low-cost measure capable of generating significant benefits for society while helping Mediterranean regions adapt to a warmer future. □

Configurational entropy: the key to corrosion resistance in new Palladium-based metallic glasses

Reference

Zhou, Y., Bruna, P., Kato, H., Wada, T., & Qiao, J. (2026). Influence of configurational entropy on the corrosion resistance of Pd-based metallic glasses. *Chemical Engineering Journal*, 176647.

Research article in the prestigious *Chemical Engineering Journal* investigates how atomic order and chemical complexity can be used to improve the service life of metallic materials in aggressive environments.

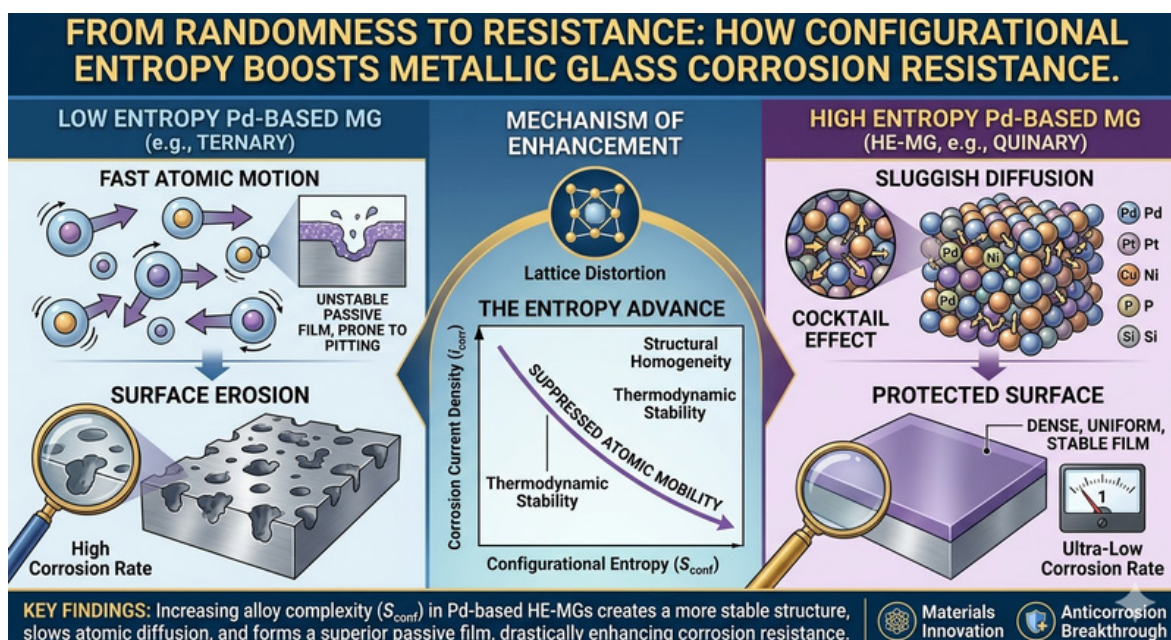
> Corrosion is one of the most common causes of degradation and failure in metallic materials, generating substantial maintenance costs and economic losses worldwide every year. Extending the lifetime of metallic components is therefore a major scientific and technological challenge, particularly in sectors such as energy production, transportation, chemical processing and advanced manufacturing, where materials are routinely exposed to aggressive environments.

Researchers from the Department of Physics of the Universitat Politècnica de Catalunya (UPC), in collaboration with Tohoku University (Japan) and Northwestern Polytechnical

University (China), have addressed this challenge through the study of a new generation of metallic glasses. Their work, published in the prestigious *Chemical Engineering Journal*, investigates how configurational entropy influences the corrosion resistance of Palladium (Pd)-based High-Entropy Metallic Glasses (HE-MGs), a class of materials characterized by their atomic disorder and chemical complexity.

Understanding how configurational entropy itself contributes to corrosion resistance is therefore essential for the rational design of more durable metallic materials.

The key research findings of the study are, first, the superior corrosion resistance: the corrosion current density of the high-entropy metallic glass is only about 0.3% of that of a traditional ternary metallic glass with lower entropy. Second, the researchers identified the protection mechanism responsible for this behavior. Using X-ray Photoelectron Spectroscopy (XPS), they found that high entropy facilitates the formation of an extremely stable and dense oxide film that



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Metallic glasses are particularly attractive because their amorphous structure lacks grain boundaries, dislocations and other crystalline defects that often act as preferential sites for corrosion. High-Entropy Metallic Glasses take this concept one step further by combining several principal elements in near-equiatomic proportions. The resulting increase in configurational entropy promotes stronger

protects the material from dissolution in acidic environments. Finally, the study establishes a direct correlation between binding energy and corrosion resistance, demonstrating that controlling high-entropy characteristics is a powerful strategy for designing new materials with unprecedented durability.

These findings are particularly relevant for technological applications where materials are exposed to corrosive environments, such as chemical processing plants, energy systems, biomedical devices and advanced manufacturing technologies. Improving corrosion resistance not only extends the service life of components but also reduces maintenance costs, material consumption and the environmental impact associated with replacement and repair operations. □

Multinational retrospective analysis on real-world impact of nirsevimab immunisation and maternal RSV vaccination against respiratory disease

Reference

The Lancet
Regional
Health – Europe
2026;63:101597.
Published online
3 February 2026.
DOI: 10.1016/j.
lanepe.2026.101597

Researchers of the department of Physics in collaboration with a team of European institutions have evaluated the effects of Nirsevimab, a preventive medicament against broncolitis which has been published in a journal of the prestigious group Lancet.

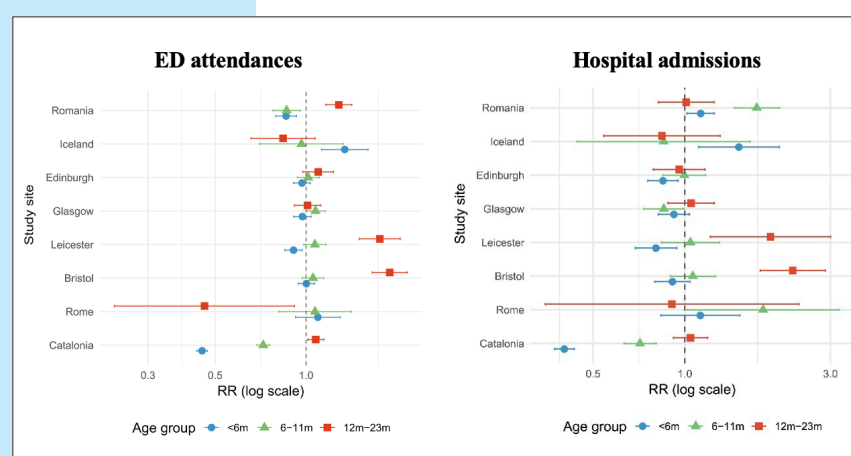
> Respiratory syncytial virus (RSV) is a highly common virus that causes infections of the respiratory tract, including the lungs, usually producing mild cold-like symptoms. However, RSV can also cause severe respiratory illnesses such as bronchiolitis and pneumonia, making it especially dangerous for infants and one of the leading causes of hospitalization among young children worldwide. Recently, a major breakthrough in RSV prevention was achieved with the development of nirsevimab, a long-acting monoclonal antibody that provides protection during the period of highest vulnerability in early life.

Nirsevimab was approved for commercialization by the European Medicines Agency (EMA) in 2022, and was pioneeringly introduced in Catalonia (Spain) in October 2023. After the success of the 2023–2024 immunisation campaign in Spain, Luxembourg and other European countries, more have adhered to it in the 2024–2025 season, such as Italy. Nevertheless, coverage, provision and public health policy differed between countries. Alternatively, maternal immunisation with the Respiratory Syncytial Virus prefusion F vaccine (RSVpreF) vaccine was licensed in 2023. The United Kingdom (UK) introduced the RSVpreF in the 2024–2025 season, also with differing coverage and provision within regions.

This study is the first multinational European investigation to compare the real-world impact of different RSV prevention strategies on bronchiolitis-related emergency department attendances and hospital admissions in infants. The analysis also allowed the evaluation of the consistency of nirsevimab protection across different seasons and implementation settings. By including hospitals from Iceland and Romania, where no RSV preventive measures had been introduced, the study was able to account for natural year-to-year variations in RSV circulation, providing a more robust assessment of the effectiveness of the interventions.

In the 2024–2025 season, in Catalonia, there was a reduction in the risk ratio (RR, Figure 1) for bronchiolitis ED attendances [0.45 (95% CI 0.43–0.47)] and admissions [0.40 (95% CI 0.37–0.43)] in infants of age <6 months. This translates to an estimated reduction of almost 60% of attended ED bronchiolitis. However, this reduction was not seen in Rome, the other region with nirsevimab immunisation. In two of the sites representing the UK in the study, where the RSVpreF vaccine was delivered, there was a significant but modest reduction of hospital admissions due to bronchiolitis for infants of age <6 months (0.80 (95% CI 0.69–0.94) and 0.85 (95% CI 0.76–0.95), respectively). These differences are likely to relate to the reduced uptake of RSV prevention products in these settings compared to Catalonia. The visualization of the Impact (risk ratio [RR]) of nirsevimab and RSVpreF on ED attendances (left) and hospital admissions from ED (right) with bronchiolitis in the 2024–2025 season in different centers can be observed in the image.

The findings highlight that the success of RSV prevention programmes depends not only on the effectiveness of the preventive products themselves, but also on how they are implemented. The more limited impact observed in the United Kingdom during the first season of maternal RSV immunisation may be related to lower uptake during the initial phase of the campaign, underlining the importance of launching preventive programmes well before the start of the RSV season and promoting public awareness to maximize coverage. Similarly, the absence of a measurable impact in Rome contrasts with the results observed in Catalonia, where uptake rates were higher and eligibility criteria were broader, emphasizing the need for coordinated and well-organised implementation strategies. □



The aim of the study was to analyse emergency department (ED) attendances and admissions to hospital due to bronchiolitis following RSVpreF and nirsevimab introduction, with hospitals in Iceland and Romania, where no intervention was introduced, used as comparators.

Thesis 1

Study for energetic characterization with PELE with application to real cases

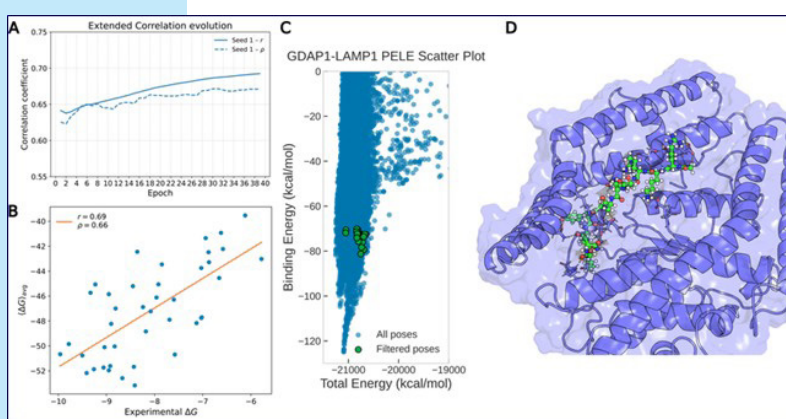
Ignasi Puch Giner defended his doctoral thesis, supervised by Víctor Guallar Tasies, at the North Campus on April 16, 2026. Titled “Optimization of Monte Carlo and Molecular Dynamics Techniques for Receptor–Ligand Binding Studies”, the thesis focuses on taking advantage of the theoretical framework of Monte Carlo methods to design a protocol applicable to the energetic characterization of ligand–protein interactions. In addition, these methodologies, combined with other computational techniques, have been applied in three collaborations oriented to real cases related to pathologies of the nervous system and the cardiac system.

> Drug discovery is a complex and resource-intensive process that relies on identifying molecular candidates with optimal binding properties. This

thesis advances computational strategies for biomolecular modeling by integrating physics-based molecular mechanics methods—such as Monte Carlo and molecular dynamics simulations—with state-of-the-art machine learning approaches. The objective is to improve scoring functions, enhance simulation accuracy, and develop an efficient framework applicable to real-world pharmacological challenges.

A central contribution of this work is the systematic characterization of the PELE (Protein Energy Landscape Exploration) simulation framework, including the evaluation of binding energy estimators in terms of predictive performance and computational efficiency. These benchmark studies address existing limitations in scoring methodologies and enable more reliable protein–ligand interaction predictions.

The proposed methodologies are validated through pharmacologically relevant case studies, including the structural characterization of the amino acid transporter Asc1/CD98hc, the exploration of novel drug–DNA interactions involving Meis1–Hoxb13 transcription factors, and the investigation of GDAP1–LAMP1 dysfunction in Charcot–Marie–Tooth disease. Collectively, this research establishes a scalable computational framework that bridges traditional molecular simulations and AI-driven predictions, with significant implications for both academic research and industrial drug discovery. □



Thesis 2

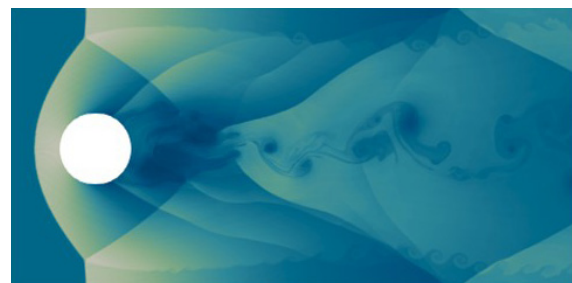
On the development of accurate and efficient numerical methods for real-world applications of computational fluid dynamics

Antonio Blanco Casares defended his thesis co-directed by Oriol Lehmkuhl and Daniel Mira on May 8, 2026 at Campus Nord. The thesis is titled “A Numerical Framework for Solving Complex Flow Regimes with Continuous Galerkin Methods” and investigates how new advances in numerical methods improve the computational simulations of physical systems involving flow problems.

> Numerical simulations of fluid flows are fundamental to advancing our understanding of a wide variety of physical systems, from aerodynamics and atmospheric studies to combustion engines, chemical reactors and medical applications. Both scientific research and industrial modeling demand practical, large-scale simulations that balance computational efficiency with high-accuracy results. In recent years, significant advances in this field are driven by supercomputers with new architectures such as GPUs, and also by the development of modern numerical methods.

The finite element method is proven to be a powerful and versatile computational technique for numerical simulations. Its main strengths lie in its flexibility to handle complex geometries

using unstructured meshes, the support of higher-order approximations, and its solid mathematical foundation that ensures convergence. However, there are several difficulties for achieving a stable solution. Solving nonsymmetric and nonlinear advection terms causes instabilities. Also, strong gradients may produce oscillations. To address these problems, additional stabilization techniques are required.



The thesis develops a stabilization strategy well-suited for high-order elements, designed to effectively eliminate numerical instabilities while introducing minimal numerical dissipation to achieve a high accuracy solution. The thesis focus on projection-based methods that provide a good stabilization using the unresolved components of the solution. Based on

recent literature, our stencil features a combination of a high- and low-order stabilization ruled by a smoothness sensor. High-order stabilization is applied in smooth regions to maintain physical profiles, while a low-order viscous stabilization is activated only near strong gradients to suppress non-physical oscillations. The proposed numerical framework is applied to several problems. In combustion simulations, the approach handles tabulated chemistry and delivers a proper representation of the flame-front. For

compressible flows, a smoothness sensor based on the Mach number has been developed, effectively solving complex flow features such as shock waves. For incompressible flows, the high-order stabilization term avoids instabilities, while at the same time allowing the accurate resolution of the most relevant scales of the fluid movement. The proposed framework achieves convergence and provides a robust and scalable tool for applied computational fluid dynamics. □

Thesis 3

Study of itinerant ferromagnetism and polarons in degenerate Fermi gases

Jordi Pera i Ferreruela defended his doctoral thesis co-directed by Joaquim Casulleras i Ambrós and Jordi Boronat Medico on April 17, 2026 at Campus Nord. The thesis, entitled Itinerant ferromagnetism and polarons in SU(N) Fermi gases, focuses on determining under which regimes Fermi gases become ferromagnetic and, if so, how they get there. On the other hand, it also includes a small exploration of the behavior of impurities in these gases.

> This thesis presents an in-depth study of the magnetic properties of repulsive Fermi gases in the continuum. Once a purely academic subject, Fermi gases can now be realized experimentally in ultra-cold atom laboratories, making a theoretical understanding of their behavior both timely and necessary. The analysis focuses primarily on whether such systems favor a transition to a ferromagnetic state or remain paramagnetic. To address this question, a perturbative approach is employed that systematically includes the effects of higher-order

terms, temperature, and mass imbalance. In the final part of the thesis, the Fermi polaron problem is addressed.

The study begins with the simplest case of a Fermi gas with equal masses at zero temperature up to second order in perturbation theory. The description of the interaction is then refined by extending the analysis to third order in perturbation theory and considering a wide range of interaction potentials. Temperature is subsequently incorporated as an additional variable, followed by the study of systems with different mass ratios. Finally, the scope is extended beyond magnetic properties to investigate the fermionic polaron, an impurity immersed in a Fermi sea.

Altogether, this work offers a detailed and thorough exploration of Fermi gases, providing both qualitative insight and quantitative predictions relevant to current experimental efforts. □

Thesis 4

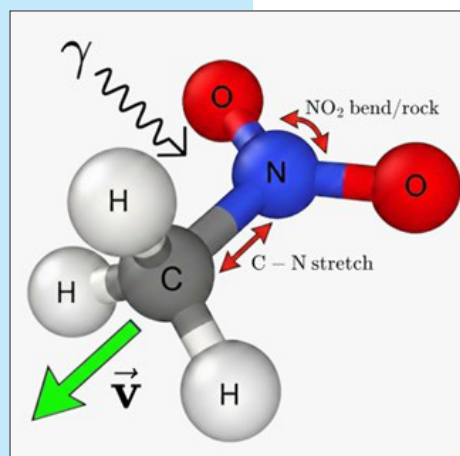
Study of self-propelling particles at the molecular scale

Arnau Jurado Romero defended his thesis supervised by Rossend Rey Oriol (UPC) and Carles Calero Borralló (UB) on May 28th, 2026 at Campus Nord. The thesis, with the title “Self-Propulsion of Molecular Swimmers”, demonstrates a propulsion mechanism for a small molecule, via all-atom molecular dynamics simulations. It also

fully investigates the nature of the resulting propulsion, for both single self-propelling particles and many-body systems. It concludes by applying state-of-the-art machine learning techniques to thermophoresis in aqueous solution, a closely related problem to self-propelling molecular swimmers.

> Active matter systems have the ability to exhibit self-propulsion by consuming energy to produce mechanical work, staying out of equilibrium. A major goal in the field is the development of artificial micro- and nano-scale particles capable of self-propulsion, so-called swimmers. These swimmers hold the potential for groundbreaking applications, such as targeted drug delivery, non-invasive microsurgery, and water purification. However, achieving propulsion at such small scales is severely limited, prompting the search for novel propulsion mechanisms.

This thesis demonstrates a propulsion mechanism for a small molecule, nitromethane, via all-atom molecular dynamics simulations. The molecule is subject to a high energy vibrational excitation which is then released anisotropically onto the surrounding water solvent. □



Capturing the unknown



Dr. Jose Trull's research focuses on experimental studies in nonlinear optics and photonics. He coordinates the nonlinear optics lab of the DONLL research group at ESEIAAT. He became an Associate Professor at UPC in 2003 and was promoted to Full Professor in 2023.

> Experimental photonics has been the common thread of my research activity throughout my whole career. I finished my Bachelor degree in 1991 and incorporated to the group of C.N. Afonso at the Optics Institute of CSIC, where I felt the fascination of experimental physics learning how to work in a laboratory while recording and erasing bits using lasers in data storage platforms. After one year I moved to UPC following Prof. R. Vilaseca who gave me the opportunity, together with Prof J. Martorell, to conduct my PhD in the field of photonic crystals, starting the Nonlinear Optics and Lasers laboratory, my “second home” since then.

For the last thirty years I have been contributing to different research lines, mainly in the fields of nonlinear optics and light-matter interaction in structured materials. I have learned different techniques, acquired lab skills, trained the right attitude in the laboratory, while also trying to translate this knowledge to our students.

When faced with an experimental task, what usually comes to mind is the transition from concepts to prototypes and lastly to devices. However, in fundamental physics this process is better described as checking a theoretical idea, demonstrating new possibilities, understanding if the theoretical approximations are consistent with the implemented setup and visualizing new ways to obtain a measure.

One of the most interesting problems I have faced during my research activity has been the characterization of ultrashort pulses, one of the shortest events ever created by humans. How to measure something in the 0.000000000000001 seconds scale?

No electronics to help us, but the beauty of nonlinear optics comes into play to provide us with the possibility of capturing what happens at those scales.

The first day I came to the lab during my postdoctoral stay in Università dell'Insubria (Italy) I met a few theoreticians talking about X pulses: stationary solutions for the propagation of EM wave packets in media with normal dispersion (I had never heard about these solutions, which by the way were known and used time ago in acoustics). The solution was a complex spatio-temporal pattern. Its dimensions: few microns wide, few femtoseconds long. No electronic detectors available, no specific techniques developed at that ultrafast dynamic range for spatio-temporal wave packets. Being confident of their results, they were searching for a convincing demonstration that such solutions were coming out from the experimental setup. When the meeting ended, my boss, Paolo di Trapani, faced me with his penetrating eyes. *So, Jose, do you accept this challenge...?*

Of course I accepted. It was fun way to interact with the people who were developing the shortest available light sources at Vilnius Laser Center, learning about nonlinear optical gates, space-time correlations...and finding how X pulses came out finally from the experiment!

Back in Terrassa, I met prof. Crina Cojocaru coming back from her post doc in Paris. We decided to join our efforts to lead the lab in common research lines which have been the center of our activity in the last 26 years. We faced other problems, followed other paths and still got the opportunity to meet the problem of pulse characterization again, this time

using a new mechanism that we found by chance working in a different problem! Improving our first intuition we could establish new collaborations and develop the idea that has been implemented finally in a commercial device for full-field ultrashort pulse characterization, exploiting the concepts of single-shot autocorrelations and single-shot D-scan technique, based on nonlinear interactions in media with random distribution of the nonlinearity.

My experience has convinced me that this is how real laboratory work unfolds and that your experience entails new possible directions to face new challenges. Currently, we work on nonlinear measurements at nanoscale. We are trying to implement different techniques for the measurement of parametric processes in metasurfaces and metamaterials seeking for light emission in the UV and other related issues. Different problem, same approach... always driving our enthusiasm for capturing the unknown. □

