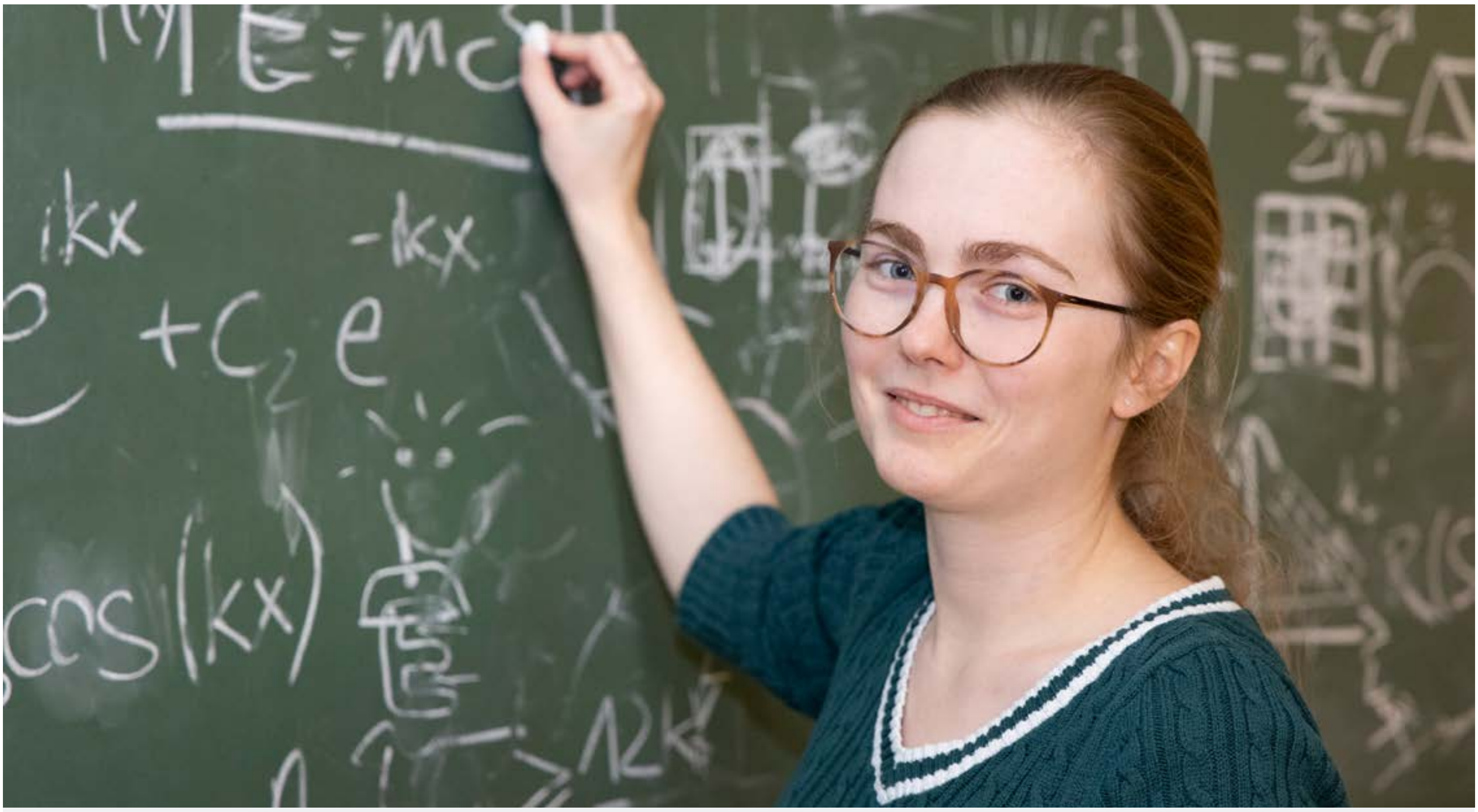
IAP

FROM FUNDAMENTALS TO APPLICATIONS: SHAPING FUTURE TECHNOLOGIES

TU WIEN | INSTITUTE OF APPLIED PHYSICS



VERSATILE RESEARCH ON HIGHLY EXCITING TOPICS

THE INSTITUTE OF APPLIED PHYSICS (IAP) AT TU WIEN

With around 60 years of tradition, the IAP is a state-of-the-art research institution combining excellent fundamental research with innovative applied research – including contract research for industrial partners. Under the leadership of Univ. Prof. Dr. techn. Markus Valtiner highly qualified research teams work at the atomic and molecular level – from the atom to concrete applications – on pioneering projects.

Our five research areas consist of Applied Interface Physics, Atomic and Plasma Physics, Biophysics, Surface Physics, and the Physics of Three-Dimensional Nanomaterials. For experimental and theoretical research in these fields, we use cutting-edge technical equipment such as high-resolution microscopy instruments, specialized laboratories, and advanced computer clusters for simulation-based studies.

We maintain close cooperation with national and international universities, research institutions, and industrial partners. One of our research focuses is in the area of energy conversion and thus the development of sustainable and resource-efficient systems that will secure our future energy supply. For example, we are involved in the international nuclear fusion reactor project ITER and conduct research on tomorrow's energy storage solutions as part of a Cluster of Excellence.

For prospective students, the IAP offers an exciting learning environment in which teaching and research are closely interlinked. We welcome motivated individuals who want to dive into the fascinating world of physics and secure a place at the interfaces of future technologies. Whether it's simulation, theoretical physics, experimental physics, programming, or handling complex machines – we bring science to life and shape the future!

WE DECODE SURFACE PHENOMENA – ONE ATOM AT A TIME

SURFACE PHYSICS

This research group analyzes, how individual metal atoms on oxide surfaces influence catalytic reactions in order to develop new materials with tailor-made properties, for example for more efficient solar cells, higher-performance electronic components, or innovative catalysts. Using ultra-high vacuum (UHV) techniques, we create optimal conditions for contactless atomic force microscopy (nc-AFM) and scanning tunneling microscopy (STM). These methods are further complemented by photoelectron spectroscopy (XPS), low-energy electron diffraction (LEED), temperature-programmed desorption (TPD), and infrared spectroscopy (IRAS). A pulsed laser deposition (PLD) system also allows us to precisely tailor material properties for surface science studies.

Expertise and Focus Areas:

- Surface science on the atomic scale
- Single-atom and oxide catalysis
- Advanced imaging and surface characterization
- Thin film growth
- Instrument development
- Interdisciplinary collaboration

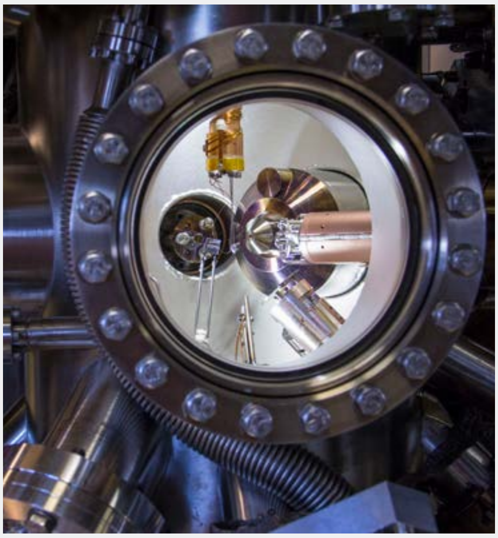
Project: Solved – The Mystery of the Aluminum Oxide Surface
Alumina (Al_2O_3) plays a key role in catalysis and electronic applications, but its insulating properties have long made its atomic surface structure difficult to access. Using atomic force microscopy with atomically controlled tip termination, we could image the positions of the single oxygen and aluminum atoms in the (0001) surface – something previously considered impossible. Our study showed that instead of a metallic aluminum layer, the surface undergoes a stoichiometric reconstruction, stabilizing itself without losing oxygen.

Cluster of Excellence: Materials for Energy Conversion and Storage (MECS)

In the MECS Excellence Cluster, researchers from TU Wien, the University of Vienna, ISTA, and the University of Innsbruck are working together to develop sustainable solutions for energy conversion and storage. The focus is on the chemical storage of renewable energy, either in hydrogen (via water splitting) or in carbon-based fuels (via CO_2 conversion). The "Applied Interface Physics" and "Surface Physics" research groups at TU Wien are key contributors to this cluster, bringing their expertise in surface science and the design of novel catalysts to advance the field.

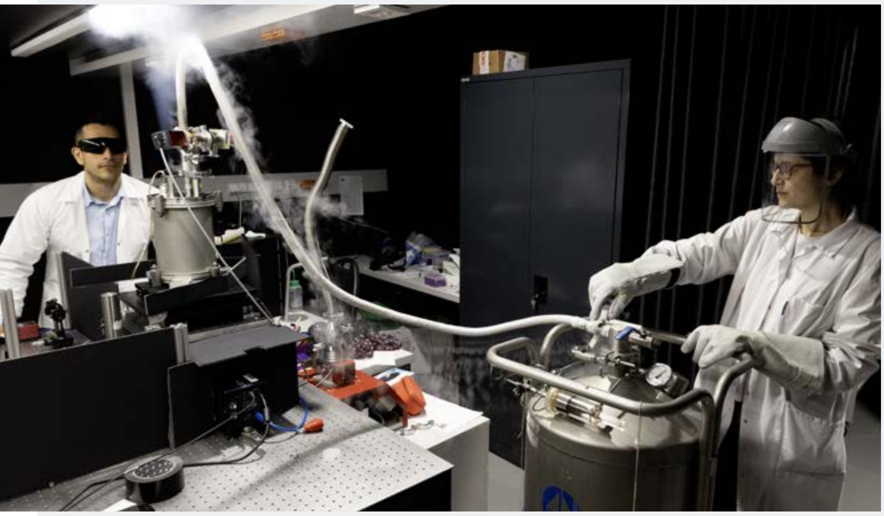
Surface Physics
Univ. Prof. Dr. Gareth Parkinson, Univ. Prof. Ulrike Diebold
Ass. Prof. Margareta Wagner, Ao.Univ.Prof. Michael Schmid,
Dr. Jiri Pavelec, Dr. Michele Riva

More information ➔



UNDERSTANDING THE PHYSICS OF LIFE

BIOPHYSICS



Biophysics is an interdisciplinary research field that combines physical principles with biological questions. We focus on investigating fundamental biophysical processes, analyzing molecular interactions and cellular mechanisms with a particular emphasis on membrane biophysics, immunology, neuroscience, and development. Our goal is to reveal the physical foundations of biological functions and thereby gain new insights for medicine, biotechnology, and synthetic biology. To study structures and processes with maximum precision, we use state-of-the-art imaging methods in our lab, such as single-molecule microscopy, atomic force microscopy (AFM), protein micro- and nanopatterning, DNA origami technology, and the theory of active matter.

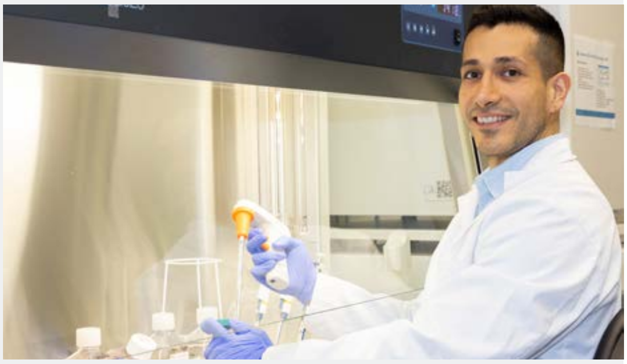
Biophysics
Univ. Prof. Gerhard Schütz
Assoc. Prof. Eva Sevcsik, Ass. Prof. Sebastian Fürthauer, Dr. Mario Brameshuber

Expertise and Focus Areas:

- Investigation of molecular interactions through high-precision single-molecule imaging
- Development of biomimetic surfaces for studying membrane organization and cell communication
- Theoretical and computational modeling of cellular structures and processes

Research Focus: Plasma Membrane–related Processes

The immune system's ability to distinguish between harmful and harmless structures is a crucial aspect of adaptive immunity. We investigate, how T cells recognize antigens via T-cell receptors (TCRs) and how these molecular interactions influence the immune response. Our research provides valuable insights into the understanding of immunological processes and their importance for medicine.



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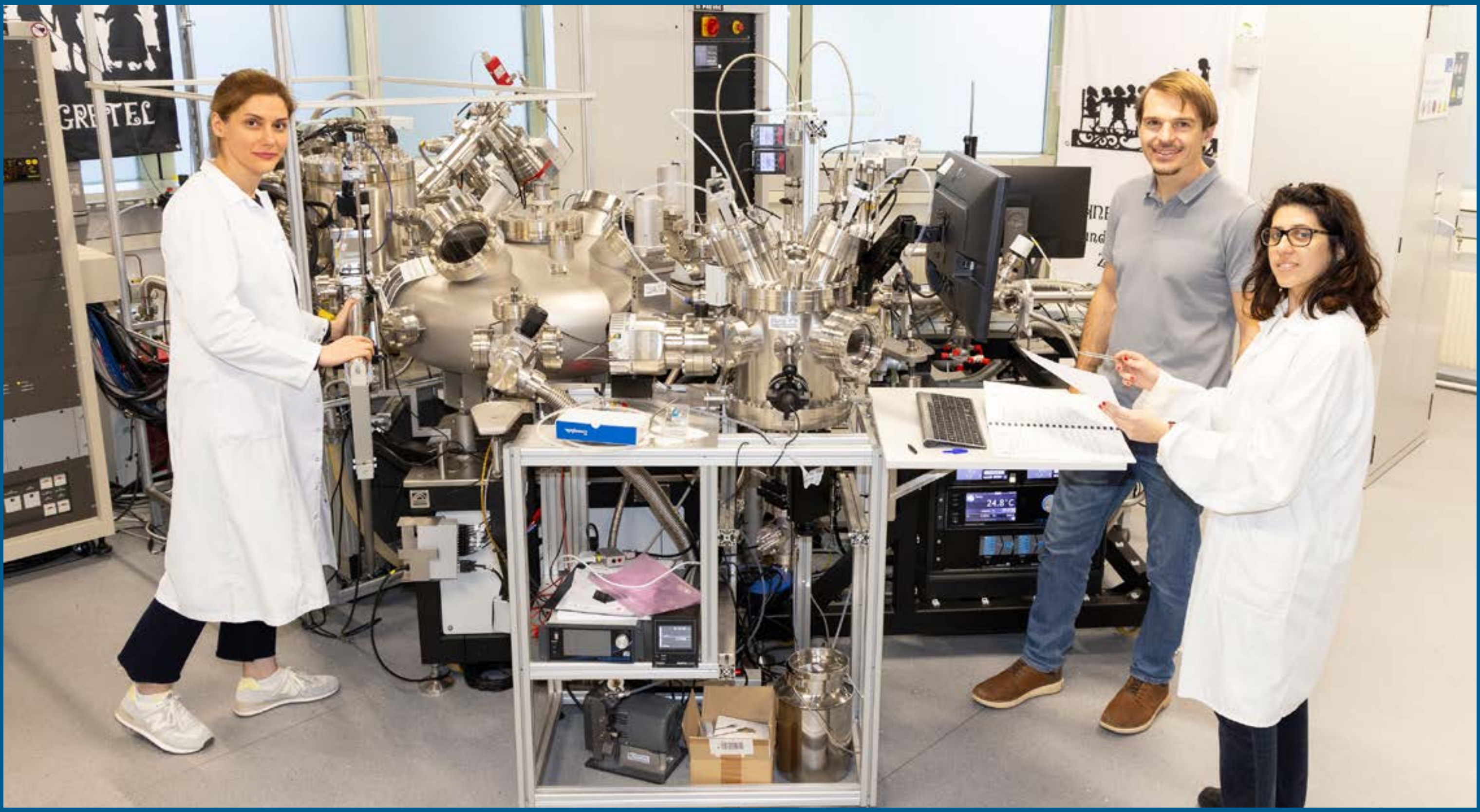


Applied Interface Physics
Univ. Prof. Dr. Markus Valtiner
Dr. Laura Mears, Dr. Alper Celebi, Dr. Michael Hollerer

APPLIED INTERFACE PHYSICS

Applied Interface Physics investigates fundamental processes at interfaces, placing a special focus on electrochemical analysis. By combining atomic-level and macroscopic methods, we bridge the gap between basic research and practical applications. A central focus lies on catalytically active materials – both in understanding their activity mechanisms under real operating conditions and in investigating their corrosion and wear behavior. In this way, we create novel material concepts for sustainable functional applications in a variety of technological fields.

Competencies and Focus Areas:

- Electrochemical analysis
- Interface interactions, tribology, and surface forces (AFM, SFA)
- Synthesis and characterization of materials for renewable energy
- Modeling and simulation of complex interfacial processes
- Contract research & collaboration with industrial partners

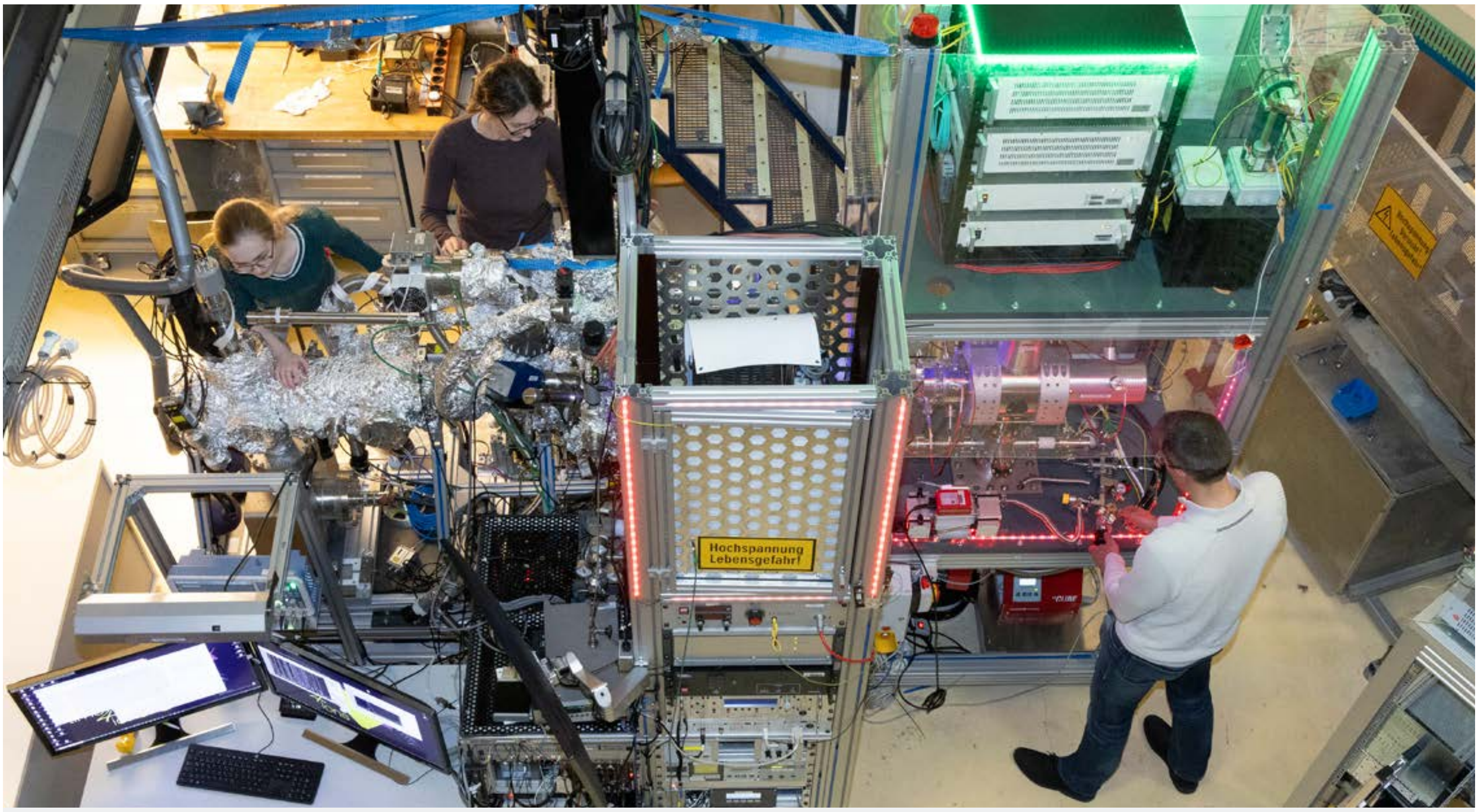
Example Project: Zinc Oxide Corrosion

Despite its excellent electronic properties, zinc oxide (ZnO) tends to corrode under real-world conditions. To investigate this phenomenon, we developed a custom-built flow cell in which ZnO crystals are operated under UV irradiation in controlled electrolytes. This cell is coupled with an ICP-MS (Inductively Coupled Plasma Mass Spectrometer), enabling real-time detection of even the smallest amounts of ZnO dissolution, while in-situ AFM techniques monitor surface changes. This approach provides in-depth insights into ZnO's behavior and helps us devise strategies for improving its stability.

Christian Doppler Laboratory for Surface and Interface Engineering

The Applied Interface Physics group hosts a renowned Christian Doppler Laboratory (CD-Laboratory), conducting research in close collaboration with industrial partners. The goal is to deepen our understanding of reactive interfacial processes – particularly in the steel and semiconductor sectors (e.g., SiC, GaN) – to minimize harmful corrosion mechanisms and surface defects. This research helps prevent hydrogen embrittlement and enables the development of high-quality surfaces for microelectronic applications. The insights gained extend beyond these fields and offer valuable contributions to industries such as biomedicine and renewable energy, highlighting the broad impact of industry-oriented research within a CD-Laboratory.

← More information



ADVANCED SPECTROSCOPY FOR MATERIALS AND PLASMAS

ATOMIC AND PLASMA PHYSICS

Highly charged ions play a key role in fusion research and for the development of new materials. Our team investigates how ion beams interact with solid materials, what structural damage arises, and how surfaces change in the process. We also examine fundamental processes in fusion plasmas. With advanced spectroscopy methods, we decipher complex couplings between material modifications and electronic properties. At our disposal are ion beam facilities for low energies, specialized ion sources for highly charged ion beams (HCIs), high-precision quartz crystal microbalances (QCMs), very low energy electron beams, coincidence detectors (rEELS, (e,2e)), as well as a femtosecond laser in the IR and UV.

Expertise and Focus Areas:

- Ion–solid interaction
- Ultrashort ion pulses
- Electron pair emission spectroscopy
- Fusion research
- Space weathering
- Biomimetics

Project: Research for the Development of Sustainable Fusion Energy

This project focuses on plasma-wall interactions and edge physics in devices like ASDEX Upgrade. Using advanced diagnostic methods such as lithium beam injection and high-precision quartz crystal microbalances, we develop stability scenarios for fusion plasmas to be implemented in the future ITER experimental fusion reactor.

Atomic and Plasma Physics
Univ. Prof. Richard Wilhelm
Assoc. Prof. Ille Gebeshuber, Univ. Prof. Aumayr, Ao. Univ. Prof. Wolfgang Werner, Dr. Anna Niggas, Dr. Gyula Nagy

More information →

PHYSICS OF THREE-DIMENSIONAL NANOMATERIALS

Our research group focuses on studying three-dimensional nanomaterials and nanostructures, in particular magnetic systems that hold great promise for developing new, environmentally friendly computer technologies. We develop new fabrication and characterization methods, use advanced X-ray and electron microscopy, and investigate physical phenomena arising from interfacial and geometric effects at the nanoscale.

Expertise and Focus Areas:

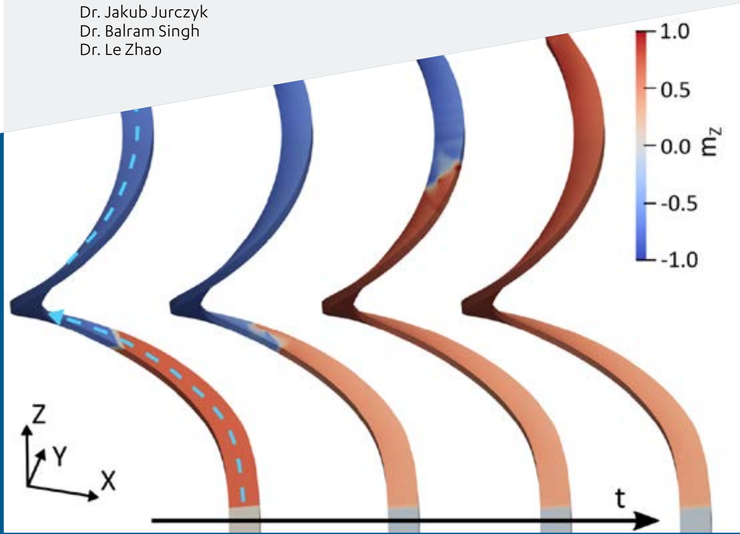
- 3D nanomagnetism and spintronics
- 3D nanofabrication using electron- and photon-based techniques
- Magneto-optics
- Interfacial effects in thin-film multilayers
- Chiral nanomaterials and devices

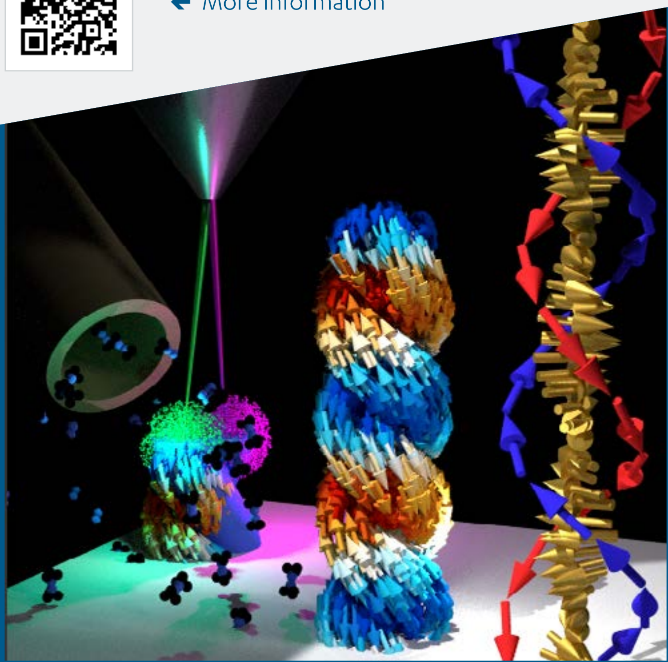
3D nano
Univ. Prof. Dr. Amalio Fernandez-Pacheco
Dr. Jakub Jurczyk
Dr. Balram Singh
Dr. Le Zhao

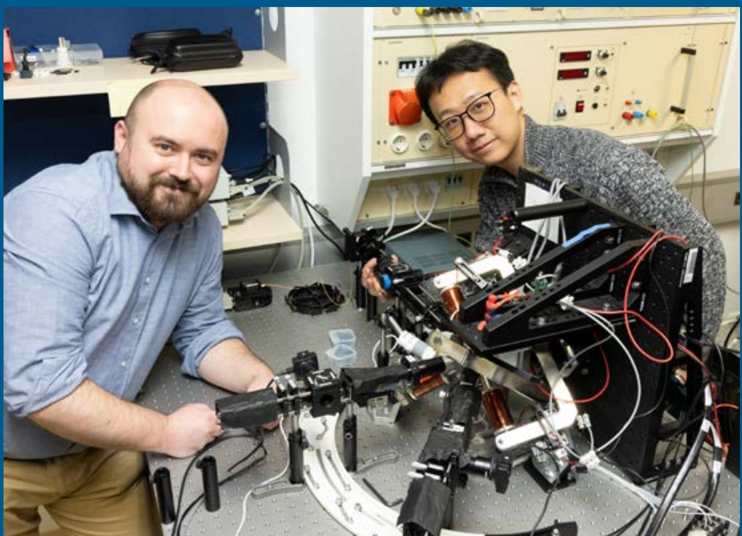
Project: Three-Dimensional Spintronics

Three-dimensional magnetic nanostructures exhibit unique physical properties that can be exploited for novel green computing technologies, particularly in spintronics, which utilizes both the charge and spin of electrons to process and store information. The EU-funded 3DNANOMAG project is pioneering experimental research on advanced 3D nanomagnetic systems, exploring multilayer materials, complex geometries, and chiral spin configurations. To achieve this, we employ newly developed 3D nanoprinting techniques and state-of-the-art magneto-optical tools, enabling unprecedented control and characterization of 3D spintronic devices.

More information







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