Programme et Equipements Prioritaires de Recherches Exploratoire

Spintronic innovations for a frugal, agile, and sustainable digital future

SPIN

We’re hiring!

Who we are

The Priority Research Program SPIN (PEPR) is an Exploratory program under the France 2030 investment plan.

It aims to develop a new generation of components for a more frugal, agile, and sustainable digital world. With a funding of 38 million euros over eight years, the SPIN Research Program is intended to contribute to supporting a new cycle of innovation in spintronics.

Co-led by CEA and CNRS, this program to address various scientific challenges, strengthen a national network for the development of innovative materials, and support interdisciplinary and innovative research.

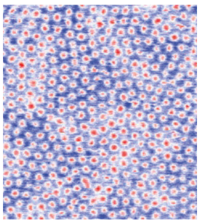
In figures

38	8	47	+30	440
Millions of euros in budget	Years the duration of the Program	Concerned Laboratories	Institutional partners	Scientists

Our Projects

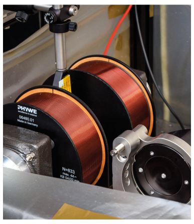
Moonshot Projects

Five Moonshot Projects have been identified around emerging themes in spintronics, showcasing a strong potential for innovation.



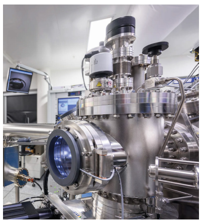
CHIREX

Beyond CMOS with chiral textures



TOAST

Towards spin-based THz technology

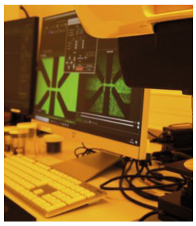


SWING

Spin waves for signal processing

SPINCOM

For intelligent communication

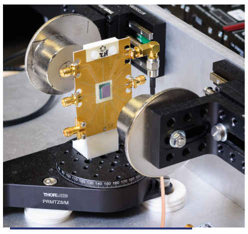


ADAGE

Next-generation magnetic detection

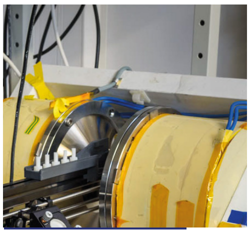
Transverse Actions

Three Cross-cutting Projects have been identified and are collaborating jointly with the targeted projects.



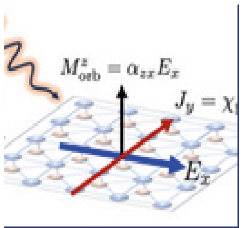
SPINMAT

Advanced materials for spintronics



SPINCHARAC

Advanced characterization equipment



SPINTHEORY

Multi-scale theory and modeling

Others projects

Over the course of the eight-year project, calls for proposals will be launched. These calls for proposals will allow for additional projects to support the targeted and cross-cutting projects across various fields.

SURFACE ACOUSTIC WAVES FOR SPINTRONICS

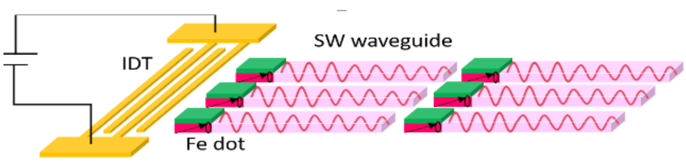


Figure 2: Fe dots and SW waveguide excited by a surface acoustic wave

Directors: Laura Thevenard & Pauline Rovillain
Duration: 3 years
Place: Institut des Nanosciences de Paris
Starting date: September 2024
Salary: 2100€ gross/month

MISSIONS

Context:
A substantial portion of today's magnetism research community dedicates its efforts to achieving highly integrated, rapid, and energy-efficient information and communication technologies that can operate at room temperature. In this context, Spin Waves (SW) emerge as promising contenders. They are collective excitations of electron spins within magnetic materials, traversing the spin lattice to convey information. Current interests lie in instigating SWs within nanostructures through external stress and acoustic means.

Objectives:
The aim will be to externally control the emission of spin waves and manipulate thei interaction in different independant wave-guides, using the ferromagnetic resonance driven by a surface acoustic wave.

PROFILE

Qualifications:
Master 2

Competencies:
In nanosciences
Good background in solid state physics

Qualities:
Taste for experimental physics
Autonomous and reliable,
Capable to work in a group and provide feedback

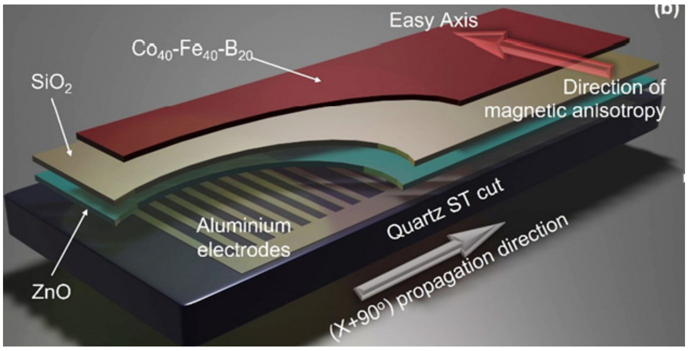
The laboratory:

The INSP is located at the centre of Paris on the largest campus of the country and has about 150 people working on a broad array of fields related to nanosciences: acoustics, spintronics,supraconductivity, quantum optics, growth (MBE) etc. – .

Job link:

https://w3.insp.upmc.fr/insp-theses/surface-acoustic-waves-for-magnonic-devices-3/
http://www.insp.jussieu.fr/

ADAGE



Analysis of Magnetic Noise in SAW Magnetic field Sensors Systems: Toward high sensitivity sensors in [nT-pT] range.

Directors: N. Tiercelin and O. Elmazria
Duration: 36 months
Place: IJl (Nancy) and IEMN (Lille)
Starting date: October 2024
Salary: 2100€ gross/month

MISSIONS

Context:

Magnetic sensors have a huge scope of applications in automobiles, robotics, mobile phones, space equipment, geophysics, military weapons, etc. They have a great potential in biomedical applications where they are employed for biomagnetic signal detection or point-of-care diagnostics1. The former involves the detection of the magnetic field emanating from the organs like heart (magnetocardiography-MCG), brain (magnetoencephalography-MEG), muscles (magnetomyography-MMG), and neurons (magnetoneurography-MNG). The latter calls for the detection of proteins, drugs, cells, nucleic acids, and other biomarkers which are usually labelled with magnetic particles.

Objectives:

Surface acoustic waves (SAW) based sensors use piezoelectric crystals coupled with interdigitated electrode transducers (IDTs) to generate the guided SAW waves. The active element of this device is a magnetoresistive/magnetoelastic layer, whose elastic modulus changes in response to the magnetic field thereby modulating the SAW wave proportionately. To maximize the sensitivity, one has to carefully configure the sensor geometry by considering the pitch of the electrodes, spacing, thickness of the active layer, the orientation of easy-axis of the magnetostrictive layer, etc. However, detection of weak magnetic field intensity in the range of nT – pT, requires sensors with high limit of detection (LoD). To maximize the limit LoD of such sensor systems, it is of high importance to understand and to be able to quantify the relevant noise sources. The LoD is governed by the noise in the sensor device but also in the electronic system considered for signal detection and processing.

This multidisciplinary project will be an opportunity for you to contribute to the design, microfabrication and characterization of new magnetic sensors thanks to advanced equipment at Institut Jean Lamour.

PROFILE

Certifications:

Master 2

Competencies:

Solid sate Physics, Electronics

Qualities:

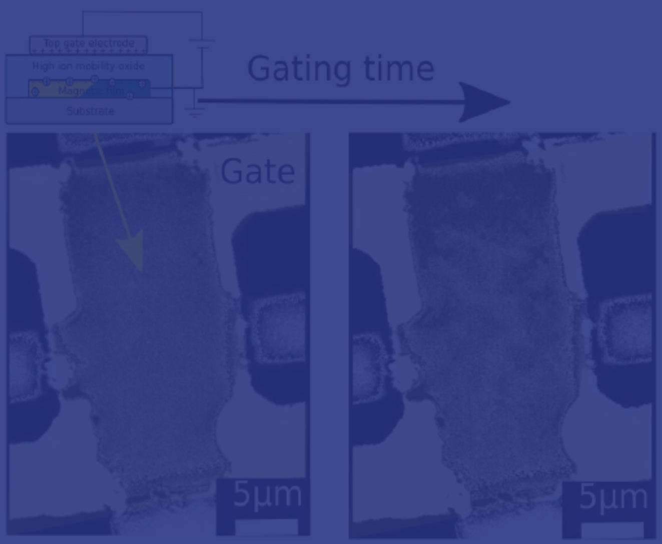
Problem solver, Team player, Communication skills

The laboratory

The Institute Jean Lamour (IJL) is a joint research unit of CNRS and Université de Lorraine.
Focused on materials and processes science and engineering, it covers: materials, metallurgy, plasmas, surfaces, nanomaterials and electronics.
Partnerships exist with 150 companies and our research groups collaborate with more than 30 countries throughout the world.
Its exceptional instrumental platforms are spread over 4 sites; the main one is located on Artem campus in Nancy.

Job link: contact by mail

CHIREX



Magneto-ionic control of chiral structures for neuromorphic computing'

Director: Liza Herrera Diez
Duration: 3 years
Place: Centre for Nanoscience and Nanotechnology (C2N), Palaiseau, France
Starting date: September 2024
Salary: 2100€ gross/month

Offer filled

MISSIONS

Context:
Magneto-ionics is an emerging field that others great potential for reducing power consumption in spintronics memory applications. By combining the concept of voltage-controlled ionic motion from memristor technologies, typically used in neuromorphic applications, with spintronics, this field also provides a unique opportunity to create a new generation of neuromorphic functionalities based on spintronic devices. Our group has been at the forefront of investigating the magneto-ionic control of magnetic anisotropy, magnetic domain wall motion, and the Dzyaloshinskii Moriya interaction in various materials. Through our research, we have demonstrated large, reversible, and non-volatile effects in magnetic properties due to the chemical interaction between the mobile ions and the magnetic atoms. These findings have significant implications for the development of low-power spintronics memory and neuromorphic devices.

PROFILE

Certifications:
Candidates motivated to work on this project are invited to apply for a PhD position (also master project + PhD) or an 18 month post doc position, immediately available.

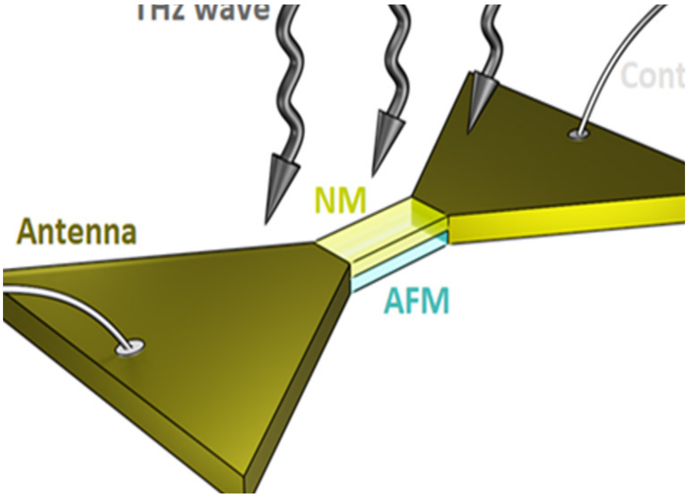
Competencies:
For PhD candidates, a good basis of solid state physics and magnetism will be required, experience in experimental physics will be greatly appreciated. Ability to communicate in English is expected. Experience in magneto-ionics, domain wall dynamics and/or neuromorphic spintronics will be a great advantage.

Qualities:
Postdoc candidates should demonstrate expertise in spintron-ics device measurements, in particular, current induced switching of magnetisation, and have significant experience in nanofabrication.

The laboratory

The project will greatly benefit from our team's collective expertise in both magneto-ionics (Liza Herrera Diez) and neuromorphic computing architectures (Damien Querlioz) and the close collaboration with the spintronics neuromorphic team at CNRS-Thales laboratories in the Saclay campus. The PhD degree will be awarded by Université Paris Saclay.

Web site link: https://integnano.c2n.u-psud.fr/



THz detection using spintronic mechanisms

Director: Dr.Matthieu BAILLEUL,
Duration: 3 years
Place: IPCMS in Strasbourg
Starting date: October 2024
Salary: 2100€ gross/month

MISSIONS

Context:

Electromagnetic waves in the frequency range 300 GHz -30 THz have various applications for imaging, chemical detection or high-speed communication. However, convenient emitters and detectors are still missing in this range, known as the THz gap. Existing devices are mostly based on semiconductors and have limited performances. The use of new physical mechanisms, not relying on semiconductors structures, appears as a possible route for the further development of the field of THz physics. In this context, spintronic based technologies appear particularly promising. The discovery of spintronics THz emitters shows that it is possible to outperform laser driven semiconductor THz sources when using a different, spin based, emission scheme. This discovery lead to an unprecedented development of THz spintronics. However, these works are mostly focused on emission and there is a clear need for efficient scheme for THz detection. In this PhD project, we propose to use the antiferromagnetic resonance for spintronic THz detection.

Objectives:

Antiferromagnets have their natural resonance mode in the THz range, due to the strong exchange interaction between their magnetic sub-lattices. In this PhD thesis, we propose to design and use a novel detection scheme consisting in integrating the antiferromagnet within a micrometer scale electromagnetic antenna structure to concentrate the THz field and access antiferromagnetic resonance at a reduced scale. In addition, we will take advantage of the so-called inverse spin Hall effect occurring in a heavy metal layer adjacent to the antiferromagnet to detect the interfacial spin current generated at resonance. The aim of the PhD project is to study experimentally the antiferromagnetic resonance in microstructures. The project includes design and simulation work aiming at optimizing THz confinement. In a second step the most promising devices will be fabricated onto selected antiferromagnetic systems using cleanroom facilities (STnano). The structures will then be characterized using both a time-resolved optical set-up and a continuous wave THz platform (0-1.2 THz). During the thesis, a secondment at SPINTEC and LNCMI in Grenoble will aim at adapting the design for measurements at the high magnetic field THz set-up of LNCMI.

PROFILE

Certifications:

Master’s degree in Physics or material science

Competencies:

Condensed matter physics, material science, optics, high frequency physics

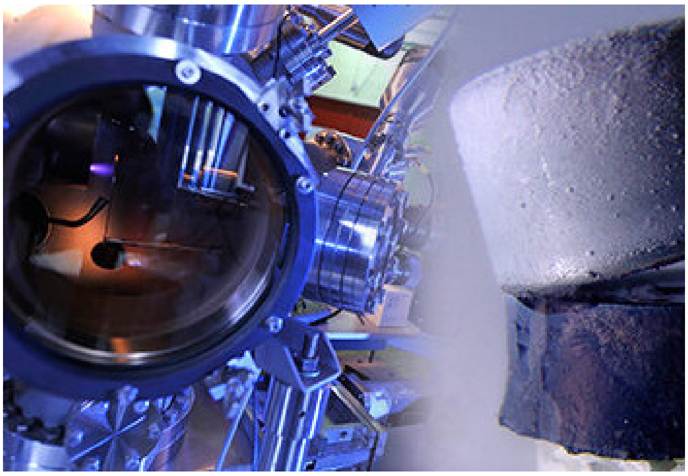
Qualities:

Curiosity, problem solving abilities, experimental abilities

The laboratory

Strasbourg institute of materials physics and chemistry (IPCMS) is focused on the study of materials through interdisciplinary approaches combining physics and chemistry. Key research areas include nanoscience, functional materials, theoretical physics and modeling, as well as advanced spectroscopy and microscopy techniques.

Job link: https://www.ipcms.fr/emploi/thz-detection-using-spintronic-mechanisms/



Ferroelectric oxides for spintronic applications

Duration: 36 month
Place: Caen - CRISMAT
Starting date: October 2024
Salary: 2100€ gross/month

MISSIONS

Context:

In the quest of low energy consumption devices, the use of ferroelectric materials appears to be a very promising pathway toward efficient materials: the reversal of spontaneous polarization represents a lower energy cost than the reversal of magnetization. The next step consists of coupling ferroelectricity with magnetic and electronic properties: this can be achieved (i) in multiferroic materials combining ferroelectric and magnetic orders or (ii) in non-magnetic materials presenting a sizable spin-orbit interaction and in which the amplitude and orientation of the spontaneous polarization enables a non-volatile control of the spin textures. The coupling of ferroelectricity with the electronic and magnetic properties of materials appears to be a strong lever for designing energy-efficient materials able to respond to current climate problems.

Objectives:

The aim of the thesis is to produce ferroelectricity in magnetic materials and/or in materials possessing a strong spin-orbit interaction in order to design compounds (i) combining ferroelectricity and magnetism and (ii) showing optimal properties. To that end, the highly multifunctional character of perovskite oxides, among which the most popular ferroelectrics like $BaTiO_3$ and many magnetic materials belong, will be harnessed. These studies will be performed with Density Functional Theory (DFT) simulations allowing to resolve the electronic problem in matter and to reliably model the properties of materials.
Activities:
- Materials modelling
- Lattice mode couplings
- Data analysis
- Extract physical trends and rules
- Make hypothesis and perform numerical checks

PROFILE

Certifications:

The candidate must possess a Research Master's degree in Solid State Physics or Materials Science or hold an engineering title in these fields

Competencies:

The candidate must have a strong background in condensed matter physics and be familiar with numerical simulations and crystallography

Qualities:

Skills about solving the electronic problem in materials (DFT) is strongly welcome, as well as familiarity with the Linux world.

The laboratory

The CRISMAT laboratory is a joint CNRS, ENSICAEN and Normandy University research unit located in Caen and entailing a hundred of researchers and engineers. It is a laboratory internationally recognized for its expertise on oxide materials. The PhD student will become a member of the Thin Films, Interfaces and Surfaces group at CRISMAT and will be supervised by Julien Varignon, Lecturer at ENSICAEN and theoretician. The PhD student will enjoy a favorable environment to carry out the missions with access to numerous techniques and tools locally.

Job link: https://emploi.cnrs.fr/Offres/Doctorant/UMR6508-SOIMIL0-009/Default.aspx?lang=EN

Programme de Recherche SPIN

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