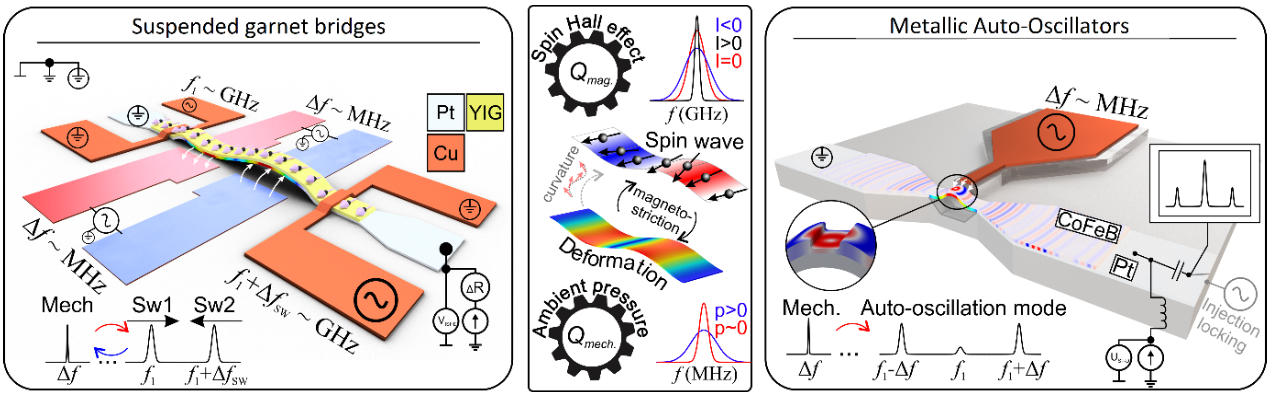
Nanomagnetism and Spintronics Group

Summer Student Positions 2024

Aalto University
School of Science

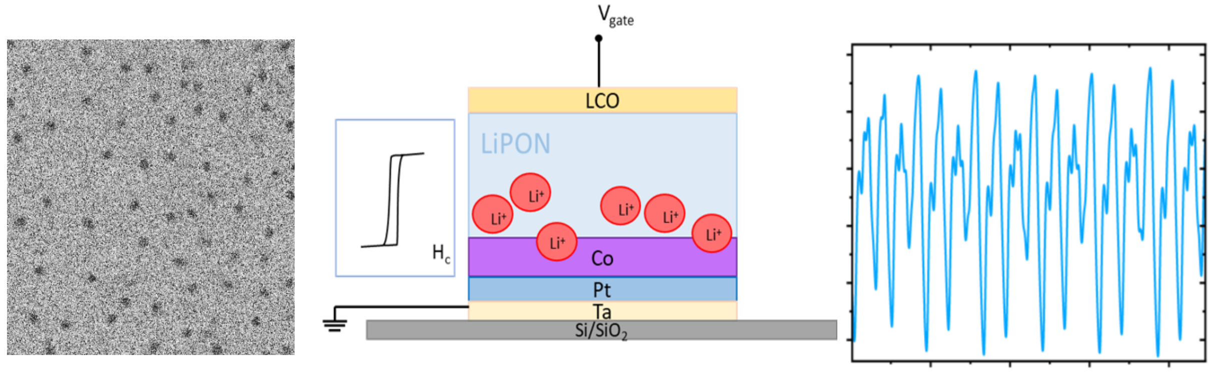
(1) Magnon-phonon coupling in suspended YIG bridges

Magnonics is a field of science where spin waves propagating in magnetic materials can attain nanoscale wavelengths and frequencies from GHz to THz. Since the wavelength of spin waves is several orders of magnitude smaller than that of electromagnetic radiation at the same frequency, magnonics holds a great promise for future microwave processing and telecommunication devices with scalable footprints. In this project, we aim at extending the already very rich functionalities of magnonic systems by coupling magnon excitations to micromechanical oscillations (phonons) in suspended yttrium iron garnet (YIG) bridges. Moreover, we will use the relativistic spin Hall effect to lower the magnetic damping of the suspended bridges to enhance the magnon-phonon coupling strength. As a summer student, you will learn how to fabricate suspended micromechanical bridge oscillators by pulsed laser deposition and advanced lithography, and you will image magnon and phonon excitations using a state-of-the-art time-resolved optical microscopy technique.



(2) Reservoir computing with lithium-ion controlled magnetism

A reservoir computing system utilizes a non-linear physical reservoir for mapping inputs into a high-dimensional space and a readout for pattern analysis of the high-dimensional states in the reservoir. In this type of neuromorphic computing system, the reservoir is fixed and only the readout is trained using linear regression and classification methods. Reservoir computers are particularly suitable for predicting time series data, such as those produced by biological systems. Magnetic systems provide an ideal platform for the implementation of reservoir computing devices due to their many degrees of freedom, intrinsic memory, and non-linear behavior. To make energy efficient neuromorphic devices, we are using solid-state lithium-ion battery technology to create voltage-controlled magnetic systems. The magnetic systems consist of topological magnetic particles known as skyrmions, which act as the non-linear physical reservoir. Skyrmions are created and annihilated by controlling the properties of the hosting magnetic layer. We have previously demonstrated the feasibility of controlling magnetic skyrmions in hybrid magnetic/lithium-ion devices through applied voltages. As a summer student, you will create and characterize skyrmion devices to study the possibility of using them for reservoir computing tasks. In the project, you will learn how to make lithium-ion hybrid devices (multilayer film growth using magnetron sputtering and lithography), how to measure the magnetic properties under applied voltages (magneto-optical Kerr effect microscopy), how to simulate skyrmion devices (micromagnetic simulations in MuMax3 software), and how to characterize reservoir computing tasks.



(3) Neuromorphic *X* perceptions

Neuromorphic *X* perceptions (*X* = visual, tactile, auditory, smell, taste, or combination of them), emulating neural sensory perceptions, are of great interest for applications in machine vision, intelligent speech, smart prosthetics, food safety, and environmental science. We are currently exploring neuromorphic multisensory perceptions, such as observational learning, by integrating new sensors, memristive devices, optoelectronic devices, as well as machine learning algorithms in hardware-software hybrid systems. As a summer student, you will have the opportunity to work at the frontiers of neuromorphic sensing and computing. You will also be trained in neuromorphic system design, integration, and characterization, as well as nanofabrication and machine learning.