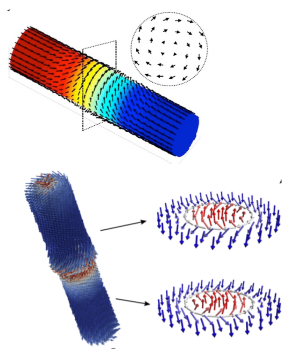
DYNAMICS OF TOPOLOGICALLY NON-TRIVIAL 3D DOMAIN WALLS IN CYLINDRICAL GEOMETRIES.

Magnetic nanostructures constitute building blocks for different nanotechnologies in data storage, sensing, magneto-mechanical actuation, bio applications etc. Particularly, nanomagnetic spintronic devices are considered for future energy efficient replacement of CMOS-based electronics; and spincaloritronics as the way of energy harvesting from the electronic heat [1]. While many traditional realizations of nanodevices use 2D planar structures, the future implementation of the nanoscale “internet of things” will call for the use of 3D magnetic nanostructures [2]. Cylindrical Magnetic Nanowires is a clear and promising example for building blocks for 3D nanomagnetism. These nanowires can offer multifunctional responses to electric and magnetic fields, electric current, mechanical stresses or thermal gradients and thus can be used for the necessary interconversion between different functionalities.



Modelled magnetisaiton configuration of the Bloch-point domain wall and the skyrmion tube

The use of these magnetic structures will require “information carriers” whose role is played by 3D domain walls and spinwaves. While domain walls and their dynamics are well explored in planar nanostructures, the 3D domain walls in cylindrical nanowires have a strong influence of the geometry (the typical walls have cylindrical vortex-like structure with the magnetic singularity in the center called Bloch point and are, in fact, 3D hedgehog skyrmions) and their dynamics is practically unexplored. These domain walls have intriguing properties related to their topology: they can achieve large velocities and their dynamics depend on their characteristics.

The objective of the project will be to explore theoretically and by means of modelling techniques the possibility to move these domain walls by spin-polarized current (related to the area of spintronics) and/or by thermal gradients (related to spincalortironics). Both methods [1] provide important energy saving functionalities and their development is important for building future micro/nano electronics based on green technology.

Theoretical research will be done in collaboration with the experimental efforts in the group which aim at learning to control the domain wall motion. It will aim at evaluation of the most efficient way to move Bloch point domain walls in relation to material properties and geometries. While the planned work is theoretical, a constant contact with experiment will provide the student with understanding of realistic conditions.

The work will be done at the Instituto de Ciencia de Materiales de Madrid, CSIC, Campus UAM under the supervision of Dr. Oksana Chubykalo-Fesenko (https://wp.icmm.csic.es/magsim/oksana-chubykalo-fesenko/) in the group of Nanomagnetism and Magnetisation Processes (https://wp.icmm.csic.es/gnmp/). Please, contact oksana@icmm.csic.es for further information.

References:

[1] B.Dieny et al Opportunities and challenges for spintronics in microelectronics industry, Nature Electr 3, 446 (2020)

[2] A. Fernández-Pacheco et al.,Three-dimensional nanomagnetism Nature Comm. 8, 15756 (2017)