Postdoc position: *Dzyaloshinskii-Moriya Interaction in Iron Garnets: from crystalline growth to chiral structures and spin-waves*

Description of the offer: Postdoc position in spintronics and magnetization dynamics at the Service de Physique de l'État Condensé (SPEC), CEA Paris-Saclay, Gif-sur-Yvette (France).

Starting date: October 2024 or later

Duration: 12 months

Yearly income: about 40 k€ gross/year, depending on experience

Research area: spintronics, nanomagnetism, magnonics, magnetic thin films

The postdoc candidate will work in the frame of the ANR project DeMIuRGe (2022–2026), which is a collaboration between five labs : Laboratoire Albert Fert, Laboratoire de Physique des Solides, C2N, SPEC (all located on campus Paris-Saclay), and Lab-STICC (Brest).

Context:

Recent progress in material synthesis opened novel perspectives to generate new classes of magnetic excitations stemming from the Dzyaloshinskii-Moriya interaction (DMI). The objective of the DeMIuRGe project is to understand and ultimately control how chiral interactions of the Dzyaloshinskii-Moriya form can be induced in thin films of ferrimagnetic insulators (FMIs), namely iron garnets. They possess a magnetic damping in the 10^{-4} range, typically two orders of magnitude smaller than ferromagnetic 3d metals, making them a unique model system to study the complex properties of the magnetic quasi-particles, the magnons. The inclusion of chiral interactions in garnets will allow the exploration of many recent theoretical predictions that can be experimentally realised exclusively in such low-damping materials, including asymmetric spin wave propagation, specific excitation modes and nonlinear properties.

More broadly, FMIs are of interest for spintronics because they avoid resistive losses and possess interesting magnetic dynamic properties. The generation of chiral spin textures (*e.g.*, skyrmions) in FMIs or the excitation of their antiferromagnetically coupled spins in the THz range are also exciting and challenging research fields for the next generation spintronic technology. In this framework, rare-earth iron garnets (RIGs), $R_3Fe_5O_{12}$ (with R= Y, Tm, Er…), are fascinating FMIs with unusual magnetic properties (high Curie temperatures, compensation temperatures, tunable magnetic anisotropy, chiral structures…). With the progress in the crystalline growth of oxide thin films and associated heterostructures, it has been shown that high quality RIG thin films can be epitaxially grown on various substrates with the possibility of tailoring the magnetic anisotropy via the epitaxial strain. Yttrium iron garnet (YIG), that is extensively used in microwave filters and oscillators due to its ultra-low intrinsic Gilbert damping constant (as low as 3.10^{-5}), is now routinely produced in the form of ultra-thin films (thickness < 100 nm) for spintronic and magnonic devices. There is also an interest in looking at other members of the RIGs family by substituting the non-magnetic Y^{3+} ions in YIG by other rare-earth ions: R= Gd, Er, Tm… For example, several groups have recently reported the presence of chiral magnetic textures or skyrmions in thulium iron garnet (TmIG) thin films via the topological Hall effect in Pt/TmIG bilayers. The chiral exchange interfacial DMI enables to stabilize these novel topological spin textures.

Objectives:

The goal of this postdoc project is to probe and ultimately control how chiral interactions, in particular the DMI one, can be induced in RIG thin films. First, the postdoc will be in charge of optimizing the crystalline growth of RIG thin films (with R= Y, Tm, Er…) by pulsed laser deposition (PLD) on different $Gd_3Ga_5O_{12}$ (GGG) and substituted (sGGG) substrates. The different samples will be characterized in details by X-ray diffraction and magnetometry (VSM, Polar Kerr). In addition, the dynamic magnetic properties of thin films will be probed by ferromagnetic resonance. Secondly, by combining the RIG oxide with a heavy metal overlayer with a strong spin-orbit coupling (Pt, Ta…), magneto-transport analyses (topological Hall effect), which could reveal the presence of DMI and skyrmions, will be performed. Finally, specific signatures in the spin-wave spectrum of RIG microstructures, related to the presence of DMI, will be probed using the technique of magnetic resonance force microscopy (MRFM) developed at SPEC.

Requirements:

A successful applicant is expected to have a PhD degree in Physics (Condensed Matter). They must have a solid theoretical and experimental background in material science / spintronics / nanomagnetism / magnetic thin films / magnetization dynamics. They should demonstrate expertise in thin film growth and in spintronic device testing. Skills as ferromagnetic resonance, nanofabrication and micromagnetic simulations will be particularly relevant.

Contact and application:

The application should include a statement of research interest, CV, a copy of the PhD thesis, or equivalent, published articles and other relevant materials, if available. Also, letter(s) of recommendation can be included.

For further information about the position please contact:

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