EXCHANGE ANISOTROPY OF MACROSPINS IN SUPERFERRIMAGNETIC STRUCTURE

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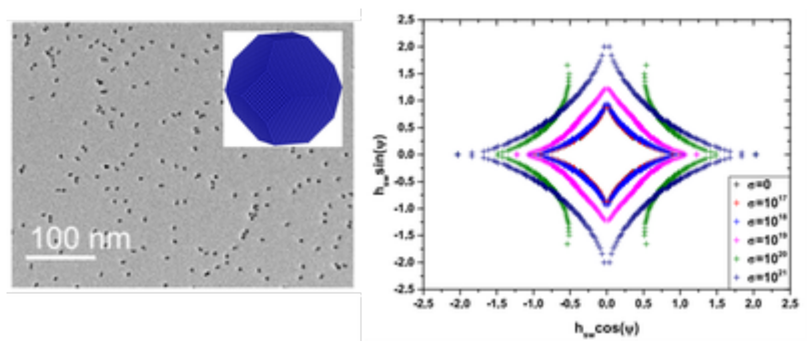
SCIENTIFIC CONTEXT :



(left) Assembly of Co nanoparticles (right) calculated switching fields in SFiM structures

Magnetic nanoparticles (NPs) are used in many applications, including as potential building blocks for information storage. Single-domain magnetic nanoparticles present peculiar physical properties, which significantly differ from the same materials in the bulk state. In sufficiently small single-domain ferromagnetic particles (FMs), all spin moments rotate coherently and can thus be assimilated to macrospins [Stoner1948]. Moreover, the relatively large fraction of atoms occupying surface sites leads to a strong sensitivity of their magnetic properties (anisotropy, magnetic order, magnetization) to the surrounding environment, and many fundamental questions remain to be explored.

In this work, we will investigate the magnetic properties of NPs integrated in a superferrimagnetic (SFiM) heterostructure. A ferrimagnetic material (FiM) is characterized by the coexistence of two sublattices of spins, of different moments, coupled antiparallel by exchange. In the case of SFiM, these are two FM phases, of different magnetizations, coupled antiparallel by exchange at the interface. The concept of SFiM was proposed by Akdogan et al [Akdogan2014] to increase the resistance against demagnetization of permanent magnets. Its field of exploration has so far been restricted to bulk systems or micrometer-thick films [LeRoy2014], made of magnetically hard, multidomain FM grains, associated with a magnetically soft intergranular phase and supposedly exchange-coupled antiparallel.

MISSIONS :

The project aims to investigate the superferrimagnetic (SFiM) principle in single-domain nano-grain systems, a regime that remains largely unexplored. It focuses on assemblies of Co nanoparticles deposited on or embedded in a Gd layer. The objective is to experimentally quantify how antiparallel interfacial exchange coupling modifies the effective magnetic volume, net magnetization, thermal stability, and reversal field of the nanoparticles.

Samples will be fabricated at the PLYRA facilities (ILM-Tech platform). Co nanoparticles will be synthesized by Low Energy Cluster Beam Deposition under ultra-high vacuum (~10^{-10} mbar) and mass-selected to obtain narrow size distributions with diameters between 1 and 8 nm. Co/Gd heterostructures will be produced by sequential deposition of nanoparticles and electron-beam-evaporated Gd. Magnetic reversal and thermal stability will be investigated using SQUID magnetometry.

The project will provide fundamental insight into SFiM at the nanoscale, notably for data storage.

OUTLOOKS :

Fully funded PhD position

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