EXCHANGE ANISOTROPY OF MACROSPINS IN A SUPERFERRIMAGNETIC STRUCTURE

LABORATORY : Institut Lumière Matière

LEVEL : M2
TEAM(S) : ENERGIE

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SCIENTIFIC CONTEXT :

Single-domain magnetic nanoparticles (NPs) present peculiar physical properties, which significantly differ from the same materials in the bulk state. In a simple model describing single-domain ferromagnetic particles (FMs), all spin moments remain parallel, and they can thus be assimilated to macrospins [Stoner1948]. Real magnetic NPs are more complex as the surface atoms can differ from those of the volume, by their spin moments, their anisotropy, their orientation, 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 coupled antiparallel by exchange at the interface. The concept of SFiM was proposed by Akdogan et al [Akdogan2014] to increase the coercive field 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. The principle of SFiM has never been studied in single-domain nano-grain systems, neither integrated in a matrix nor deposited on a surface, although it is expected to lead to higher thermal stability of the macrospins.

MISSIONS :

The SFiM system to be studied in this internship will be an assembly of 3d transition metal nanoparticles (Co), deposited on (or embedded in) a layer of a rare earth element (Gd). The samples will be prepared using the equipment of the PLYRA (Plateforme LYonnaise de Recherches sur les Agrégats), at the ILM-Tech platform. The Co NPs will be synthesized using the "Low Energy Cluster Beam Deposition" process, by laser vaporization and condensation of atomic vapour, deposited at low energy on a substrate, under ultra-high vacuum (base vacuum 10^-10 mbar) conditions. The NPs will be selected in mass, upstream of the deposition, in an electrostatic deflector, which makes it possible to obtain a relatively narrow distribution of size, with a standard deviation of 15% and centered on a value chosen between 1 and 8 nm. The Co/Gd heterostructures will be obtained by sequential deposition of NPs and Gd atoms by evaporation from an electron gun. In order to investigate the macrospins reversal and thermal stability, the intern will use a Superconducting Quantum Interference Device (SQUID) magnetometer of the "Transport" characterization facility at the ILM-Tech platform.

OUTLOOKS :

Possibility of continuing this work in a PhD thesis.

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