Post-doctoral stage proposal for 20 months

Laboratories : MONARIS, Sorbonne Universté, Paris (www.monaris.cnrs.fr)
ICMPE, Universite Paris-Est Creteil Val-De-Marne (www.icmpe.cnrs.fr)
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Beginning of the stage : from may or september 2022
Salary: 2500 € gross / month (funding ANR)

Temperature profile in nanomagnet based hyperthermia devices

Magnetic hyperthermia consists in converting electromagnetic power into heat by applying an external AC magnetic field to an assembly of magnetic nanoparticles (NPs). A very localized temperature rise is then observed, which can be useful in medicine or chemistry, especially catalysis. However, although very promising, this technique is not mature yet and, in order to be developed and extended, some fundamental aspects must be clarified. In particular, the role of NP concentration and thereby of the dipolar interaction has to be investigated in a systematic way. The NanoHype project implements a global approach, from multiscale theory to innovative experiments, aiming at understanding how to control and optimize the temperature profile within magnetic nanoparticle assemblies of different concentrations. The proposed post-doctoral study is based on two experimental parts: on one hand, "chemistry" (synthesize of magnetic NP assemblies) with I. Lisiecki and A. Courty, MONARIS/SU and on the other hand, "physics" (AC magnetic susceptibility measurements) with Lotfi BESSAIS, ICMPE/Université Paris-Est Creteil Val-De-Marne and (Small-angle X-ray scattering (SAXS) measurements) in LPS/Universite Paris-Saclay. Magnetic NPs will be cobalt and maghemite characterized by a mean diameter of 8 nm and 12 nm, respectively. Maghemite NPs are already synthesized in MONARIS lab. Co NPs characterized by 12 nm will be synthesized by using colloidal chemistry. In a first step, 8 nm Co NPs (already mastered) will be synthesized by chemical reduction in reverse micelles (water droplets in oil) [1]. In a second step, the germination method will be used to growth these 8 nm-Co NPs until reaching a mean diameter of 12 nm [2]. At the end of the synthesis, Co NPs (similarly to the maghemite) will be passivated with dodecanoic acid. All the steps of this synthesis will take place under a nitrogen flow in order to avoid the material oxidation. In order to study the dipolar interactions between NPs, assemblies with different concentrations in NPs (ferrofluids) will be prepared. In addition, colloidal crystals (isolated 3D ordered NP assemblies) will be performed, offering a system with strong dipolar interactions. These colloidal crystals will be prepared by a co-evaporation method with a mixture of ethanol/hexane (well mastered in MONARIS lab). SAXS study will be performed on the ferrofluids of maghemite and cobalt NPs (8 nm and 12 nm) with tunable NP concentration.

[1]- S. Costanzo and I. Lisiecki, J. Phys. Chem. C 120, 22054 (2016)

[2]- S. Lee, … A. Courty, Nanotechnology, 32, 095604 (2021)

Candidate skills:

- Synthesis of cobalt nanocrystals by colloidal chemistry in glove box. TEM study.

- SAXS and AC magnetic susceptibility measurements studies.