LABORATOIRE PMC

Internship Proposal 2018/19

	Paramagnetic analysis inside diamagnetic nanoparticles by NMR relaxation
Location:	Laboratoire PMC - École polytechnique, Route de Saclay – F - 91128 Palaiseau
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	Details / additionnal bibliography here – Group website: here
Techniques to be used:	nanoparticles synthesis, solid-state NMR, structural studies (XRD, TEM, SEM…)
Canditate profile:	Strong interest for experimental materials science. The student will be trained to the different techniques. Knowledge in solid-state NMR (especially in relaxation) will be a plus.
Funded intersnhip – Possibility to pursue as a PhD:	yes

A vast majority of functional materials have physical properties (optical, magnetic or transport) which originate from the presence of doping elements. Often present in small amounts, their precise characterization in terms of distribution, oxidation state, etc, is a major difficulty in materials science and the development of adapted experimental techniques is an important issue. PMC lab has been working for some years on the use of solid-state nuclear magnetic resonance (NMR), specifically by taking advantage of paramagnetic dopant induced relaxation effects.[1, 2] Beyond the methodological aspect, this subject is treated in connection with luminescent nanoparticles, whose properties result from the insertion of rare earths into a crystalline matrix. These particles are of great interest in the field of biology as probes, in microfluidics, for lighting or display devices...

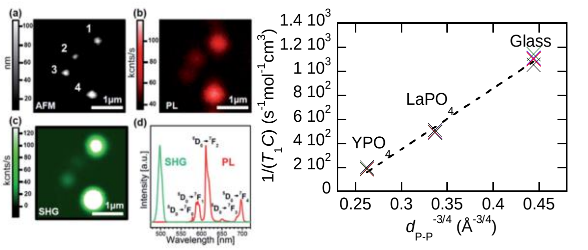

Figure 1: Left: nanoparticles of $LaPO_4$:Eu@KTP which are of great interest in biology (see details in the folder). Right: law relies on the doping concentration *C*, the mean distance $d_{P\text{-}P}$, characteristic of a material, and the relaxation time T_1

Previously, we have shown that, whatever the bulk material, crystalline or amorphous, the longitudinal relaxation rate $1/T_1$ being linear with the doping rate, there exists a law connecting the concentration in dopant C, T_1 and the average distance between each nucleus probed by the NMR experiment (^{31}P here), $d_{P\text{-}P}$. After having developed this law with bulk materials, we now want to implement it for nanoparticles which we control the synthesis, especially of $LaPO_4$ monazite phase. The monoclinic structure of lanthanum phosphate is of interest, unlike the hexagonal phase, because it contains no proton.

The internship will be conducted as follows, concomitantly:

- training NMR and relaxation;
- synthesis of lightly doped $LaPO_4$ nanoparticles by different routes;
- characterization by X-Ray diffraction, DTA/TGA, microscopy, ...;
- NMR relaxation measurements.

Depending on the progress of the project, this study may be enlarged to other nanoparticles, such as yttrium and aluminum garnet of formula YAl_2O_3. In this case, measurements on nuclei less easily detectable by NMR will be done in other laboratories.

Bibliography: [1] Maron, S. *et al*. DOI: 10.1039/C4CP02628D – [2] Maron, S. *et al*. DOI: 10.1039/C7CP00451F