Nuclear Magnetic Resonance in inhomgeneous magnetic field : towards multi-scale observation

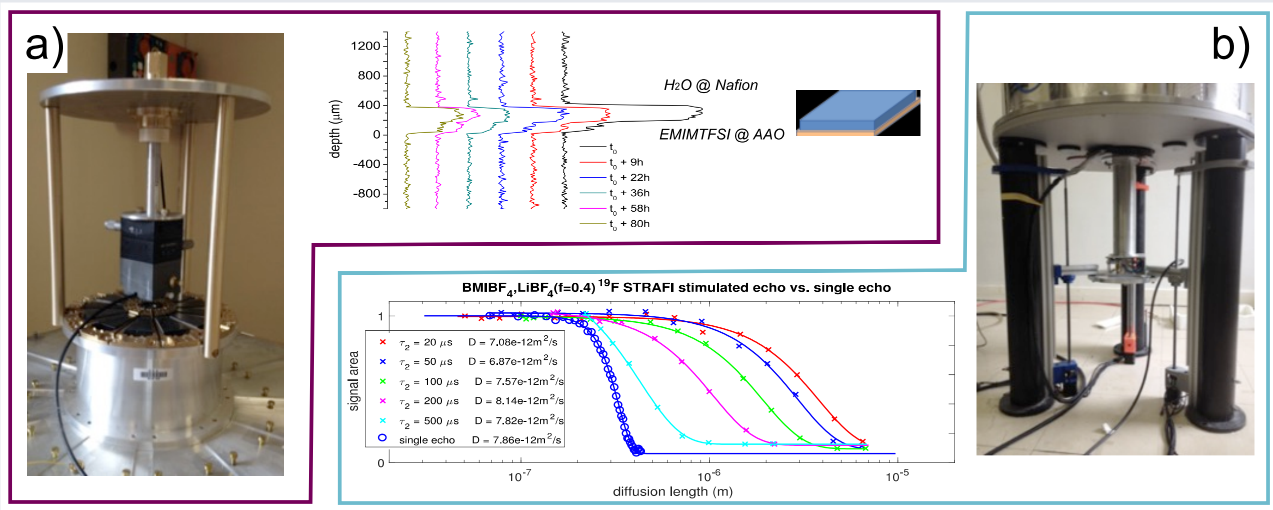
P. Judeinstein, R. Oliveira-Silva, J.-M. Zanotti (LLB, Saclay), M. Zeghal, V. Klein, J. Sanchez, S. Saranga (LPS, Orsay), D. Sakellariou (NIMBE, Saclay), K. Pilar, S. Greenbaum (CUNY, New York)

Most of Nuclear Magnetic Resonance (NMR) experiments are performed in magnetic fields which are as homogeneous as possible (deviations are typically better than 10-9 (ppb)) in order to measure chemical shifts and spin couplings, which are the clues for the determination of (bio)molecular structures and also for their intermolecular interactions. Then, these experiments allow to probe 0.1-2 nm space scale. However, information can also grabbed at larger scales (µm – mm) like probing the dynamics of molecules inside the materials through self-diffusion coefficients, or by getting images even at the scale of human body by magnetic resonance imaging (MRI). Such experiments require a spatial encoding of the magnetic field to localize molecules. It is most generally obtained by adding short magnetic field gradient pulses superimposed to the main strong and very-homogeneous field. Nonetheless, such perturbations, distort the homogeneity of the magnetic field and require complementary electronics and more sophisticated acquisition pulse sequences. To circumvent such issues, dedicated NMR methods have been developed in using the specificities of inhomogeneous magnetic fields (fringe field or stray field imaging (STRAFI) NMR).

We have developed such methods on two different speoctrmeters for various studies and applications:

a) 1D-imaging of thin films and membranes (5µm - 5mm) was optimized on a specific low-field (0.33T) single-side NMR with the addition of a controlled sample environment and optimized pulse sequences. Spin densities, relaxation times, diffusion coefficients could be measured in the different layers, and the stability of this equipment allows to follow kinetic processes during long peridods (weeks). Another important feature is the portability of this device allowing to perform in-situ experiments in various conditions, and the coupling with other techniques.

b) An original setup has been designed on a standard high-field magnet (9.4T) to perform reproducibly experiments out of the central field. STRAFI experiments at high field have been designed to measure diffusion coefficients for various nuclei, including quadrupolar nuclei with short relaxation times. The possibility to perform experiments for various diffusion times is mandatory to characterize localized and confined diffusion process.



P. Judeinstein, F. Ferdeghini, R. Oliveira-Silva, J.-M. Zanotti, D. Sakellariou, *"Low-field single-sided NMR for one-shot 1D-mapping: Application to membranes"*, J. Magn. Res., (2017), **277**, 25-29.

Résultats obtenus dans le cadre du projet RMNinhomogene financé par le thème Emergence du LabEx PALM et porté par P. Judeinstein (LLB).