Application for internship in our group is recommended (3 months min.)

A research project is available of our web site, in the "Jobs" section (Master 2 level)

Stage de recherche recommandé – Niveau M2 – entre mars et juillet 2020

Proposition de thèse / PhD topic

Date de la proposition : 15 octobre 2019

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Nom du Laboratoire / *laboratory name*: **Laboratoire Kastler Brossel**

Code d'identification : UMR8552 Organisme : ENS-PSL, CNRS, SU (UPMC), Coll. de France

Site Internet / *Web site*: http://www.lkb.upmc.fr/polarisedhelium/polarised-helium-and-quantum-fluids/

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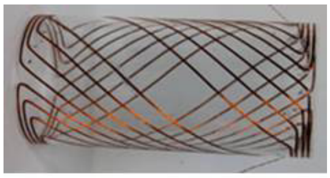
Innovative methods for low-field NMR and MRI

Context: Conventional magnetic resonance (MR) operates in dense media at thermal equilibrium in high magnetic field, B (e.g., clinical imaging involves H nuclei from body water or tissues and B ≥ 1.5T). Laser optical pumping techniques yield high out-of-equilibrium magnetisation (hence, good S/N ratio) and allow MR detection at arbitrary B in low density samples. Spin-1/2 noble gases (^{3}He or ^{129}Xe) may retain a high polarisation up to several days. They have been used for functional lung imaging (mixed with air and inhaled just before signal acquisition) in pre-clinical research studies, for instance.



Our group focuses on low-field MR (B=1–6 mT) and develops new methods for improved MR measurement or imaging efficiency of thermally- or laser-polarised samples, with a precise evaluation of their pros and cons. Application to lung imaging currently provides the driving momentum to this work and low-field operation advantageously results in fewer artefacts and longer MR signals.

We have recently implemented an emerging gradient-free imaging technique, TRASE (Transmit Array Spatial Encoding), where the phase of the NMR signal is controlled by resonant rf excitation rather than by precession in a non-uniform B field. Methodological studies and in vitro validation take place at LKB, in a home-made system, with H_2O samples or polarised gas.

PhD project: A first objective is the evaluation of the potential benefits (improved image resolution, contrast, sensitivity, specificity, etc.) and practical limitations of TRASE imaging at low field. The first results display unexpected features, possibly linked with puzzling recent observations of NMR response to very short rf pulses (a few rf periods). Under such conditions, the rf-driven magnetisation undergoes very unusual travel paths on the Bloch sphere. Our goal is to develop efficient general-purpose NMR tools, which may also find applications in quantum computing or coherent control of Qbits.

A more generic challenge in MR imaging of gases is the assessment of the impact of atomic diffusion on image quality and contrast. It must be specifically addressed in lung imaging, given the complex and multi-scale structure of the airspaces in which the gas is confined. Unusual diffusion processes are also met in nanoporous materials, for which theoretical and practical questions remain open. A new project, MARGIN, is being launched. In all cases, MR studies with polarised noble gases are expected to provide valuable insights.

The work will include quantitative low-field investigations, numerical simulations using state-of-the-art tools, and comparison with more standard techniques and high-field measurements. It will thus provide opportunities for substantial experience in NMR and MRI, with or without nuclear hyperpolarisation.

Read more: http://www.lkb.upmc.fr/polarisedhelium/polarised-helium-and-quantum-fluids/mri/

Options for financial support: ANR funding (if granted) or application for PhD contract (EDPIF)
Financement de thèse envisagé: école doctorale ou ANR (demande en cours)