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**

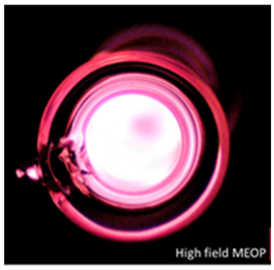
Code d'identification : UMR8552 Organisme : ENS-PSL, CNRS, SU (UPMC), Coll. de France

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

Adresse /*Address:* Laboratoire Kastler Brossel, Dep^{t} de Physique de l'ENS, 24 rue Lhomond, 75005 Paris

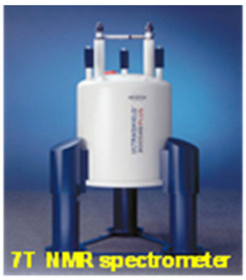
High-field hyperpolarisation in helium plasmas

Nuclear spin-polarised ^{3}He gas, currently produced in situ or remotely by laser optical pumping, has extensive scientific or practical applications. These include pre-clinical lung MRI, spin filters for neutron beams, targets for high energy physics, nuclear magnetometry, etc. (https://arxiv.org/abs/1612.04178) The growing needs of end-users constantly drive new efforts to boost up nuclear polarisation, gas density, or production rate, and to extend the range of operating conditions.



Metastability exchange optical pumping, MEOP, yields very high ^{3}He nuclear spin polarisation (up to 90%) in "standard" conditions: room temperature, low gas pressure, low magnetic field. The high efficiency of MEOP (typically, 1 polarised nucleus per absorbed photon) relies on two processes that involve a minority of atoms promoted in the metastable 2^3S level by a weak rf discharge: laser-driven OP cycles on the closed 2^3S-2^3P optical transition at 1083 nm and polarisation transfer by ME collisions between 2^3S and ground state atoms (a quick binary exchange of electronic excitation with no change of nuclear spin orientations).

We have also shown that MEOP remains very efficient in "non-standard" conditions involving high-pressure gas and high magnetic field (up to 4.7 T), a remarkable result when strong hyperfine decoupling prevails. Our recent work has focused on the fundamental limits of conventional MEOP, and the current PhD work investigates the links between a large angular momentum leak observed during OP at strong pump light power and various collision-induced population transfers.



PhD project: A new collaborative project (WideNMR) provides the challenging opportunity to extend the investigations of high field MEOP up to higher field strength (7 T) and down to cryogenic temperatures (77 K – 1 K), with potential application to high-sensitivity ^{3}He magnetometry (for high resolution mass spectrometry in ion traps, for instance). The planned investigations, launched with improved experimental and theoretical tools, will revisit some pioneering work on ^{3}He MEOP at low temperature performed at LKB and test MEOP efficiency in isotopic ^{3}He-^{4}He gas mixtures.

Additionally, the recently discovered PAMP scheme (Polarization of Atoms in a Magnetized Plasma) for hyperpolarizing ^{3}He *without* laser OP will be explored (https://arxiv.org/abs/1806.07624).

Experimental investigations of all polarisation processes at various magnetic field strengths will make use of new and complementary optical diagnoses, with visible and infrared lasers (light polarisation analysis, absorption and line shape measurements, pump-probe detection), as well as NMR quantification.

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

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)